



UNIDIR

Navigating a New Era for Nuclear Energy in the Middle East

ALMUNTASER ALBALAWI



MIDDLE EAST WEAPONS OF MASS DESTRUCTION FREE ZONE SERIES



About UNIDIR

UNIDIR is a voluntarily funded, autonomous institute within the United Nations. One of the few policy institutes worldwide focusing on disarmament, UNIDIR generates knowledge and promotes dialogue and action on disarmament and security. Based in Geneva, UNIDIR assists the international community in developing the practical, innovative ideas needed to find solutions to critical security problems.

About the author



Almntaser Albalawi is a nuclear engineer and political scientist specialising in arms control, science and technology, and international security. He has worked as a Researcher with UNIDIR's Middle East WMD-Free Zone Project since 2023. Albalawi is also an associate fellow in the international security department of the Peace Research Institute Frankfurt (PRIF). Previously, he worked at the Royal Scientific Society, Jordan, where he led the Chemical, Biological, Radiological and Nuclear Threat Office and served as a senior staff scientist at the Bio-Safety and Bio-Security Centre.

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Note

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Cover Image: Barakah Nuclear Energy Plant, United Arab Emirates. Credit: Emirates Nuclear Energy Corporation (ENEC).

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Acronyms and abbreviations

AP	Additional Protocol
AI	Artificial intelligence
COP28	28th Conference of the Parties to the United Nations Framework Convention on Climate Change
CSA	Comprehensive Safeguards Agreement
CTBT	Comprehensive Nuclear-Test-Ban Treaty
ENR	Enrichment and reprocessing
Euratom	European Atomic Energy Community
GCC	Gulf Cooperation Council
Gen IV	Generation IV (reactor systems)
GW	Gigawatt
HALEU	High-assay low-enriched uranium
HEU	Highly enriched uranium
IAEA	International Atomic Energy Agency
IUEC	International Uranium Enrichment Centre
JCPOA	Joint Comprehensive Plan of Action
LEU	Low-enriched uranium
MW	Megawatt
MWe	Megawatt electric
NNWS	Non-nuclear-weapon state
NPP	Nuclear power plant
NPT	Treaty on the Non-Proliferation of Nuclear Weapons
NSG	Nuclear Suppliers Group
NWFZ	Nuclear Weapon-Free Zone
NWS	Nuclear-weapon state
R&D	Research and development
SMR	Small modular reactor
SQP	Small Quantities Protocol
SESAME	Synchrotron-Light for Experimental Science and Applications in the Middle East
TRISO	Tristructural isotropic (fuel)
UAE	United Arab Emirates
WMD	Weapons of mass destruction
WMDFZ	Weapons of Mass Destruction-Free Zone

إسراج الطاقة النووية ثلاث مرات بحلول عام 2050 الإمارات العربية المتحدة، ديسمبر 2023

TRIPLING NUCLEAR ENERGY BY 2050 United Arab Emirates, December 2023

Introduction

Tripling Nuclear Energy by 2050, UN Climate Change Conference, Dubai, United Arab Emirates, 2 December 2023. Credit: Dean Calma / IAEA.

Since the Declaration to Triple Nuclear Energy was launched at the 28th United Nations Climate Change Conference (COP28) in 2023, nearly 40 states have signed up to its pledge to boost global nuclear energy capacity by 2050 in order to combat climate change and achieve Net Zero by minimising pollution. This commitment came amid a surge in private-sector fundraising for artificial intelligence (AI) and data centres, which have contributed to the global rush to expand nuclear energy in the coming decades. Although interest in nuclear energy has often been overstated, it may now gain renewed momentum, including in the Middle East, in line with this global trend.

The past few years have witnessed several developments that could mark a new phase of nuclear energy activities in the Middle East.¹ The Islamic Republic of Iran, which was the first to operate a nuclear power plant in the region, has signed a US\$25 billion deal with the Russian Federation to build new nuclear power plants. Meanwhile, in the face of international pressure, it has doubled down on maintaining its domestic fuel cycle capabilities. The fourth nuclear unit in the United Arab Emirates (UAE) has entered commercial operation. As electricity demand, driven by desalination needs and economic ambitions, is projected to grow both domestically and regionally, the country plans to expand its programme with a second nuclear power plant.²

¹ For the purpose of establishing a Middle East WMDZF, as defined by United Nations General Assembly Decision 73/546 and the IAEA Report by the Director General (GOV/2018/38-GC(62)/6), the region encompasses the members of the League of Arab States, Iran, and Israel.

² International Energy Agency (IEA), “Electricity Demand is Surging Across the Middle East and North Africa, Driven by Cooling and Desalination Needs”, 18 September 2025, <https://www.iea.org/news/electricity-demand-is-surging-across-the-middle-east-and-north-africa-driven-by-cooling-and-desalination-needs>.

Meanwhile, Egypt has reported progress in the construction of its first nuclear power plant. Saudi Arabia, which has repeatedly expressed interest in nuclear energy, including commercialising its national uranium reserves, has rescinded its Small Quantities Protocol (SQP) – a step commonly taken by states advancing towards nuclear power programmes – and reportedly concluded negotiations with the United States on nuclear cooperation to build nuclear power reactors.

Several other states in the Middle East are continuing to develop their regulatory capacities and human resources as interest in nuclear energy remains strong. This is particularly driven by the ongoing exploration of small modular reactors (SMRs) as a promising potential for localised



The impact of the United States–Israel war with Iran on global energy markets may strengthen the economic case for nuclear energy and its role in energy security, while also highlighting the risks of targeting nuclear and other relevant energy and critical infrastructure.

power production and water desalination. The impact of the United States–Israel war with Iran on global energy markets and oil prices has made nuclear energy more economically viable and a strategic choice for energy security, while also highlighting the risks of targeting nuclear and other relevant energy and critical infrastructure.

Beyond energy and water security, interest in nuclear energy and enrichment technology may also be driven by strategic motives. As Middle Eastern states have historically pursued domestic enrichment technology

as an assurance against external supply vulnerability, as a source of political leverage and as a potential hedge against security threats, the development of advanced nuclear technology capabilities is increasingly viewed by some of the region’s states as a strategically compelling option.

The expansion of nuclear activities, if realised, could have an impact on the regional proliferation landscape. If not reasonably justified or if they lack adequate safeguards and transparency, nuclear energy activities may heighten mistrust and tensions on top of the inherent nuclear security and safety risks. They may also have implications for the initiative to establish a future Middle East Zone Free of Weapons of Mass Destruction (WMD), possibly regarding prohibitions, obligations and verification.

This publication examines the current drivers for pursuing nuclear energy in the Middle East and how they may evolve in the near and medium terms. In particular, it examines how regional policy discourses and assumptions about security, climate change, energy, nuclear, and AI technologies shape interest in nuclear energy and influence decision-making. Understanding these drivers, together with the political and technical frameworks governing nuclear energy cooperation, is crucial for assessing risks and informing effective risk mitigation and regional cooperation.

The first section of the publication highlights key evolving drivers and their implications for nuclear energy policy in the Middle East. The second section examines specific cases of regional nuclear energy programmes, assessing their current status and outlook. The third section analyses the regional nuclear non-proliferation landscape and the evolving threat perceptions under which these programmes operate.

The fourth section reviews models for technology sharing and cooperation in the nuclear fuel cycle. The final section discusses possible implications for the Middle East WMD-Free Zone initiative and outlines cooperative risk-mitigation measures.

This publication does not seek to predict, endorse or discourage nuclear energy expansion; nor does it attempt to assess the success or failure of specific nuclear projects. Rather, it analyses the complex decision-making environment in which nuclear energy choices are being made in the Middle East, including the long-term risks and implications that commitments to nuclear energy might face in the current regional and international contexts.



This publication does not seek to predict, endorse or discourage nuclear energy expansion; nor does it attempt to assess the success or failure of specific nuclear projects.



1. Nuclear energy trends

IAEA's Nuclear Energy Summit, Brussels, 21 March 2024. Credit: Klaus Iohannis via X.

Global nuclear energy grew rapidly around the world until the 1990s, driven by the promise of cheap, clean energy, especially in response to the 1970s oil crisis. During this period, nuclear energy accounted for nearly 18 per cent of global electricity production.³ However, public fear and disapproval following the 1986 Chernobyl accident led to a drastic decline in interest and growth, prompting policies to phase out nuclear programmes, along with stricter regulations and safety standards. These measures, along with supply chain disruptions, increased costs and construction times, reduced the economic viability of nuclear energy. Until the end of the 2010s, the outlook for nuclear energy appeared to diminish, as more countries adopted policies to decommission existing plants and shift away from nuclear power.

In the Middle East, nuclear energy has been of interest since the 1970s; the region's first nuclear power reactor, in Iran, entered operation in the 1990s. High and volatile oil prices in the 2000s, among other reasons, prompted other states in the region to consider nuclear energy in order to achieve energy cost stability and reduce dependence on oil, particularly for domestic consumption. However, these efforts faced the same global challenges and were further complicated by regional security concerns, including conflicts and fears about the proliferation of nuclear weapon technology. Public fears about the safety of nuclear energy were reignited by the 2011 Fukushima accident. Of more than 10 countries in the Middle East that have considered or planned nuclear energy programmes, only the UAE and Iran currently operate nuclear power plants, while Egypt's first plant is under construction and scheduled to begin operating in 2028.

³ World Bank, "Electricity Production from Nuclear Sources (% of Total)", World Development Indicators, <https://data.worldbank.org/indicator/EG.ELC.NUCL.ZS>, accessed 14 April 2026.

Recent developments have contributed to the resurgence of interest in nuclear energy globally and regionally. These have included the climate change debate over decarbonisation and nuclear energy; the prioritisation of energy security; supportive policies and increased financing aimed at revitalising nuclear power; the promise of technological innovations in nuclear systems; and the growing need to meet the energy demand of data centres, especially for AI workloads. Accordingly, the International Atomic Energy Agency (IAEA) has repeatedly revised its projections for nuclear energy expansion upwards over the past five years.⁴

1.1. Emerging drivers for renewed interest in nuclear energy

This subsection highlights three key evolving drivers of renewed global and regional momentum in nuclear energy: supporting policies, the AI–nuclear nexus and technological advancements. It also reviews their potential implications (and limitations) for nuclear policy and nuclear energy programmes in the Middle East.

1.1.1. Supporting policies and financing

A new trend for nuclear energy in recent years has been the adoption by governments of more supportive policies. These have included reforms to licensing, taxation and regulatory frameworks for cooperation, as well as new financing models and partnerships between states, the private sector and international organisations.

An early driver of this trend was the vulnerability caused by the gas and energy crisis triggered by the war in Ukraine since 2022. This led to the lifespan of nuclear plants being extended and to the reconsideration of past nuclear power plant plans. Climate commitments, including the COP28 Declaration to Triple Nuclear Energy by 2050, have further strengthened the case for using nuclear energy to meet carbon-emission targets, especially for states concerned about their ability to meet their targets predominantly with renewable sources of energy. The AI revolution and the race for computing power dominance have also reinforced the growing belief that AI is a key enabler of future economies that rely heavily on abundant, secure energy, with nuclear energy arguably a crucial component for achieving that.

Global and regional support for nuclear energy is also driven by new regulations in the United States and reforms initiated since 2025 under the administration of President Donald J. Trump, which aim to revitalise the US nuclear industry and regain market leadership. This is evident in the 2025 US National Security Strategy and the executive orders revisiting nuclear energy policies; these all treat the promotion of nuclear energy technology exports, including to the Middle East, as a national security priority and emphasise the need to rescind or ease restrictions on exports

⁴ International Atomic Energy Agency (IAEA), “IAEA Raises Nuclear Power Projections for Fifth Consecutive Year”, Press Release 89/2025, 15 September 2025, <https://www.iaea.org/newscenter/pressreleases/iaea-raises-nuclear-power-projections-for-fifth-consecutive-year>.

and cooperation policies.⁵ The US administration has also allocated funding and formed partnerships with the private sector to recommission shutdown reactors, extend operational lifespans, build new reactors, and accelerate research and development (R&D) and licensing of SMRs and other advanced nuclear reactor and fuel technologies. The United Kingdom, Japan and member states of the European Union have adopted similar promotion policies, such as the French Nuclear Renaissance 2024, the British Advanced Nuclear Fund (including the Sizewell C project) and Japan's reopening of its largest nuclear power plant in 2026, which had been shut down for almost a decade. Easing policies could expedite regulatory approvals for innovations in reactor and fuel technology, bringing them closer to commercial demonstration and market readiness.

The overhaul of US nuclear export restrictions aims to rebuild the US industrial base amid fierce competition and past market losses to Russia and, potentially, China, which have also adopted favourable policies to promote their nuclear industries. The Middle East is a crucial part of the US policy for creating long-term international demand and investment. International cooperation is also perceived to serve non-proliferation goals by creating technical and economic leverage and raising the cost of proliferation, which puts pressure on partner countries not to risk their strategic relationship with the technology provider.



Some states in the Middle East that are pursuing nuclear energy programmes have long regarded the non-proliferation policy of the United States as unduly restrictive.

Some states in the Middle East that are pursuing nuclear energy programmes have long regarded the non-proliferation policy of the United States as unduly restrictive. They argue that exaggerated concerns have led to unjustified and selective additional restrictions and requirements, which have hindered nuclear energy cooperation. Experts have long warned that such approaches may discourage potential partners and allies, thereby pushing them towards China or Russia instead.⁶ The

current US administration seems more open to easing restrictions and conducting case-by-case reviews of potential cooperation projects.⁷ It has set a milestone to “aggressively” pursue at least 20 international peaceful nuclear cooperation agreements (so-called Section 123

⁵ The White House, “2025 National Security Strategy of the United States of America” (Washington, DC: The White House, November 2025), <https://www.whitehouse.gov/wp-content/uploads/2025/12/2025-National-Security-Strategy.pdf>, and The White House, “Reinvigorating the Nuclear Industrial Base”, “Reforming Nuclear Reactor Testing”, “Deploying Advanced Nuclear Reactor Technologies for National Security”, “Reform of the Nuclear Regulatory Commission”, Executive Orders, 23 May 2025, <https://www.whitehouse.gov/presidential-actions/executive-orders/>.

⁶ Sarah Sobalvarro, “U.S. Inaction Is Ceding the Global Nuclear Market to China and Russia”, Wilson Center, 2 April 2025, <https://www.wilsoncenter.org/article/us-inaction-ceding-global-nuclear-market-china-and-russia>.

⁷ Fred McGoldrick, “U.S.–UAE Nuclear Cooperation Agreement: A Gold Standard?”, (Washington, DC: Center for Strategic and International Studies, 30 November 2010), https://csis-website-prod.s3.amazonaws.com/s3fs-public/legacy_files/files/publication/101130_McGoldrick_USUAENuclear.pdf.

agreements) globally by early 2029.⁸ This has presented an opportunity to revive stalled cooperation (e.g., between the United States and Saudi Arabia) and to encourage other US allies in the region (e.g., Jordan and Bahrain) to pursue nuclear energy collaboration (e.g., the recent US–Bahrain Memorandum of Understanding to expand talks on peaceful nuclear energy cooperation, including the construction of nuclear power plants).

Reforms and government-led incentives are also evident across the region. As energy demand in the Middle East is expected to grow rapidly by 2035 due to population and economic growth,⁹ some emerging economies in the region are increasingly convinced that nuclear energy will be a key driver of economic growth and the rapid expansion of infrastructure and technology, similar to what other emerging economies have achieved in their transition to advanced economies. Advanced economies typically exhibit high value-added industrial and technological maturity, with strong innovative capacity and advanced R&D ecosystems. The support provided by the UAE’s Barakah reactor for the building of other national industries is cited as a regional example of nuclear energy’s economic development value. Likewise, Middle Eastern states hope to utilise the potential of nuclear energy to help achieve climate targets. Egypt, the UAE and Saudi Arabia have ambitious climate commitments, including those outlined in the COP28 declaration, making it difficult to meet their goals without expanding their energy portfolio, including nuclear energy.

Another key aspect of global supporting policies is the mobilisation of new sources of financing, which have traditionally been absent and have hindered the expansion of nuclear energy. Due to its large scale, high upfront capital costs, associated risks, long construction timelines and delayed returns, nuclear energy has historically been difficult to finance. Jordan is an example from the region of a country that abandoned a large nuclear power plant project due to, among other reasons, high costs and technical difficulties (e.g., grid upgrades and cooling), which increased the financial risk.

Momentum is growing among global financial institutions, international banks and governments to mobilise new financing for nuclear energy.¹⁰ The World Bank has lifted its decades-long ban on funding nuclear energy projects and is currently working with the IAEA to identify a pilot project for financing. The IAEA is also collaborating with international banks and funds to develop investment strategies that promote nuclear energy, including support from some of the 14 international banks that pledged support for nuclear financing at New York Climate Week in 2024 (e.g., the UAE’s Abu Dhabi Commercial Bank).¹¹

⁸ The White House, “Deploying Advanced Nuclear Reactor Technologies for National Security”, Executive Order, 23 May 2025, <https://www.whitehouse.gov/presidential-actions/2025/05/deploying-advanced-nuclear-reactor-technologies-for-national-security/>.

⁹ IEA, “The Future of Electricity in the Middle East and North Africa”, (Paris: IEA, 2025), <https://iea.blob.core.windows.net/assets/a205959d-3d98-4abb-ac0e-fb97b3b05a8d/TheFutureofElectricityintheMiddleEastandNorthAfrica.pdf>.

¹⁰ For examples of how the IAEA and governments are increasingly exploring new models for financing nuclear power plants, see IEA, “The Path to a New Era for Nuclear Energy”, (Paris: IEA, 2025), 69, <https://iea.blob.core.windows.net/assets/b6a6fc8c-c62e-411d-a15c-bf211ccc06f3/ThePathtoaNewEraforNuclearEnergy.pdf>.

¹¹ “International Banks Express Support for Nuclear Expansion”, World Nuclear News, 14 October 2025, <https://world-nuclear.org/net-zero-nuclear/news/international-banks-express-support-for-nuclear-expansion>.

Additionally, the IAEA has worked actively with the Organisation of the Petroleum Exporting Countries (OPEC) Fund for International Development, with Saudi Arabia as a key state, to explore financing options for nuclear energy programmes.

1.1.2. The AI–nuclear nexus

Growing global and regional interest in emerging technologies such as AI is driven by data sovereignty and economic development.¹² AI is viewed as a means that states could use for adapting and localising technologies to their future political and economic ecosystems without relying on foreign sources. It is also seen as a tool for harnessing economic opportunities in the AI sector, where data centres play a crucial role.¹³ This indicates that countries are increasingly committed to developing AI infrastructure.

As states compete to position themselves for the AI revolution and the emerging AI race, energy supply is becoming a critical enabler for this competition. Energy production is vital to advancing AI computing, which is powered by data centres with computer chips that generate computational power. For example, the Stargate project in the United States, one of the world's largest data plants under construction, will consume about 1.2 gigawatts (GW), the equivalent

of the output of one large nuclear power reactor. This is why states are increasingly linking nuclear energy, which is seen as a viable source of mass energy, to their AI ambitions.¹⁴



States are increasingly linking nuclear energy, which is seen as a viable source of mass energy, to their AI ambitions.

Several states in the Middle East, especially members of the Gulf Cooperation Council (GCC), are actively promoting the localisation of data centres and investment in AI infrastructure. Saudi Arabia, Oman

and the UAE have established economic zones for data centres and AI infrastructure to attract investment.¹⁵ Public investment funds of Saudi Arabia and the UAE have also made substantial investments in large-scale data centre projects in the region, indicating a strong interest in the significant growth of digital infrastructure capacity in the Middle East.

¹² Rya Kuewor, “The UAE’s Stargate project hints at how AI can be integrated into national infrastructure”, World Economic Forum, 6 June 2025, <https://www.weforum.org/stories/2025/06/stargate-uae-ai-national-infrastructure/>.

¹³ Thibault Werlé et al., “AI Data Centers: An Opportunity in the Middle East”, White Paper (Boston Consulting Group, November 2025), <https://media-publications.bcg.com/AI-Data-Centers-ME.pdf>.

¹⁴ “Putin Links Nuclear Buildout to Russia’s AI Ambitions”, Nuclear Engineering International, 2 December 2025, <https://www.neimagazine.com/news/putin-links-nuclear-buildout-to-russias-ai-ambitions/>, and Chloe Williment, “The UK–US Tech Deal: Powering AI Targets with Nuclear Energy”, Sustainability Magazine, 23 October 2025, <https://sustainabilitymag.com/news/the-uk-us-tech-deal-powering-ai-targets-with-nuclear-energy>.

¹⁵ “Unlocking the Data Centre Opportunity in the Middle East”, PwC, 10 April 2025, <https://www.pwc.com/m1/en/media-centre/articles/unlocking-the-data-centre-opportunity-in-the-middle-east.html>.

Saudi Arabia's 6-GW Humain data centre and the UAE's 1-GW Stargate (and the broader 5-GW AI Campus) are also two examples where states and companies based outside the region have chosen to save money by moving computation and data offshore.¹⁶ These large AI infrastructure projects leverage lower-cost local energy production to generate computing power, which is then delivered to international clients via data transfers.

If these gigawatt-scale projects materialise, they could significantly raise current energy demand projections, potentially boosting regional growth expectations and encouraging further consideration of options for energy production, such as nuclear energy. The United States' recent approval of the export of advanced AI chips to the UAE and Saudi Arabia (restricted by export controls and conditioned on "rigorous security and reporting requirements"¹⁷) provided these two states with important tools to materialise these projects.

Some experts warn against overhyping AI-driven energy and the risks of coupling AI with nuclear build-up if AI does not live up to expectations.¹⁸ They also warn that the timelines for building the new nuclear infrastructure do not align with the rapid demand for AI infrastructure. While those are legitimate concerns, some Middle Eastern states, including the UAE and Saudi Arabia, would still value AI independently of the nuclear dimension, driven by competitiveness, in order to shape opportunities for the development of future technologies and to invest in sovereign digital infrastructure.

1.1.3. Promising advancements in nuclear reactor and fuel technology

The IAEA reports continued progress in nuclear technologies that could shape the future of energy supply and strengthen the competitiveness of nuclear power. Recent developments include efforts to streamline regulatory and licensing frameworks for SMRs and to expand experimental work on other advanced Generation IV (Gen IV) reactor systems, including the construction of experimental and prototype units and the allocation of funding for specialised fuels such as Tristructural Isotropic (TRISO) and high-assay low-enriched uranium (HALEU).¹⁹ These steps are central to accelerating licensing and demonstration programmes.

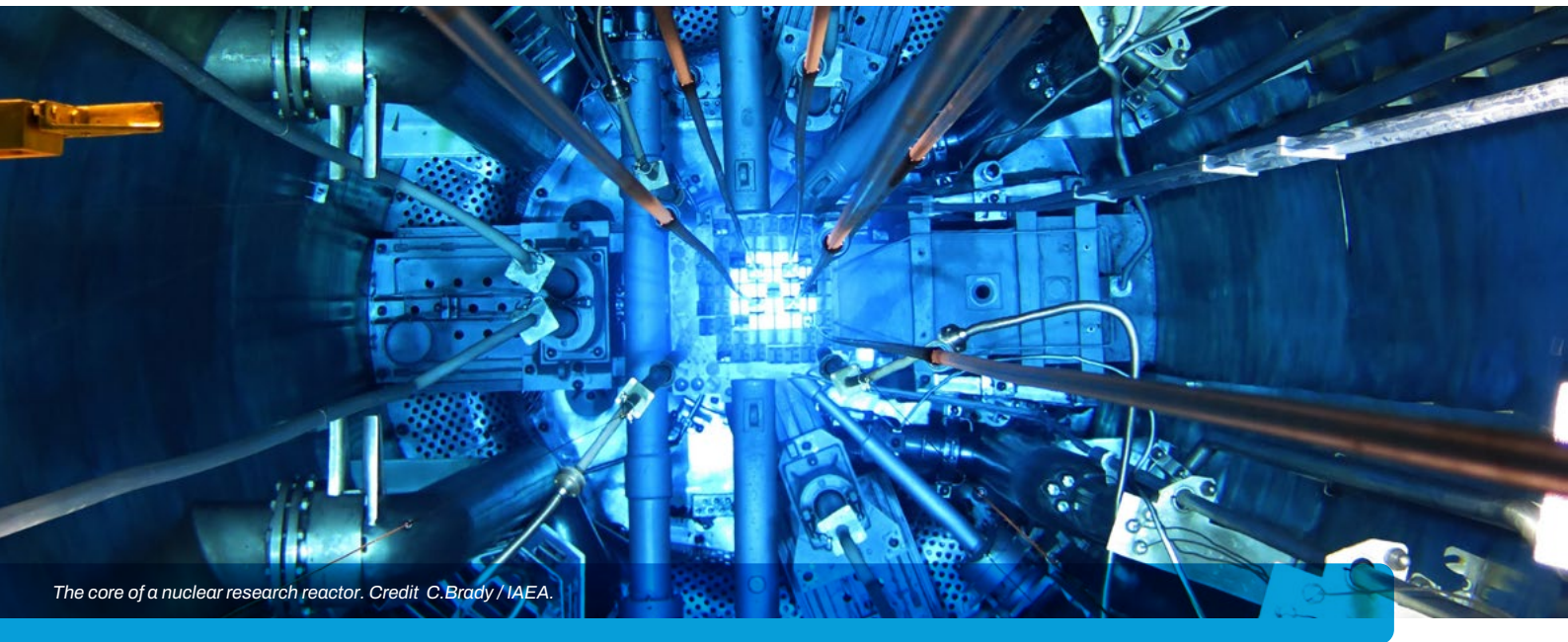
Taken together, the pace of development suggests increased momentum, particularly for SMRs, as designs approach commercialisation. This matters in the Middle East, where states increasingly tie the case for civil nuclear programmes to the maturity, viability, cost and deployment of

¹⁶ "Saudi AI firm Humain unveils 6 gigawatt data centre plan and new AI operating system", Reuters, 27 October 2025, <https://finance.yahoo.com/news/saudi-ai-firm-humain-unveils-070124331.html>, and "First 200 MW from UAE's Stargate AI campus to come online next year", Reuters, 14 October 2025, <https://www.reuters.com/business/media-telecom/first-200-mw-uaes-stargate-ai-campus-come-online-next-year-2025-10-14/>.

¹⁷ US Department of Commerce, "Statement on UAE and Saudi Chip Exports", Press Release, 19 November 2025, <https://www.commerce.gov/news/press-releases/2025/11/statement-uae-and-saudi-chip-exports>.

¹⁸ Dan Yurman, "What Future for SMRs if the AI Boom Is a Bubble?", Neutron Bytes, 19 October 2025, <https://neutronbytes.com/2025/10/19/opinion-what-future-for-smrs-if-the-ai-boom-is-a-bubble/>.

¹⁹ IAEA, "Nuclear Technology Review 2025", Report by the Director General, GC(69)/INF/9, 27 August 2025, <https://www.iaea.org/sites/default/files/gc/gc69-inf9.pdf>, and IAEA, "Small Modular Reactors: Advances in SMR Developments", (Vienna: IAEA, 2024), https://www-pub.iaea.org/MTCD/Publications/PDF/p15790-PUB9062_web.pdf.



The core of a nuclear research reactor. Credit C.Brady / IAEA.

improved reactor technologies. Many have considered SMRs, such as Bahrain, Israel, Jordan, Kuwait and Morocco, alongside those that have already deployed or begun construction of large reactors. Their future decisions depend on the viability and potential of those systems.

Renewed interest in nuclear energy has primarily focused on promising advances in SMR and Gen IV nuclear reactor technology. SMRs, in particular, are often presented as an attractive alternative to conventional large reactors because they may offer greater deployment and operational flexibility, lower upfront capital costs and limited cost overruns. They also have modular factory-style manufacturing and construction characteristics, allowing for phased deployment that can shorten construction time, and are suitable for smaller electric grids. While all these advantages are yet to be proven, these characteristics are particularly appealing for newcomers to nuclear energy and states with limited financial resources, which could deploy the first unit independently, with additional modular units to be built and assembled in areas where demand arises (e.g., industrial sites, remote locations, desalination sites and military installations)²⁰ or added as demand increases.

Designs for a subset of SMRs, such as micro-reactors that generate up to 30 megawatts (MW) of thermal power, are currently being licensed in the United States for civilian and military uses. Possible uses include disaster and emergency recovery, service restoration in remote areas and critical infrastructure, and air defence systems. Deploying these micro-reactors may

²⁰ Organisation for Economic Cooperation and Development (OECD), “Advanced Nuclear Reactor Systems and Future Energy Market Needs”, (Paris: OECD Publishing, 2021), https://www.oecd.org/content/dam/oecd/en/publications/reports/2021/12/advanced-nuclear-reactor-systems-and-future-energy-market-needs_4f92e165/beb24009-en.pdf.

encourage states in the Middle East to consider using them to allow habitation of remote and desert areas or to power military bases or infrastructure.²¹

Generation IV reactors promise higher heat-to-electricity efficiency, improved fuel utilisation and enhanced passive safety levels compared to Generation III and III+ designs. Gen IV reactors are also capable of supporting higher-efficiency, low-carbon hydrogen-production processes (e.g., thermochemical cycles and high-temperature steam electrolysis), which are crucial to the energy strategies of many Middle Eastern states, especially in the GCC.²² Saudi Arabia serves as a regional example of active interest in nuclear–hydrogen coupling options, particularly through high-temperature gas-cooled reactor (HTGR) concepts (including SMR designs) and other Gen IV systems.²³ The reduced opportunities for diversion of Gen IV designs are also often cited, promising improved – but yet to be proved – proliferation resistance, which is a salient consideration in the Middle East context.

Integrating these new generations of nuclear reactors will require navigating regulatory complexity and early deployment; building supply chains and manufacturing ecosystems; and delivering economic competitiveness and proliferation-resistant features that remain to be demonstrated. In this context, the IAEA’s Nuclear Harmonisation and Standardisation Initiative, which advances shared expectations between technology developers and regulators, including nuclear safety and security requirements, could accelerate licensing and commercialisation once designs are demonstrated.²⁴

In parallel, the IAEA reports progress in nuclear fuel technology – including specialised fuel types, forms and enrichment levels for next-generation reactors – that is aimed at strengthening safety and efficiency. Developments include enhanced modelling and simulation for fuel performance, enabling the study of new fuel types and materials; commercial trials of accident-tolerant fuels; and advances in TRISO fuel manufacturing, including progress towards commercial production. The key constraint remains the scaling up of supply and fabrication capacity to meet SMR deployment timelines.²⁵

²¹ US Army, “Army Announces Next Steps on Janus Program for Next Generation Nuclear Energy”, 18 November 2025, https://www.army.mil/article/289074/army_announces_next_steps_on_janus_program_for_next_generation_nuclear_energy, and Westinghouse Electric Company, “eVinci™ Microreactor”, n.d., <https://westinghousenuclear.com/energy-systems/evinci-microreactor/>.

²² OECD and Nuclear Energy Agency, “Advanced Nuclear Reactor Systems and Future Energy Market Needs”, (Paris: OECD, 2021), https://www.oecd.org/content/dam/oecd/en/publications/reports/2021/12/advanced-nuclear-reactor-systems-and-future-energy-market-needs_4f92e165/beb24009-en.pdf.

²³ Afaque Shams et al. (eds), “Challenges and Recent Advancements in Nuclear Energy Systems: Proceedings of the Saudi International Conference on Nuclear Power Engineering (SCOPE)”, (Cham: Springer, 2024), <https://www.springerprofessional.de/challenges-and-recent-advancements-in-nuclear-energy-systems/27371050>, and Abdulrahim Al Judaibi, Sharaf AlSharif and Saleh Al Harbi, “Hydrogen Production Using Nuclear Energy”, in *The Clean Hydrogen Economy and Saudi Arabia*, eds Abdulrahim Al Judaibi et al. (London: Routledge, 2024), chapter 25, <https://www.taylorfrancis.com/chapters/oa-edit/10.4324/9781003294290-28/hydrogen-production-using-nuclear-energy-abdulrahim-al-judaibi-sharaf-alsharif-saleh-al-harbi>.

²⁴ IAEA, “Small Modular Reactors: Advances in SMR Developments”, (Vienna: IAEA, 2024), https://www-pub.iaea.org/MTCD/Publications/PDF/p15790-PUB9062_web.pdf.

²⁵ IAEA, “Nuclear Technology Review 2025”, 27 August 2025, <https://www.iaea.org/sites/default/files/gc/gc69-inf9.pdf>.

1.2. Long-term risks and uncertainties

Any assessment of nuclear energy in the Middle East must recognise nuclear power as a long-term commitment. Power plants typically take 6–10 years to construct and then operate for 40–80 years, with additional decades for decommissioning and waste management. Policy choices and decision-making must therefore account for long-term risks and assumptions over time horizons beyond the immediate geopolitical and economic conditions.

Nuclear power plants are vulnerable throughout their entire life cycle. Projects may be delayed or even abandoned before construction is completed due to financial constraints, cost overruns, policy reversals, or other regional or global events. By 2024, a total of 93 nuclear power reactors worldwide had been abandoned and suspended after construction had officially started.²⁶ These vulnerabilities are further compounded by heightened security threats. In the Middle East, these have included documented kinetic and cyberattacks targeting nuclear power reactors and fuel cycle facilities. The potential radiological consequences of such deliberate attacks, including operational disruptions and accidental release, are a central long-term risk. While the probability of a severe accident remains low, the consequences could have long-term and transboundary public health and environmental impacts.²⁷ Such events have historically triggered negative public perceptions and national policies towards nuclear energy.

Regional wars and conflict spillovers further challenge the implementation of nuclear safety and security requirements. Extended crises may disrupt supply chains, maintenance and

access to technical assistance, limiting a state's ability to ensure safe and secure operation of its nuclear reactors.



The potential radiological consequences of deliberate attacks on nuclear facilities, including operational disruptions and accidental release, could be devastating.

Nuclear energy cooperation agreements may also be subject to political risks, including constraints on political alignment and reduced national control over energy assets, particularly in build-own-operate (BOO) arrangements where the suppliers build, own and operate the reactor.

Exclusive single-vendor arrangements,

where a state contracts a single supplier from another state to operate a facility, could also increase vulnerability to political tensions and disruptions if relations between the two states deteriorate, risking sanctions or political pressure.

²⁶ Mycle Schneider, “World Nuclear Industry Status Report 2024”, 2024, https://www.worldnuclearreport.org/IMG/pdf/wnisr2024-figure15_nuke_world_abandonedconstructions-2.pdf.

²⁷ Thomas Spence and Ali Ahmad, “Risks to Persian Gulf Cities from Spent Fuel Fires at the Barakah and Bushehr Nuclear Power Plants”, *Science & Global Security*, vol. 29, no. 2 (2021): 3–25, https://scienceandglobalsecurity.org/archive/2021/11/risks_to_persian_gulf_cities_f.html.



Fire and plumes of smoke rise from an oil facility in Fujairah, caused by debris from a drone interception, UAE, 14 March 2026. Credit: AP Photo / Altaf Qadri.

In addition, some technology exporters, wary of proliferation risks and sanctions, may be more cautious about entering into nuclear cooperation agreements in the Middle East without imposing conditions beyond those set by international treaties. This increases the political costs, particularly regarding sovereignty and security, of pursuing new nuclear energy programmes and may therefore influence a state's decision to pursue it.

Promises of advancements in nuclear reactor and fuel technology – including economic competitiveness, enhanced safety and non-proliferation features, and improved timelines – remain uncertain and have yet to be demonstrated. For instance, many SMR designs – which are frequently cited by states in the Middle East as key enablers for nuclear energy decisions – have yet to progress beyond design development. Even the few designs that have entered the demonstration or first-of-a-kind deployment phase will still have to navigate regulatory complexity for licensing and safety assessments. Transition to commercialisation entails further challenges beyond licensing, including the timely development of manufacturing capacity, ecosystems and supply chains needed to achieve economic competitiveness – all of which introduce additional uncertainty about commercialisation timelines for Middle Eastern states.²⁸

²⁸ These challenges, among others, are frequently cited by regional officials during technical briefings. See, for example: Salman M. Alshehri et al., “Navigating the Energy Landscape: Considerations for Deploying Small Modular Reactors in Saudi Arabia” (presentation, International Conference on Small Modular Reactors and Their Applications, Vienna, Austria, 21–25 October 2024), King Abdulaziz City for Science and Technology, <https://conferences.iaea.org/event/374/contributions/30963/attachments/18292/30834/ID%23104-NAVIGATING%20THE%20ENERGY%20LANDSCAPE%20CONSIDERATIONS%20FOR%20DEPLOYING%20SMALL%20MODULAR%20REACTORS%20IN%20SAUDI%20ARABIA.pptx>.



Yellowcake sealed steel drums. June 2010. Credit: Dean Calma / IAEA.

Public opinion is another key uncertainty as it can shape policy trajectories and lead to delays or policy reversals in nuclear energy programmes. It cannot, however, be assessed solely through historical analogies and safety risks, as it also reflects a dynamic interplay of trust in government and access to credible information.²⁹ This underscores the need for a transparent safety culture and proactive public engagement, especially as nuclear energy programmes in the region transition from the planning to the operational phase.

1.3. The proliferation dilemma

Most civilian nuclear power reactors use low-enriched uranium fuel, typically enriched to 3–5 per cent of the fissile isotope U-235. Because uranium in nature contains only about 0.72 per cent U-235, enrichment is necessary to increase its concentration to levels suitable for nuclear reactor fuel. New reactor designs, especially SMRs, are expected to rely on HALEU, which requires higher enrichment levels than traditional LEU, in the ranges from 5 to less than 20 per cent U-235.

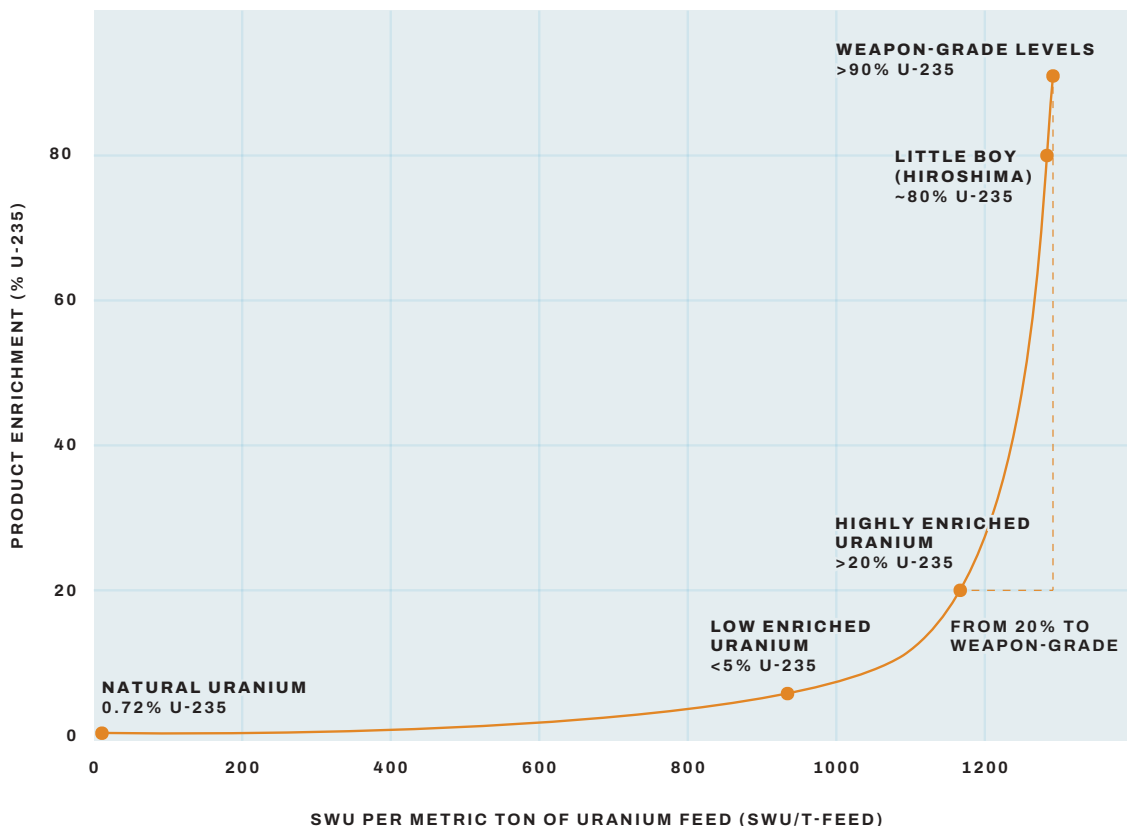
Enrichment beyond 20 per cent is considered highly enriched uranium (HEU) and is rarely justified for peaceful civilian applications. Furthermore, enrichment to 20 per cent U-235 is widely regarded as a critical proliferation threshold because achieving it completes the most technically demanding and time-consuming portion of the enrichment process, significantly reducing the effort required to reach weapon-grade levels (~90 per cent U-235; see Figure 1).

²⁹ Martin B. Malin, “Nuclear Energy in the Middle East? Regional Security Cooperation Needed”, *Afkar/Ideas*, Spring 2017, Project on Managing the Atom, Belfer Center for Science and International Affairs, <https://www.belfercenter.org/publication/nuclear-energy-middle-east-regional-security-cooperation-needed>.

In other words, a state that possesses the capability to produce HEU also holds the technical means to produce weapon-usable material and can significantly shorten the weaponisation timeline should a decision to pursue a nuclear programme be made.³⁰

The technical overlap between civilian and military applications puts enrichment at the core of nuclear proliferation risks and makes it one of the most heavily scrutinised elements of the nuclear fuel cycle. Given the experience of misuse of enrichment and reprocessing (ENR) facilities in the Middle East, even declared civilian fuel cycle programmes without a clear economic justification may raise suspicions of latent weaponisation ambitions.

FIGURE 1.
Uranium enrichment effort is non-linear³¹



³⁰ Matthew Fuhrmann and Benjamin Tkach, “Almost Nuclear: Introducing the Nuclear Latency Dataset”, *Conflict Management and Peace Science*, vol. 32, no. 4 (2015): 443–61, <https://www.jstor.org/stable/26271400>, and John Carlson, “‘Peaceful’ Nuclear Programs and the Problem of Nuclear Latency”, Nuclear Threat Initiative, 19 November 2015, <http://www.nti.org/analysis/articles/peaceful-nuclear-programs-and-problem-nuclear-latency/>.

³¹ Note: About 90% of the total effort (measured in separative work units (SWU)) needed to reach weapon-grade levels (>90%) is already expended by the time 20% enrichment is achieved.



2. Regional outlook for nuclear energy and the status of civil programmes

Barakah Nuclear Power Plant, UAE. 2026. Credit: extracted from a publicly released video by Emirates Nuclear Energy Corporation (ENEC).

States in the Middle East have shown interest in nuclear energy since the early days of its commercialisation. This is evident in the number of states that joined the US Atoms for Peace programme in the 1950s (including Egypt, Iran, Iraq, Jordan, Lebanon, Libya, Saudi Arabia, Sudan, Syria and Yemen).³² To date, only two states in the region have successfully operated nuclear power plants: Iran and the UAE. According to the IAEA's 2025 report, five countries in the Middle East and North Africa (Algeria, Iraq, Morocco, Sudan and Tunisia) are among the 50 countries categorised as “embarking countries” – that is, they are evaluating the option of nuclear power without having reached a final decision. Although not included in the IAEA's list, Israel can be said to be in the decision-making phase, as the government has recently announced that it is “seriously examining” the option and is currently developing a national nuclear energy strategy.³³ The IAEA categorises three additional states from the region (Egypt, Jordan and Saudi Arabia) as being in the post-decision-making phase, as they have decided to introduce nuclear power, are building the necessary infrastructure, or have signed a contract and have started or will soon start construction.³⁴

³² Mara Drogan, “The Atoms for Peace Program and the Third World”, *Cahiers du monde russe*, vol. 60 (2019), <https://doi.org/10.4000/monderusse.11249>.

³³ Ilana Curiel, “Israel Selects Site for First Nuclear Power Plant”, Ynetnews, 11 May 2025, <https://www.ynetnews.com/environment/article/s10cuk0egg>, and Sever Plocker, “Energy Minister: ‘We Are Examining the Construction of a Nuclear Power Plant in Israel’”, Ynetnews, 11 December 2025, <https://www.ynetnews.com/article/rynsp100mzl>.

³⁴ IAEA, “Nuclear Technology Review 2025”, 27 August 2025, 18, <https://www.iaea.org/sites/default/files/gc/gc69-inf9.pdf>.

This section primarily examines the status of national nuclear energy programmes in six states in the Middle East, including those with established programmes (i.e., Iran and the UAE), as well as embarking countries where recent or ongoing policy developments suggest renewed consideration of nuclear energy (i.e., Egypt, Jordan, Saudi Arabia and Israel), and provides accounts of the most recent developments in these programmes (see also Figure 2). The goal is to understand the broader policies that drive these programmes, including potential shifts from original strategies and evolving motives, as well as overlapping goals and shared interests across the programmes. The section also discusses the interest of some regional states in fuel cycle technology, particularly uranium enrichment. This will improve understanding of the regional nuclear energy outlook, thereby enabling analysis in the following sections of the non-proliferation landscape, of the proliferation concerns around some of these programmes and of opportunities for regional cooperation on peaceful uses of nuclear energy.

2.1. Iran

Iran was among the first Middle Eastern countries to establish a nuclear energy programme in 1957, under the US Atoms for Peace programme, and was the first to operate a nuclear power plant in 2011. The economic goals were to expand water-desalination capacity and free domestic gas and oil resources for export to earn foreign currency.³⁵ In the early 1970s, agreements were reached with West Germany and France to build several nuclear power reactors and desalination plants, and the construction of the Bushehr-1 reactor commenced in 1975. Iran also agreed to invest in the European uranium-enrichment facility, Eurodif, for fuel supply. However, all these plans collapsed following the revolution in 1979; construction of the reactor was abandoned, and the site was attacked during the 1980–1988 Iran–Iraq War.

Under a renewed agreement in 1991 with Russia, construction of Bushehr-1 resumed, and it began operation in 2011. As Iran's only operational nuclear unit, with a capacity of 915 MW electric (MWe), Bushehr-1 accounted for less than 2 per cent of the country's power generation.³⁶ A second unit, Bushehr-2, has been listed in the IAEA's official Power Reactor Information System (PRIS) database as being under construction since 2019.

Amid severe water scarcity and droughts, water security became a top priority for Iran. In 2022, construction of Iran's first nuclear-powered desalination plant commenced in Bushehr.³⁷

Iran has moved further towards nuclear cooperation with Russia as a consequence of, among other things, the collapse of the Joint Comprehensive Plan of Action (JCPOA) – which promised Iran deeper cooperation on peaceful nuclear applications in exchange for compliance – the subsequent deadlock in negotiations, the October 2025 snapback of United Nations Security Council sanctions, and the attacks by the United States and Israel on Iran's key nuclear facilities.

³⁵ World Nuclear Association (WNA), "Iran: Nuclear Power in Iran", n.d., <https://world-nuclear.org/information-library/country-profiles/countries-g-n/iran>.

³⁶ Ibid.

³⁷ "Iran to Open Its First Nuclear Desalination Plant Next Year", PressTV, 2 November 2025, <https://www.presstv.ir/Detail/2025/11/02/758070/Iran-nuclear-desalination-plant-opening-plan-Eslami!>.

The most recent agreement, valued at \$25 billion and primarily involving Russian investments, aims to significantly expand Iran–Russia nuclear energy cooperation. It includes four new units at Bushehr (including Bushehr-2) and four additional units at both existing and new sites, such as Hormozgan.³⁸

Beyond energy and water security, Iran’s large-scale expansion of nuclear energy is also linked to the scarcity of foreign investment and alternative options. This has been a consequence of international sanctions due to non-compliance with the international nuclear

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Expanding nuclear capacity could reinforce and justify increasing or retaining domestic enrichment and fuel fabrication capabilities.”

safeguards, while Russia does not accept the legality of the recent snapback. Additionally, civilian nuclear energy infrastructure built or invested in by Russia may be perceived safe from US and Israeli attacks. This was evident during the 2025 and 2026 attacks, when Bushehr-1 and the construction sites of Bushehr-2 and -3 were not targeted. There is also a connection between expanding nuclear energy and maintaining nuclear enrichment: expanding

nuclear capacity would reinforce and justify increasing or retaining domestic enrichment and fuel fabrication capabilities, in which Iran has heavily invested over the years and were the center of the international concerns.

2.2. United Arab Emirates

The UAE, the first Arab state to operate a nuclear power plant, is considered a model for a swift approach to developing a nuclear energy programme. It has established strong national capacities, governance structures and construction capabilities. The country officially published its national nuclear strategy in 2008, independently of the GCC’s proposed joint nuclear energy programmes, in order to accelerate the process, citing the competitiveness of nuclear energy for energy security and economic growth.³⁹ Construction of the first unit, Barakah-1, began in 2012 and was completed in 2018. Three additional units were subsequently built. By 2024, all four advanced pressurised water reactors (APR 1400), designed by Korea Electric Power Corporation with a total capacity of 5,348 MWe (about 22 per cent of the UAE’s electricity production), were operational.⁴⁰

³⁸ “Iran, Russia Sign \$25 Billion Agreement to Build Four Nuclear Power Plants in Iran – IRNA”, Reuters, 26 September 2025, <https://www.reuters.com/business/energy/iran-russia-sign-25-billion-agreement-build-four-nuclear-power-plants-iran-irna-2025-09-26/>, and “Iran Says Planning for LargeScale Nuclear Energy Expansion”, World Nuclear News, 3 November 2025, <https://www.world-nuclear-news.org/articles/iran-says-planning-for-large-scale-nuclear-energy-expansion>.

³⁹ Government of the United Arab Emirates, “Policy of the United Arab Emirates on the Evaluation and Potential Development of Peaceful Nuclear Energy” (Abu Dhabi: Emirates Nuclear Energy Corporation, 2008), <https://www.enec.gov.ae/doc/uae-peaceful-nuclear-energy-policy-5722278a2952f.pdf>.

⁴⁰ IAEA, “United Arab Emirates”, Power Reactor Information System (PRIS), <https://pris.iaea.org/pris/CountryStatistics/CountryDetails.aspx?current=AE>.

The UAE model is often regarded as a “gold standard” for developing a nuclear energy programme as the country has committed to transparency and non-proliferation standards that exceeded those under the Treaty on the Non-Proliferation of Nuclear Weapons (NPT). The UAE has pledged close cooperation with the IAEA and has voluntarily waived its right to enrich uranium and reprocess spent fuel, commitments formalised in national legislation and in its nuclear cooperation agreement with the United States.⁴¹

The motivation for and the Emirati approach to its nuclear energy programme have been primarily economic. This explains the UAE’s confidence in not building a nuclear research reactor first and forgoing enrichment, as it has not seen that pursuing these would be economically viable or necessary for a commercial programme.

The UAE recently updated its 2050 energy strategy to include ongoing consideration of expanding domestic nuclear energy or investing in foreign nuclear projects. The UAE has shifted its focus to leveraging its investments in the energy sector in order to develop national capacities, governance frameworks and investment opportunities. It is continuously assessing emerging technologies and trends in the energy market to position itself in the future nuclear industry, enhance its R&D and innovation efforts, strengthen domestic expertise, and identify key technologies for investment.⁴² For example, the Emirates Nuclear Energy Company, which oversees the UAE’s nuclear energy programme, has launched the national ADVANCE programme to evaluate the latest advanced SMRs and micro-reactor technologies.

The UAE is also pursuing a strategy to attract foreign investment and collaboration, including in foreign nuclear energy projects.⁴³ It has signed more than 100 cooperation agreements with partners in more than 15 nuclear technology-exporting countries to explore opportunities for investment in the construction of new reactors globally, SMR designs and deployment models, nuclear fuel technology, and supply chain development.⁴⁴

This dual approach – driven by projected increases in energy demand resulting from industrialisation, growth in AI and data centre markets, and climate commitments – remains under continuous review and evaluation.⁴⁵

⁴¹ US Congress, “Agreement for Cooperation Between the Government of the United States of America and the Government of the United Arab Emirates Concerning Peaceful Uses of Nuclear Energy”, House Document 111–43, 2009, <https://www.govinfo.gov/content/pkg/CDOC-111hdoc43/pdf/CDOC-111hdoc43.pdf>.

⁴² Emirates Nuclear Energy Corporation (ENEC), “ENEC Launches ADVANCE Program to Accelerate Decarbonization Through Advanced Nuclear Technologies”, 29 November 2023, <https://www.enec.gov.ae/news/latest-news/enec-launches-advance-program-to-accelerate-decarbonization-through-advanced-nuclear-technologies/>.

⁴³ “UAE to Collaborate with Westinghouse on AP1000 Nuclear Plant Deployment in US”, NucNet, 25 July 2025, <http://nucnet.org/news/uae-to-collaborate-with-westinghouse-on-ap1000-nuclear-plant-deployment-in-us-7-5-2025>.

⁴⁴ Jamie Ingram, “ENEC Speaks with MEES About Abu Dhabi’s Game-Changing Barakah Nuclear Plant”, Middle East Economic Survey (MEES), 17 October 2025, <https://www.mees.com/2025/10/17/power-water/enec-speaks-with-mees-about-abu-dhabis-game-changing-barakah-nuclear-plant/a103f0e0-ab50-11f0-a13c-abf29aecb861>.

⁴⁵ “Gulf State UAE Considers a Second Nuclear Power Plant”, Reuters, 17 July 2024, <https://www.reuters.com/business/energy/gulf-state-uae-considers-second-nuclear-power-plant-2024-07-17/>, and Government of the United Arab Emirates, “UAE Energy Strategy 2050”, 2017, <https://u.ae/en/about-the-uae/strategies-initiatives-and-awards/strategies-plans-and-visions/environment-and-energy/uae-energy-strategy-2050>.

2.3. Egypt

Egypt is the only one of the three states in the post-decision-making phase that is actively building a nuclear power plant. It is constructing four Russian-designed VVER-1200 units, totalling 4,400 MWe in El-Dabaa, west of Alexandria. Egypt's nuclear energy ambitions date back to the 1950s. It established one of the earliest nuclear energy programmes in the region with its Atomic Energy Commission, founded in 1955. The Soviet Union supplied Egypt with its first research reactor in 1961. Over the years, Egypt developed national capabilities and research in the Hot Laboratories and Waste Management Centre (HLWMC), and it built another research reactor in 1997. The selection of the current site under construction, El-Dabaa, was made in the 1980s; however, plans were put on hold for nearly two decades following the Chernobyl accident. Significant growth in electricity demand and energy crises revived the programme in the early 2000s. Per capita electricity consumption has increased by more than 65 per cent over the past 25 years, and it is estimated that El-Dabaa will produce about 10 per cent of the country's electricity.⁴⁶

Construction at El-Dabaa began in 2022, following delays on both sides. Egypt had signed an agreement with Russia in 2016, backed by a Russian loan covering about 85 per cent of the project's estimated \$30 billion cost. A major milestone was achieved in November 2025 with the installation of the reactor vessel for El-Dabaa-1 (the first of four units). The war in Ukraine does not appear to be causing significant delays, as Rosatom, Russia's state-owned nuclear technology provider, is not subject to sanctions, and the French supply of reactor turbines is on schedule.⁴⁷ The first unit is expected to be delivered by 2028, and all units are projected to be completed by 2029.⁴⁸

Amid rising energy demand, population growth and water shortages, the El-Dabaa nuclear programme has become increasingly strategically critical to Egypt beyond energy security, as it is expected to also supply power and heat to water-desalination plants.⁴⁹

Beyond enhancing national pride, similar to the nationalisation of the Suez Canal or the construction of the Aswan High Dam, the programme aims at enhancing Egypt's domestic industry and supply chain, manufacturing and high-technology sectors, human resources, regulatory and institutional frameworks, and existing infrastructure.

⁴⁶ IEA, "Egypt: Electricity", n.d., <https://www.iea.org/countries/egypt/electricity>.

⁴⁷ Lansing Institute, "U.S. Sanctions Lifted on Rosatom: The Case of Hungary's Paks II Nuclear Power Plant", 30 June 2025, <https://lansinginstitute.org/2025/06/30/u-s-sanctions-lifted-on-rosatom-the-case-of-hungarys-paks-ii-nuclear-power-plant/>; "Electricity Minister Inspects Turbine Manufacturing Progress in France for Dabaa Nuclear Plant", Daily News Egypt, 3 June 2025, <https://www.dailynewsegypt.com/2025/06/03/electricity-minister-inspects-turbine-manufacturing-progress-in-france-for-dabaa-nuclear-plant/>, and "Dabaa Nuclear Plant's 1st Unit to Start Operations in H2 2028: Egypt PM", Ahram Online, 23 July 2025, <https://english.ahram.org.eg/News/550125.aspx>.

⁴⁸ WNA, "Egypt", n.d., <https://world-nuclear.org/information-library/country-profiles/countries-a-f/egypt>, and Mycle Schneider, "World Nuclear Industry Status Report 2025", 2025, <https://www.worldnuclearreport.org/IMG/pdf/wnsr2025-v1.pdf>.

⁴⁹ WNA, "Egypt".



In addition to diversifying its energy mix, reducing reliance on imports and meeting its climate goals, nuclear energy could also offer Egypt significant opportunities across Africa. Egypt could export its expertise to African states, which are increasingly interested in affordable nuclear options. In the long term, it could position itself as a nuclear technology hub for Africa.

2.4. Saudi Arabia

Saudi Arabia decided in the 2000s to pursue nuclear energy to meet projected energy demand and strategic goals, such as energy diversity and water security, given that it consumes over a quarter of its oil production and desalinates approximately 70 per cent of its drinking water.⁵⁰

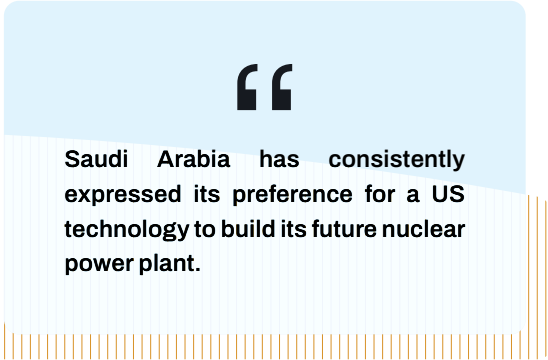
King Abdullah City for Atomic and Renewable Energy, founded in 2010, is the agency that oversees the programme's planning, training, site surveys and tender specifications. Progress has been slow, with the initial construction plans of 2016 subsequently scaled back to two reactors. Saudi Arabia has focused on domestic capacity-building to support the programme, including establishing governance, partnerships, research and education infrastructure, and the construction of a research reactor, which began in 2018.⁵¹

⁵⁰ Achref Chibani, "The Costs and Benefits of Water Desalination in the Gulf", Arab Center Washington DC, 12 April 2023, <https://arabcenterdc.org/resource/the-costs-and-benefits-of-water-desalination-in-the-gulf/>.

⁵¹ Mohammed Abulaban, "Saudi Arabia's Legal and Regulatory Framework" (presentation, IAEA-KINS Basic Professional Training Course, October 2024), Saudi Nuclear and Radiological Regulatory Commission (NRRC), <https://gnssn.iaea.org/main/ansn/Activity%20Documents%20%20Public/IAEA-KINS%20Basic%20Professional%20Training%20Course%20on%20Nuclear%20Safety/Country%20Presentation/saudi.pdf>.

Saudi Arabia established a holding company in 2020 as the national developer and invited bids in 2022 to build two pressurised water nuclear reactors. It has since expressed interest in developing low-enrichment and fuel-fabrication capabilities for domestic use and export.⁵² Industry sources suggested that bidding deadline was repeatedly extended, with bids received from the Republic of Korea, China, France and Russia.⁵³ Meanwhile, Saudi Arabia has engaged in bilateral talks, including with the United States.

Saudi Arabia has consistently expressed its preference for a US bidder to build its future nuclear power plant. The Saudi approach to nuclear cooperation with the United States has so far been similar to the Aramco model, which exemplifies successful US–Saudi collaboration, having led to a \$1.5 trillion company that influences global markets and advances Saudi economic



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Saudi Arabia has consistently expressed its preference for a US technology to build its future nuclear power plant.

objectives. The logic behind such an approach is that cooperation agreements on nuclear energy and other advanced technologies (e.g., AI and critical minerals) will strengthen the strategic ties between the two countries, their interdependence and trust. Other long-term benefits include talent acquisition, access to restricted technologies and localisation of technology. All of these would pave the way for further strategic alignment, expanded cooperation

in other domains, and strengthening Saudi Arabia’s position in the future global energy and technology market.

In the absence of a bilateral nuclear cooperation agreement, however, US companies have not submitted full bids. Negotiations on a bilateral nuclear cooperation agreement have been ongoing since the early 2010s and have been forestalled over US demand that Saudi Arabia sign the IAEA’s Additional Protocol (AP) and forgo domestic enrichment rights. These demands reflected a long-standing U.S. non-proliferation policy, reinforced by concerns over past Saudi statements linking future nuclear policy to Iran’s nuclear programme and the broader regional security developments.

In November 2025, Saudi Arabia and the United States jointly announced the completion of negotiations on civil nuclear energy cooperation as the “legal foundation for a decades-long, multi-billion-dollar nuclear energy partnership”.⁵⁴

⁵² Luke Caggiano, “Saudi Arabia Aiming for Complete Nuclear Fuel Cycle”, *Arms Control Today*, March 2023, <https://www.armscontrol.org/act/2023-03/news/saudi-arabia-aiming-complete-nuclear-fuel-cycle>.

⁵³ Jennifer Aguinaldo, “Saudi Arabia sets July nuclear plant bid deadline”, *Middle East Business Intelligence (MEED)*, 3 June 2024, <https://www.meed.com/saudi-arabia-sets-july-nuclear-plant-bid-deadline>.

⁵⁴ The White House, “Fact Sheet: President Donald J. Trump Solidifies Economic and Defense Partnership with the Kingdom of Saudi Arabia”, November 2025, <https://www.whitehouse.gov/fact-sheets/2025/11/fact-sheet-president-donald-j-trump-solidifies-economic-and-defense-partnership-with-the-kingdom-of-saudi-arabia/>, and Ministry of Energy of Saudi Arabia, LinkedIn post, November 2025, <https://shorturl.at/GWAuc>.

It is unclear whether and how the agreement addresses issues such as the Additional Protocol, controls on ENR, or the deployment of US enrichment technologies. Comments by the US Energy Secretary suggest that the framework does not include enrichment in Saudi Arabia and that non-proliferation standards will be ensured through bilateral safeguards agreements.⁵⁵

Nuclear energy projects are long-term, making it unlikely that Saudi Arabia will have an operational power unit before 2035.⁵⁶ At the same time, it continues to pursue collaborations with other countries, such as the Republic of Korea and China, to develop and deploy nuclear technologies, especially SMRs. Most recently, Saudi Arabia's cabinet authorised new nuclear cooperation negotiations with Türkiye and Jordan.⁵⁷

2.5. Jordan

Jordan is another Middle Eastern state that has actively planned for nuclear energy over the past 20 years. It has made significant progress in its programme by developing regulatory and human capacity infrastructure. Jordan's energy dependency is among the highest in the world, with over 80 per cent of the country's energy being imported. Jordan's rationale for pursuing nuclear power was that two units of a large nuclear reactor could supply about half of the country's energy needs. Additionally, interest in nuclear energy is driven by the growing recognition of water security as a critical national issue and a priority on the national agenda, especially given that the country is considered the second most water-scarce country in the world. In 2015, Jordan reached a \$10 billion agreement with Russia to build two 1000-MWe VVER units, but the agreement was later cancelled due to funding risks and technical challenges.⁵⁸

SMRs have emerged as a more attractive option for Jordan's nuclear energy and desalination goals. They are more suitable for Jordan's small electrical grid, eliminating the need for grid upgrades and the challenge of limited access to cooling water. Additionally, they are expected to provide economic value by contributing to electricity exports to neighbouring countries. Heightened tensions with Israel following the Gaza war, which led to Jordan's withdrawal from a bilateral water-for-energy deal and Israel withholding 50 million cubic metres of water allocated to Jordan under their peace treaty, are making the case for water security even more urgent.

⁵⁵ Kelsey Davenport, "U.S., Saudi Arabia Announce Nuclear Cooperation", *Arms Control Today*, December 2025, <https://www.armscontrol.org/act/2025-12/news/us-saudi-arabia-announce-nuclear-cooperation>, and U.S. Department of Energy, "U.S. Energy Secretary and Saudi Arabia's Energy Minister Announce Deal on Civil Nuclear Cooperation", 18 November 2025, <https://www.energy.gov/articles/us-energy-secretary-and-saudi-arabias-energy-minister-announce-deal-civil-nuclear>.

⁵⁶ IAEA, "Nuclear Technology Review 2025", 27 August 2025, <https://www.iaea.org/sites/default/files/gc/gc69-inf9.pdf>.

⁵⁷ Talat Zaki Hafiz, "Saudi Arabia Charts a Safe and Sustainable Nuclear Future", *Arab News*, 28 September 2025, <https://www.arabnews.com/node/2632490/saudi-arabia>.

⁵⁸ WNA, "Jordan", n.d., <https://world-nuclear.org/information-library/country-profiles/countries-g-n/jordan>.

This has further prioritised the multibillion-dollar Aqaba–Amman Water Desalination and Conveyance Project to desalinate Red Sea water in phases, leaving room to reconsider nuclear energy – SMRs in particular – as a power source in the future.⁵⁹

Jordan has signed several cooperation agreements with SMR developers. It is reportedly closely monitoring advances in SMR commercialisation and considers issuing a bid invitation for an SMR project for electricity production and seawater desalination, once the market matures.⁶⁰

At the same time, Jordan does not rule out pursuing regional nuclear power plant projects in the future, as part of regional cooperation initiatives and joint ventures with neighbouring countries. Jordan has grid connections with Egypt, Iraq, Lebanon (via Syria), Palestine and the Syrian Arab Republic. Plans to connect to Saudi Arabia are underway, making it feasible to consider a regional nuclear joint venture that could address financial and siting challenges. Notably, precedents for such a joint venture are rare, as countries are usually hesitant to commit to long-term, large-scale, and expensive projects such as nuclear reactors that raise sovereignty, political and security issues. Nonetheless, experts do not dismiss the idea of such cooperation, particularly if more states in the region successfully complete their ongoing programmes, which may create opportunities to expand units through a joint-venture model.⁶¹

Given the constraints, Jordan has focused on uranium production and R&D. It recently signed an agreement with Kazakhstan to support expanding its commercial programme for uranium production and access international markets, potentially generating revenue for its nuclear programme. Jordan also promotes regional cooperation through technical training, knowledge transfer and initiatives such as replicating Jordan’s Synchrotron-Light for Experimental Science and Applications in the Middle East (SESAME) laboratory to establish Africa’s first regional synchrotron-light facility.⁶²

2.6. Israel

Israel currently does not have a nuclear energy programme. Discussions about constructing nuclear power reactors to achieve energy independence, including as a regional cooperation area, have been on and off at both the governmental and public levels since the 1950s. In the most recent discussions, in 2025, the energy minister confirmed “serious examination” of such

⁵⁹ “Second Largest Desalination Plant in the World and 445 km of Pipelines to Supply Drinking Water to the Cities of Amman and Aqaba”, SUEZ, 15 January 2025, <https://www.suez.com/en/news/press-releases/second-largest-desalination-plant-in-the-world-amman-and-aqaba>.

⁶⁰ IAEA, “Nuclear Technology Review 2025”, 27 August 2025, <https://www.iaea.org/sites/default/files/gc/gc69-inf9.pdf>.

⁶¹ Author’s interviews with regional experts and officials on the margins of the 69th IAEA General Conference in Vienna, 15–19 September 2025..

⁶² Jordan’s side event at the 69th IAEA General Conference in Vienna, 15–19 September 2025, and Simon Connell et al., “The African Light Source: History, Context and Future”, *Journal of Synchrotron Radiation*, vol. 31, no. 1 (2024): 1–9, <https://doi.org/10.1107/S1600577523009682>.

a step, including that drafting principles for a national strategy is underway.⁶³ Israel has strong technology sectors that could support a nuclear energy programme; however, key components will still need to be imported. Israel's non-NPT status and non-acceptance of full-scope safeguards, combined with concerns about its nuclear ambiguity (having never confirmed nor denied possessing nuclear weapons), will preclude supplies of nuclear reactor technology, especially from members of the Nuclear Suppliers Group (NSG). Israel may also face some opposition from local communities at the potential site, Shivta, in southern Israel.⁶⁴

Attempts to replicate, for Israel, the precedent of the US campaign in 2008 to exempt India from NSG restrictions without joining the NPT are yet to succeed.⁶⁵ Another approach is a US-regulated and operated reactor, possibly with an extraterritorial status; the approach was hinted at following the announcement of a US Tech Park in Israel, which may include SMRs.⁶⁶ However, such an approach would face significant risks, particularly due to the non-proliferation concerns and pressure from US legislators to scrutinise Israel's nuclear activities, which could prevent implementation.⁶⁷ Most importantly, it would effectively remove a key incentive – that is, access to nuclear peaceful uses and regional cooperation – for Israel to join the NPT and the future WMD-Free Zone (WMDFZ).



Exemptions from NSG restrictions could remove a key incentive – namely, access to peaceful nuclear technologies and regional collaboration – for Israel to join the NPT and the prospective WMD-Free Zone.

⁶³ Curiel, “Israel Selects Site for First Nuclear Power Plant”, and Plocker, “Energy Minister: ‘We Are Examining the Construction of a Nuclear Power Plant in Israel’”.

⁶⁴ Tal Shahaf, “Oppenheimer Rises: Tech Demand Pushes Israel Toward Nuclear Energy Solutions”, Ynetnews, 19 January 2025, <https://www.ynetnews.com/environment/article/ryopn2cdye>; “Israel Studying Options for Nuclear Power Plant”, Reuters, 23 March 2010, <https://www.reuters.com/article/business/energy/israel-studying-options-for-nuclear-power-plant-idUSLDE62M1MC/>, and Ari Rabinovitch and Crispian Balmer, “Israel Weighing Construction of Nuclear Power Plant”, Reuters, 9 March 2010, <https://www.reuters.com/article/world/us/israel-weighing-construction-of-nuclear-power-plant-idUSTRE6275BI/>.

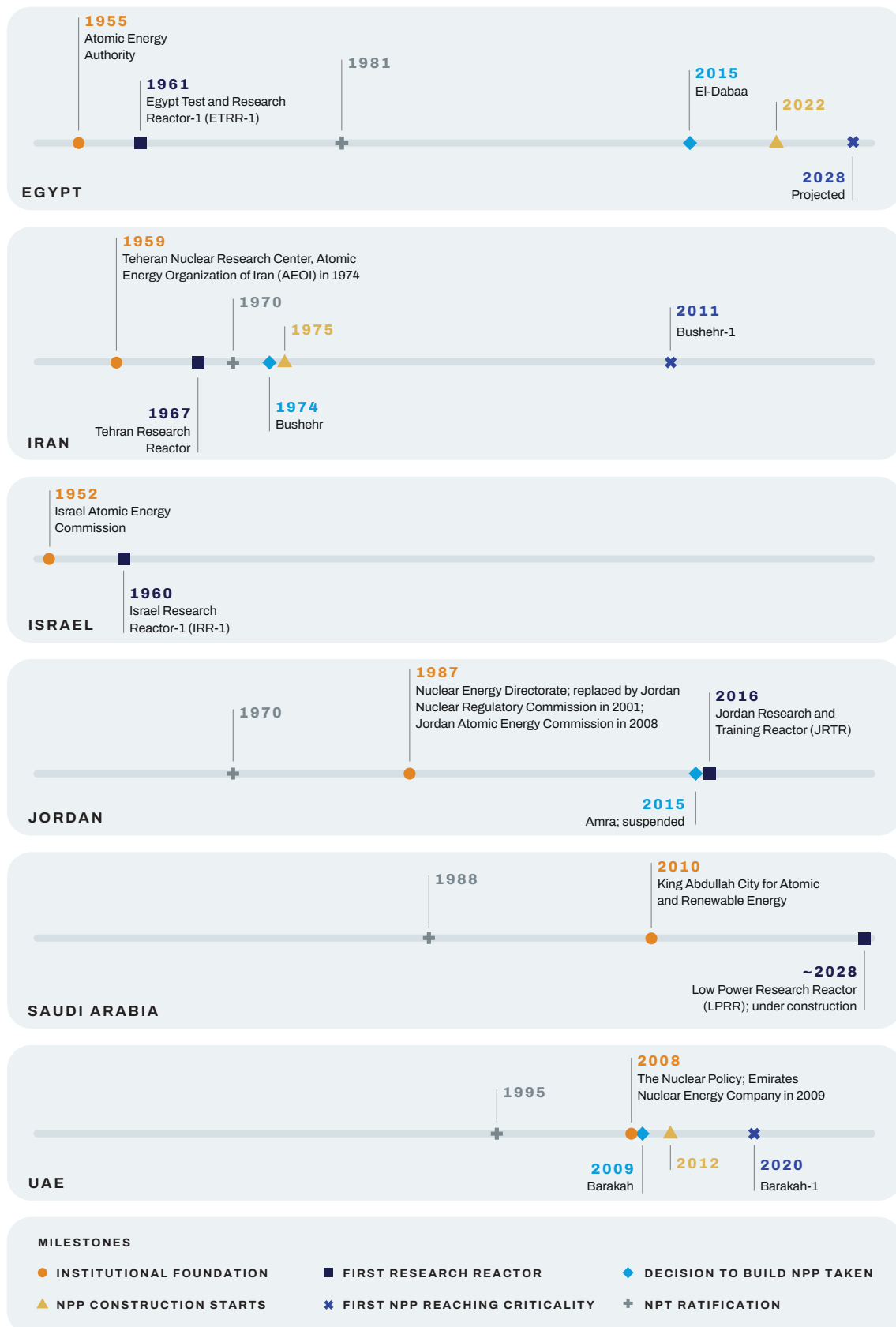
⁶⁵ “Israel Studying Options for Nuclear Power Plant”, Reuters, and Thomas Lorenz and Joanna Kidd, “Israel and Multilateral Nuclear Approaches in the Middle East”, *Arms Control Today*, October 2010, <https://www.armscontrol.org/act/2010-10/israel-and-multilateral-nuclear-approaches-middle-east>.

⁶⁶ Dan Yurman, “U.S. Tech Park in Israel May Have a Nuclear Power Plant”, Neutron Bytes, 7 February 2026, <https://neutronbytes.com/2026/02/07/u-s-tech-park-in-israel-may-have-a-nuclear-power-plant/>.

⁶⁷ John Hudson, “Some Democrats Press Trump to Break Silence on Israel’s Nuclear Arsenal”, Washington Post, 5 May 2026, <https://www.washingtonpost.com/national-security/2026/05/05/israel-nuclear-program-democrat-letter/>.

FIGURE 2.

Nuclear energy programmes in the Middle East⁶⁸



⁶⁸ Based on the IAEA Research Reactor Database and Power Reactor Information System (PRIS)

2.7. Contextualising regional interest in nuclear fuel technology

States in the Middle East have pursued different policies on fissile materials and nuclear fuel cycle capabilities. These policies reflect different objectives, threat perceptions, technical and political constraints, and the strategic value of the technology.

Iran historically operated the region's most extensive uranium-enrichment programme, including indigenised gas centrifuge capabilities, and reached industrial-level enrichment up to 60 per cent. However, these capabilities were severely damaged by Israel and the United States in the 2025 and 2026 wars. Nonetheless, Iran is widely believed to retain the technical capacity to rebuild its enrichment programme if it decides to do so.⁶⁹

Israel is the only other state in the region widely believed to have developed, as part of its nuclear weapon-related activities, both plutonium-reprocessing and uranium-enrichment capabilities, including gas centrifuge enrichment and possibly laser isotope separation.⁷⁰ Given Israel's policy of nuclear ambiguity and the absence of comprehensive IAEA safeguards, its enrichment and reprocessing capabilities and formal policy have not been disclosed.

Among Middle Eastern states with civilian nuclear programmes, the UAE stands out as the only state that has formally forgone ENR under national legislation and its so-called Section 123 cooperation agreement with the United States. Egypt's nuclear cooperation agreement with the United States expired in 2021 and was not renewed. Other states in the region, most notably Jordan and Saudi Arabia, have not yet accepted similar constraints, both of which have an interest in commercial fuel cycle capabilities as part of their civilian nuclear energy programmes and are positioning themselves as potential suppliers of uranium.

Enrichment and fuel fabrication are widely seen in the region as supporting commercial goals by promoting energy independence, building export potential, and laying the scientific foundation for developing novel fuel-cycle technologies. For states with proven commercially viable uranium resources and an interest in moving up the value chain from mining to fuel services, there is often a strong case for taking these steps.

Whether domestic, regional or global demand for enriched uranium makes the case for investment in new enrichment plants remains debatable. According to the World Nuclear Association's 2025 report on world nuclear fuel, global supplies are sufficient to meet global enrichment demand in the medium term. However, the report also highlights that, if certain suppliers fail

⁶⁹ "War Can't Entirely Eliminate Iran's Nuclear Program, the U.N. Atomic Energy Chief Says", NPR, 18 March 2026, <https://www.npr.org/2026/03/18/nx-s1-5751694/iran-retaliates-israel-kills-two-top-iranian-officials>, and Matthew Bunn, "Managing the Dangers of Iran's Remaining Nuclear Capabilities", *Arms Control Today*, no. 4 (May 2026), <https://www.armscontrol.org/act/2026-05/features/managing-dangers-irans-remaining-nuclear-capabilities>.

⁷⁰ Alexander Glaser and Marvin Miller, "Estimating Plutonium Production at Israel's Dimona Reactor", 52nd Annual INMM Meeting, 17–21 July 2011, Palm Desert, California, <https://www.princeton.edu/~aglaser/PU056-Glaser-Miller-2011.pdf>.



An exhibition on domestic nuclear achievements, Tehran, Iran, 8 February 2023. Credit: AP Photo / Vahid Salemi.

to expand production capacity as planned or are unable to enter international markets due to sanctions or other geopolitical constraints, global demand for enrichment may exceed existing capacity by the early 2030s.⁷¹

The commercial case may not be the most decisive factor when national sovereignty and energy security are at stake. For some states that operate nuclear power plants, fuel cycle capabilities are part of resilience and energy independence policies. They reduce reliance on external suppliers, which, without reliable assurances, could be conditioned on political alignment during crises and political tensions. The case of Iran and Eurodif, in which Iran failed to receive the contracted nuclear fuel after the 1979 revolution despite its co-ownership of a multilateral enrichment venture, is often cited as a cautionary example of the political vulnerability of external supply.

From this perspective, forgoing the right to enrich is often perceived by some regional states as inconceivable, particularly for states that maintain a clean non-proliferation compliance record or when such limitations are not embedded in a broader bargain linked to global or regional disarmament progress.

⁷¹ WNA, “World Nuclear Fuel Report: Global Scenarios for Demand and Supply Availability 2025–2040” (London: WNA, 17 September 2025), chapters 7 and 9, <https://world-nuclear.org/our-association/publications/global-trends-reports/world-nuclear-fuel-report-2025>.

Notwithstanding that peaceful fuel cycle activities, including uranium enrichment and plutonium reprocessing, are widely considered to be an inalienable right, the direct relevance of these capabilities to nuclear weapon programmes has reinforced suspicion when their civilian and economic rationales are difficult to justify.⁷²

ENR capabilities can also support military and security purposes such as naval propulsion or nuclear hedging. States that have never had weaponisation ambitions may still seek to develop such latent capabilities that lay a critical technical foundation for potential future weaponisation. ENR, in this sense, functions as part of a broader hedging strategy, allowing states to retain the option of nuclear weaponisation in the future if security circumstances change or to obtain some deterrence gains without actively pursuing a nuclear weapon programme or violating international obligations.⁷³

Normalising exceptions by allowing ENR capabilities that are not grounded in economic rationale and lack transparency and adequate safeguards may, in that sense, risk the credibility of the non-proliferation regime, may prompt others to revisit similar abandoned ambitions, and may complicate efforts to resolve proliferation risks of existing ENR activities in the region.



Normalising exceptions by allowing ENR capabilities that are not grounded in economic rationale and lack transparency and adequate safeguards may risk the credibility of the non-proliferation regime

⁷² Mark Goodman, “The Right to Peaceful Use of Nuclear Energy: A Disputed Matter”, *Arms Control Today*, March 2026), <https://www.armscontrol.org/act/2026-03/features/right-peaceful-use-nuclear-energy-disputed-matter>.

⁷³ Vipin Narang, “Seeking the Bomb: Strategies of Nuclear Proliferation”, (Princeton, NJ: Princeton University Press, 2022).



3. The regional nuclear proliferation landscape

Satellite imagery by Maxar Technologies shows a large hole in the Arak reactor building's domed roof caused by the Israeli airstrike, 19 June 2025. Credit: Maxar Technologies / Iran International.

Recent conflicts and increased tensions and rivalry in the Middle East have reshaped the regional nuclear proliferation landscape; they have elevated the salience of nuclear weapons and deterrence for key states, while at the same time prompting urgency in nuclear arms control and diplomacy.⁷⁴

This section examines the regional nuclear non-proliferation landscape and the dynamics through which nuclear energy programmes unfold, including shifting threat perceptions that affect these programmes and are, in turn, influenced by their trajectories. The section demonstrates this by analysing recent regional nuclear and security trends and developments, accession to and compliance with relevant international nuclear treaties, limitations of nuclear diplomacy and arms control engagements, and evolving threat perceptions of nuclear weapons.

3.1. Regional compliance and universalisation of the non-proliferation regime

Threat perceptions and nuclear policies are often linked to the status of accession to and compliance with international treaties such as the Non-Proliferation Treaty, IAEA safeguards and the Comprehensive Nuclear-Test-Ban Treaty (CTBT). They are also influenced by transparency in nuclear policies, activities and infrastructure, including the presence or development of nuclear weapon capabilities.

⁷⁴ Abdolrasool Divsallar, "Combating Weapons of Mass Destruction in the Middle East: The Role of the WMD-Free Zone Initiative", (Geneva: UNIDIR, 2025), <https://www.doi.org/10.37559/MEWMDFZ/2025/CombatingWMD>.

The NPT, the key pillar of the nuclear non-proliferation regime, has near-universal membership in the Middle East, with all states in the region except Israel having acceded to it. Following Somalia's ratification in 2026, all NPT state parties in the region have signed a Comprehensive Safeguards Agreement (CSA) with the IAEA, and 11 have ratified the AP (see Figure 3).

The implementation of safeguards has been considered a critical indicator of nuclear transparency. They enable the agency to draw conclusions on compliance with non-proliferation obligations at varying levels of confidence. A full-scope CSA enables the IAEA to confirm that declared nuclear material in a state remains in peaceful activities. When complemented by the AP, the IAEA has additional tools to detect undeclared materials and activities. The combination of a CSA and an AP can enable the IAEA to draw the broader conclusion that all nuclear material in the state remains in peaceful uses.

All but one regional state, Yemen, have amended their Small Quantities Protocols or rescinded them in favour of a full-scope CSA or an AP. The most recent examples are Oman (amended) and Saudi Arabia (rescinded).⁷⁵

Israel, a non-NPT state, is the only state in the region without a CSA. It has a limited scope, an item-specific safeguards agreement with the IAEA covering certain declared materials at the Soreq Nuclear Research Centre. This regional exception is perceived as providing no assurance regarding the nature of nuclear activities not covered by safeguards. It raises concerns related to Israel's capabilities, as well as the spread of nuclear weapons and the prevention of universalisation of the NPT and safeguards in the Middle East.

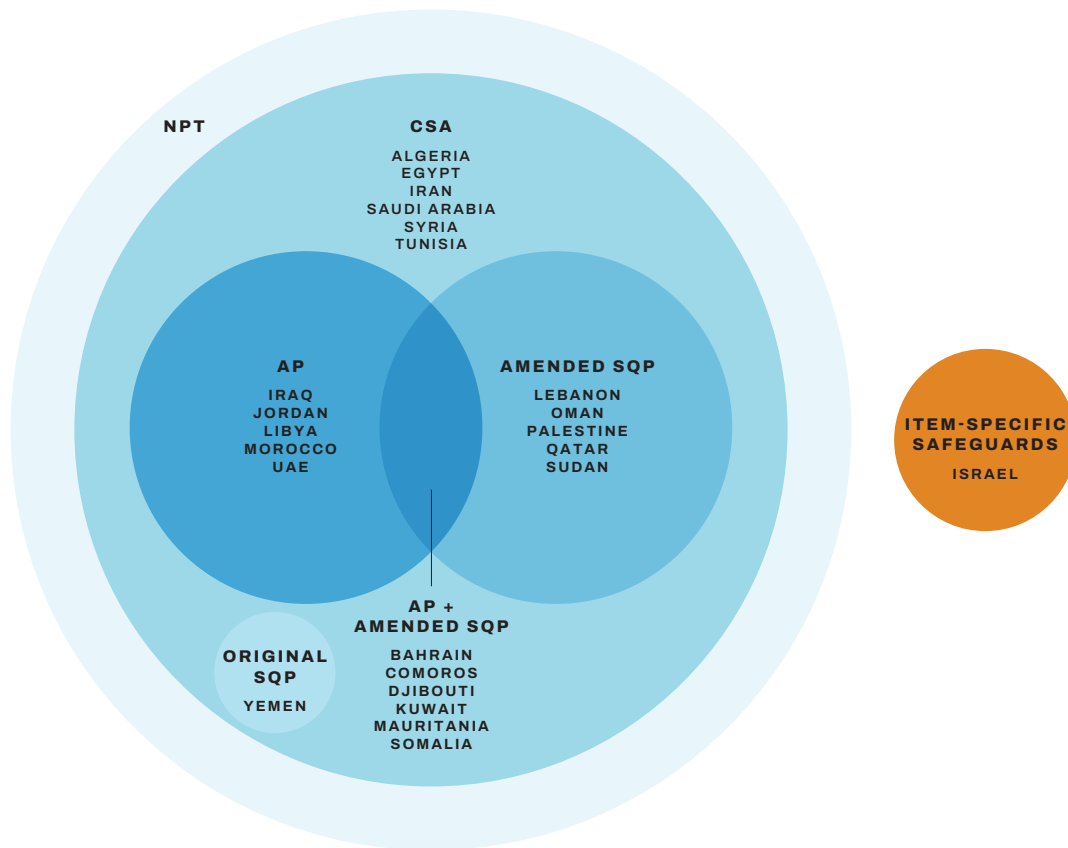
On the CTBT front, following Somalia's signature in 2023, all of the region's states, except Saudi Arabia and Syria, are signatories to the treaty banning nuclear testing. Four of these states have yet to ratify it: Yemen, along with three states listed in Annex 2 of the Treaty, Egypt, Iran, and Israel. All Annex 2 states must ratify before the CTBT can enter into force. However, these states continue to tie their ratification to progress in the universalisation of the NPT in the region, the establishment of the WMDFZ and other regional security concerns.

Membership status, however, is not synonymous with compliance; it is a necessary but insufficient condition. Although almost all Middle Eastern states demonstrate full compliance with IAEA safeguards and broader NPT obligations, ongoing noncompliance cases and the legacy of past violations and clandestine nuclear proliferation outside the NPT continue to deepen mistrust and shape threat perceptions in the region. Nonetheless, developments in Syria following the fall of the Assad regime, including increased cooperation of the current government with the IAEA to address past violations of undeclared nuclear activities, suggest progress towards closing one of the two remaining long-standing non-compliance cases in the region.

⁷⁵ IAEA, "Status List: Amendment to Small Quantities Protocols – Status as of 31 December 2025", December 2025, <https://www.iaea.org/sites/default/files/20/01/sg-sqp-status.pdf>.

FIGURE 3.

NPT accession and safeguards status (ratification) in the Middle East, as of May 2026



3.2. The nuclear proliferation landscape amid nuclear energy expansion

In the wake of the Hamas attack on Israel on 7 October 2023 and the subsequent wars between the United States and Israel, and Iran, regional threat perceptions have shifted dramatically, including on long-standing nuclear proliferation challenges that have shaped the increasingly fragile regional nuclear status quo.

A central challenge is the legacy of Iran’s non-compliance case and the deadlock in resolving concerns about its programme following the collapse of the JCPOA. In the absence of cooperation to resolve outstanding issues, in June 2025, the IAEA Board of Governors adopted a resolution finding that Iran had failed to uphold its safeguards obligations.⁷⁶ Subsequent Israeli and US attacks on Iran’s nuclear facilities, combined with the decision to reinstate Security Council sanctions through the snapback mechanism in October 2025, have so far only diminished Iran’s willingness to cooperate with the IAEA on safeguards and verification.

⁷⁶ IAEA, “NPT Safeguards Agreement with the Islamic Republic of Iran”, GOV/2025/38, 12 June 2025, <https://www.iaea.org/sites/default/files/25/06/gov2025-38.pdf>.

Since the attacks in June 2025, Iran has not permitted IAEA access to the attacked sites, including its stockpile of more than 400 kilogrammes of highly enriched uranium (HEU) enriched to 60 per cent. More broadly, Iran appears to have embraced a greater ambiguity regarding its nuclear activities, particularly its uranium enrichment.

The challenge of the secret Israeli nuclear weapon programme and the long-standing policy of nuclear opacity has no less of an impact on the regional proliferation landscape. Many states believe that possession of nuclear weapons capabilities and exemption from NPT obligations have only triggered spiral dynamics in the region and continue to drive motives for hedging and latency among regional rivals.

Israel's nuclear posture has also drawn attention and become especially problematic amid recent conflicts and tensions. Israeli officials invoked the potential use of nuclear weapons with reference to the war in Gaza.⁷⁷ In parallel, satellite imagery of Israel's nuclear complex in Dimona has revealed what independent experts believe is an expansion of nuclear weapon-related infrastructure consistent with potential modernisation or expansion of the nuclear weapons arsenal, referred to as vertical nuclear proliferation.⁷⁸ If earlier reports that work began around 2018 or 2019 are accurate, these developments would suggest a long-standing policy of nuclear modernisation and expansion, rather than a post-October 2023 policy shift.⁷⁹ Recent conflicts have shifted Israel's conventional posture and further reinforced preferences for deterrence over arms control.⁸⁰



Recent conflicts have shifted Israel's conventional posture and further reinforced preferences for deterrence over arms control.

All of these developments have only heightened concerns about miscalculation and nuclear escalation, especially as Iran increasingly moves towards greater opacity and as Israel's

⁷⁷ Edith Lederer, "China, Iran, Arab Nations Condemn Israeli Minister's Statement about Dropping a Nuclear Bomb on Gaza", Associated Press, 14 November 2023, <https://apnews.com/article/israel-nuclear-weapons-gaza-iran-china-1e18f34dcec40582166796b0ade65768>, and Louis René Beres, "It's Time to End Israel's Nuclear Ambiguity", Israel National News, 7 August 2024, <https://www.israelnationalnews.com/news/394253>.

⁷⁸ Jon Gambrell, "Israel Is Building at a Suspected Nuclear Weapons Site, Satellite Photos Show", Associated Press, 3 September 2025, <https://apnews.com/article/israel-dimona-nuclear-weapons-construction-re-actor-3f5cbd0aaf25e2c087b881f6352d7de4>, and Lipi Shetty, "Construction Detected at Israeli Nuclear Weapons Site", *Arms Control Today*, October 2025, <https://www.armscontrol.org/act/2025-10/news-briefs/construction-detected-israeli-nuclear-weapons-site>.

⁷⁹ Sang-Min Kim, "New Work Underway at Israeli Nuclear Site", *Arms Control Today*, April 2021, <https://www.arms-control.org/act/2021-04/news/new-work-underway-israeli-nuclear-site>.

⁸⁰ Udi Evental, "מניעה וקוץ בה" [A blessing in disguise], X (formerly Twitter), 15 July 2025, <https://x.com/UEvental/status/2047918410344865997>, and Almutaser Albalawi, "From Asymmetry to Autonomy: Rethinking Arms Control in the Middle East", PRISME Initiative, June 2025, <https://prismeinitiative.org/publications/asymmetry-autonomy-rethinking-arms-control-middle-east-almuntaser-albalawi/>.

nuclear doctrine is less understood, including who has the authority to authorise the use of nuclear weapons and the crossing of which red lines would prompt their use.⁸¹

Statements by officials in Saudi Arabia about the potential pursuit of nuclear capabilities in parity with rivals, along with its evolving defence agreement with Pakistan (an extraregional nuclear-armed state) that may include elements of nuclear deterrence, are additional evolving challenges that add to uncertainty about the regional non-proliferation landscape.⁸² While this is not unique to the region and is consistent with broader global trends, such rhetoric raises questions about the motives behind certain nuclear energy activities. This includes, in particular, enrichment and reprocessing programmes beyond economic and clearly justified needs, which can be seen as steps in pursuing nuclear hedging or latency.

Unsafeguarded programmes and nuclear activities beyond peaceful purposes drive instability and spur further proliferation. Rivals may emulate one another's opacity or seek to develop similar capabilities to achieve parity, ultimately heightening threat perceptions. At the same time, perceived asymmetries and double standards have been further exacerbated by expectations that some states in the Middle East must indefinitely accept non-proliferation obligations while others need not. Incentives for arms control and the path to a WMD-Free Zone have only been complicated by the perception that regional stability results from tolerating certain states' selective proliferation and nuclear capabilities, while justifying military actions when held by others.⁸³

Therefore, the planned nuclear energy programmes in the region do not, by themselves, pose unique nuclear risks, provided that they are in full compliance with safeguards. However, if these programmes unfold within an already fragile regional order marked by deep mistrust and heightened threat perception, alleviating this mistrust will require consistent application of safeguards, strengthened verification measures, and other confidence-building measures (e.g., information-sharing and reporting).

⁸¹ Marni McFall, "Trump Adviser Warns of Possible Israel Nuclear Escalation in Iran Conflict", Newsweek, 14 March 2026, <https://www.newsweek.com/david-sacks-trump-administration-israel-nuclear-escalation-iran-war-11678063>, and John Hudson, "Some Democrats Press Trump to Break Silence on Israel's Nuclear Arsenal", Washington Post, 5 May 2026, <https://www.washingtonpost.com/national-security/2026/05/05/israel-nuclear-program-democrat-letter/>.

⁸² "Saudi Arabia Signs Mutual Defence Pact with Nuclear-Armed Pakistan", Al Jazeera, September 17, 2025, <https://www.aljazeera.com/news/2025/9/17/saudi-arabia-signs-mutual-defence-pact-with-nuclear-armed-pakistan>; "Pakistan Says Defense Deal Gives Saudi Arabia Access to Its Nuclear Program if Needed", AP News, 19 September 2025, <https://apnews.com/article/pakistan-saudi-nuclear-pact-defense-e66e0ded8045812c8a-aa39e21d764836>, and Julian Borger, "Crown Prince Confirms Saudi Arabia Will Seek Nuclear Arsenal if Iran Develops One", The Guardian, 21 September 2023, <https://www.theguardian.com/world/2023/sep/21/crown-prince-confirms-saudi-arabia-seek-nuclear-arsenal-iran-develops-one>.

⁸³ Author's conversations with regional experts and officials at the 69th IAEA General Conference, Vienna, 15–19 September 2025, and statements by the regional states at various occasions at NPT and IAEA meetings, and the Middle East WMD/FZ Conference. See, for example, Sixth Session of the Conference on the Establishment of a Middle East Zone Free of Nuclear Weapons and other WMD, Statement by Kuwait on behalf of the GCC, 17 November 2025, <https://app.unidir.org/node/7386>; Fifth Session of the Conference on the Establishment of a Middle East Zone Free of Nuclear Weapons and other WMD, Statement by Saudi Arabia, 18 November 2024, <https://app.unidir.org/node/7337>, and Statement by Kuwait, 18 November 2024, <https://app.unidir.org/node/7320>.



3.3. Regional arms control engagement

Frustration with the regional nuclear status quo and past failures led Middle Eastern states to initiate a regional process at the United Nations General Assembly in 2018 to negotiate a WMDFZ treaty. This move reflected growing calls from many capitals in the region for inclusive, region-led diplomacy and international backing to address all WMD risks on an equal footing.⁸⁴

Despite ongoing conflicts and high tensions, most Middle Eastern states emphasise diplomacy and see urgency in engaging all states of the region, particularly Israel and Iran, in arms control dialogue, including through the Middle East WMDFZ Conference.⁸⁵ These calls continue to be met with resistance from Israel, which has not engaged in arms control talks with its neighbours since 2018, in objection to the modalities and scope of the General Assembly-mandated conference. Israel has not so far attended the annual sessions of the conference despite the annual invitation from the United Nations Secretary-General and calls from participating states. Israel maintains that a WMD-Free Zone should be an outcome of a comprehensive peace process, not a starting point. Its objection to the conference is that it is held under United Nations auspices, is limited to WMD and precludes discussion of regional security.⁸⁶ Israel's non-engagement has further constrained the already limited regional avenues for nuclear diplomacy and arguably reinforced militarised alternatives.

⁸⁴ Almontaser Albalawi, "A Balanced Approach to Addressing Nuclear Risks in the Middle East While Preserving the Treaty on the Nonproliferation of Nuclear Weapons", *Peace Review: A Journal of Social Justice*, vol. 36, no. 2 (2024): 238–250, <https://www.tandfonline.com/doi/full/10.1080/10402659.2024.2337870>.

⁸⁵ United Nations, General Assembly, Report of the Fourth Session of the Conference on the Establishment of a Middle East Zone Free of Nuclear Weapons and Other Weapons of Mass Destruction, A/CONF.236/2023/2, 20 November 2023, <https://depositary.unidir.org/node/7225>.

⁸⁶ Almontaser Albalawi, "Will There Ever Be a WMD-Free Zone in the Middle East?", *Arms Control Today*, January/February 2025, <https://www.armscontrol.org/act/2025-01/features/will-there-ever-be-wmd-free-zone-middle-east>.

There is no indication that the current Israeli government is likely to change this position and engage on nuclear issues as a standalone topic or within the General Assembly-mandated process. From Israel's perspective, the risks of the process under its current format and scope outweigh potential gains. Some states argue, in contrast, that Israel would gain more than it risks by engaging in arms control talks, particularly in the Middle East WMD/FZ process.⁸⁷ Participation in the conference offers region-wide engagement, including with states without established diplomatic relations, that can foster greater confidence and trust at a time when



Participation in the conference offers region-wide engagement, including with states without established diplomatic relations, that can foster greater confidence and trust at a time when military alternatives are increasingly costly, unpredictable, and unsustainable.

military alternatives are increasingly costly, unpredictable and unsustainable. Furthermore, the conference's consensus-based working modalities ensure equal consideration of national concerns and preclude outcomes imposed by outnumbering or politicisation. Past sessions demonstrated efforts to depoliticise the process and prioritise pragmatism in addressing regional nuclear risks.

⁸⁷ Conference on the Establishment of a Middle East Zone Free of Nuclear Weapons and Other Weapons of Mass Destruction, Fifth Session, "Inclusivity versus Self-Isolation: The Pressing Issue of the United Nations Conference on the Establishment of a Middle East Zone Free of Nuclear Weapons and Other Weapons of Mass Destruction", Working Paper Submitted by the Russian Federation, 18–22 November 2024, <https://depository.unidir.org/node/7325>.



4. Managing nuclear fuel technology

Storage Facility at the IAEA LEU Bank. Credit : Katy Laffan / IAEA.

Growing global tensions continue to increase concerns about energy security and supply assurance. These tensions have been fuelled by trade wars and heightened perceptions of security threats related to the renewed salience of nuclear weapons and to nuclear latency. These dynamics have further intensified interest among middle and rising powers in reconsidering strategic technologies (e.g., uranium enrichment and reprocessing) for both national security and economic gains. For example, in December 2025, the Republic of Korea, which has been constrained from pursuing uranium enrichment since 1974 by its cooperation agreement with the United States, reportedly secured a US pledge of support for developing plutonium-separation and uranium-enrichment capabilities. This move marked a significant departure from a long-standing US non-proliferation policy of limiting the spread of fissile material-production capabilities.⁸⁸

As more states globally and from the Middle East strengthen their commitments to nuclear energy in general, and domestic enrichment capabilities in particular, to meet economic and strategic objectives, long-standing proliferation risks associated with sharing sensitive nuclear technology are re-emerging.

Uranium enrichment is a dual-use technology, being a key component of both civilian nuclear and nuclear weapon programmes. This makes uranium-enrichment technology inherently sensitive from a proliferation perspective since the same facilities and expertise used for

⁸⁸ Kelsey Davenport, “U.S. Supports South Korean Enrichment, Reprocessing”, *Arms Control Today*, December 2025, <https://www.armscontrol.org/act/2025-12/news/us-supports-south-korean-enrichment-reprocessing>.

peaceful purposes can, under certain conditions, be misused and repurposed to produce weapon-useable material. The same technology that is used to produce low-enriched uranium (LEU) for the nuclear fuel of most traditional civilian nuclear reactors could be used for further enrichment of the fuel for nuclear weapons. As a result, access to and the possession of enrichment technologies have historically created complexity and tensions.

There are different proliferation pathways associated with the misuse of enrichment capabilities. A declared civilian facility may be misused and reconfigured to produce HEU in two ways. First, safeguarded LEU centrifuge cascades could be reconfigured, either by altering piping or by manipulating operating parameters such as flow rates to increase enrichment efficiency, for example, by creating longer and narrower cascades. Second, LEU could be recycled through cascades multiple times to gradually raise enrichment levels, a method known as batch recycling.⁸⁹ This misuse may involve concealed, protracted removal of LEU, falsification of materials accounting, or the transfer of know-how, declared materials, and components to undeclared parallel enrichment facilities. Another proliferation pathway is to covertly establish a parallel undeclared programme with the expertise, equipment and materials necessary to produce HEU.

Technology type and potential for indigenisation also significantly influence proliferation risks and pathway scenarios. For instance, gas centrifuge technology, which is the technology used

“
Technology type and the potential for indigenisation also significantly influence proliferation risks and pathway scenarios.

in most enrichment facilities, has a relatively small physical footprint compared to older methods (e.g., thermal diffusion or gaseous diffusion), making it easier to conceal for clandestine activities. Its modular nature means that expansion of enrichment scale and capacity, once the know-how and designs are obtained, can take place relatively quickly. Similarly, emerging enrichment technologies (e.g., aerodynamic and laser isotope separation)

while more difficult to develop and indigenise, could become attractive for undeclared enrichment due to tighter export controls on gas centrifuge technology.⁹⁰

Plutonium reprocessing, another key aspect of the nuclear fuel cycle and a pathway to acquiring nuclear weapons, is similarly dual-use; however, its civilian justification is generally weaker, given its lower economic feasibility and higher technology requirements than uranium enrichment. It can be more feasible and economically competitive when uranium prices are

⁸⁹ Chaim Braun, David Elliott, Pavel Podvig, and Dean Wilkening, “Security in a World with Expanding Nuclear Power”, (Center for International Security and Cooperation at Stanford University, August 2008), https://www.files.ethz.ch/isn/92496/2008_08_%20Security_in_a_World_with_Expanding_Nuclear_Power.pdf, and Ivanka Barzashka, “Converting a Civilian Enrichment Plant into a Nuclear Weapons Material Facility”, *Bulletin of the Atomic Scientists*, 31 October 2013, <https://thebulletin.org/2013/10/converting-a-civilian-enrichment-plant-into-a-nuclear-weapons-material-facility/>.

⁹⁰ Braun et al., *Security in a World with Expanding Nuclear Power*.

very high and in the context of large nuclear reactor fleets and a growing volume of spent fuel. Since operational and economic conditions for reprocessing for nuclear energy purposes are currently absent in the Middle East, and no state in the region has explicitly expressed interest in reprocessing as part of their nuclear energy programmes (as they have for enrichment), this section primarily focuses on uranium enrichment. It primarily examines various models for cooperation in fuel cycle capabilities and technology-sharing, as well as safeguards considerations for non-proliferation.

4.1. Models for cooperation and transfer of nuclear fuel technology

States acquire nuclear fuel technology through indigenous research and development, illicit procurement combined with indigenous development, or formal cooperation or assistance from advanced nuclear technology states.

Because fuel cycle technology is both commercially valuable and proliferation-sensitive, cooperation usually centres on a few main models that differ in the degree of access to the technology given to the recipient state. In practice, bilateral and multilateral cooperation agreements for uranium-enrichment technology can be categorised into three broad models: (a) enrichment services without access to technology; (b) full technology transfer; and (c) transfer under the “black box” model.

4.1.1. Enrichment services without access to technology (supply rights only)

The first model provides participating states with enrichment services or fuel without transferring enrichment operations, equipment, knowledge or design information. Such an arrangement can be structured as a joint venture, an equity participation or the provision of services in international markets. Enrichment plants are hosted in supplier states. The arrangement offers assurances of supply through membership or ownership stakes while limiting proliferation risks by preventing transfer and access to sensitive technology.

Under Eurodif, for example, the 1973 multinational joint venture involving Belgium, France, Iran, Italy and Spain, enrichment technology was neither exported nor indigenised by the non-host members; rather, it was operated and governed solely by France, which provided enrichment services to the other members.⁹¹ A more recent example is the International Uranium Enrichment Centre (IUEC), established in Russia in 2007 by Rosatom. With equity participation from states including Kazakhstan and Ukraine (at different times), the IUEC aimed to provide guaranteed LEU under IAEA control without transferring enrichment technology and while restricting the development of national enrichment capabilities.

⁹¹ Oliver Meier, “Iran and Foreign Enrichment: A Troubled Model”, *Arms Control Today*, January 2006, <https://www.armscontrol.org/act/2006-01/iran-nuclear-briefs/iran-and-foreign-enrichment-troubled-model>.

Urenco is another example of a uranium-enrichment services supplier, established by the 1970 Treaty of Almelo between the United Kingdom, the Netherlands and Germany. With ownership shared equally by the three states, Urenco operates enrichment plants in each country designed to prevent unilateral transfer of centrifuge know-how. While the co-owners host the enrichment plants, a joint venture between Urenco and Orano operates the facilities as “black boxes”, and the states themselves neither operate them nor have access to enrichment technology or know-how.

Operations are safeguarded through joint inspections by the European Atomic Energy Community (Euratom) and the IAEA, including routine inspections, physical inventory verification, design information verification, limited-frequency unannounced access and complementary visits. In practice, Euratom’s regime for inspection of Urenco facilities may be structurally stricter than the IAEA’s Additional Protocol due to its supranational legal authority and intensive frequency of access. The Euratom Treaty grants inspectors immediate, unannounced and legally binding access to all civil nuclear sites. Furthermore, the European Union’s European Commission has direct authority to impose legal penalties and to enforce ultimate property ownership over all special fissionable materials.⁹²

Urenco differs from the IUEC and Eurodif models in that it develops enrichment technology and, in one case, has transferred it through a “black box” model (see Subsection 4.1.3 below) beyond the co-owners’ territories to build a commercial enrichment facility in the United States. Urenco is therefore best characterised as a hybrid case: for non-members, it operates as a supplier of ‘black box’ enrichment services without access to technology, while for its co-owners,

it operates as a governed multinational consortium that develops enrichment technology and fuel under collective control and with transfer restrictions.



Full transfer of enrichment technologies to non-nuclear weapons states has been relatively rare since the 1970s due to the high risk of proliferation they pose and the emergence of international export controls.

4.1.2. Full technology transfer (with access to design and know-how)

The second model involves complete technology transfer, including access to know-how, designs and blueprints sufficient for the recipient state to indigenise the technology or fully operate it independently.

Civilian cases of full transfer have been relatively rare since the 1970s due to the high risk of

⁹² Peter Friend, “Urenco’s Views on International Safeguards Inspection”, 8th International Conference on Facility Operations–Safeguards Interface, 30 March–4 April 2008, <https://web.mit.edu/stgs/pdfs/Friend%20-%20Urenco%27s%20Views%20on%20International%20Safeguards%20Inspection.pdf>, and Grégoire Mallard, “Can the Euratom Treaty Inspire the Middle East? The Political Promises of Regional Nuclear Communities”, *The Nonproliferation Review*, vol. 15, no. 3 (2008): 459–77, <https://doi.org/10.1080/10736700802407135>.

proliferation that they carry and the emergence of international export controls. Full transfer in practice may expand the recipient state's ability to replicate, modify or transfer enrichment capabilities beyond the scope of the original cooperation.

The 1975 agreement between West Germany and Brazil is a prominent example. The agreement foresaw the construction of several nuclear power plants in Brazil and the transfer of full-cycle nuclear technology, including uranium enrichment based on the experimental West German-developed “jet nozzle” method.⁹³ The cooperation model raised proliferation concerns despite being subject to IAEA safeguards, given that Brazil was not a party to the NPT at the time. Brazil, despite receiving the technology, never fully operationalised it. Instead, it shifted its focus to indigenous, unsafeguarded gas centrifuge development in the 1980s.

4.1.3. Transfer under the “black box” model (restricted access)

The third model seeks to balance the benefits of commercial technology export, aspirations for domestic capability and the mitigation of proliferation risks by enabling the recipient state to host and, in some cases, operate enrichment facilities on its territory while restricting access to sensitive design information. There is no agreed-upon technical definition of a black box model. However, its core objectives are generally agreed: (a) preventing the replication of the technology through reverse engineering; and (b) preventing diversion or misuse of enrichment processes.

The concept originally described the supply of sensitive technology on a prefabricated basis to protect proprietary information, including trade secrets and patented designs.⁹⁴ The term has since evolved to encompass the protection of nuclear proliferation-sensitive know-how by restricting recipients' access to sensitive designs, processes and knowledge. It also prevents the alteration of technology or the bypassing of safeguards.

Historically, recipients of enrichment technology supplied on a black box basis were only NPT-recognised nuclear-weapon states (NWS) with good relations with their suppliers, such as Russia's transfer of enrichment technology to China from the 1990s.⁹⁵ Similarly, Urenco and Areva, a French company, supplied centrifuge technology to the United States through a joint venture, the Enrichment Technology Company (ETC), for a plant in New Mexico under arrangements designed to limit US access to sensitive design information. In both cases, the

⁹³ Nicolini Gabriel, João Paulo and Dawisson Belém Lopes, “Brazilian Failures to Consolidate a Domestic Nuclear Industry: The Role of Science and Technology Policies”, *International Politics*, July 2024, <https://link.springer.com/article/10.1057/s41311-024-00590-9>; Leonardo Bandarra, “From Bonn with Love: West German Interests in the 1975 Nuclear Agreement with Brazil”, *Cold War History*, vol. 21, no. 3 (2021): 337–54, <https://doi.org/10.1080/14682745.2020.1819245>, and Renata H. Dalaqua, “‘We Will Not Make the Bomb Because We Do Not Want to Make the Bomb’: Understanding the Technopolitical Regime That Drives the Brazilian Nuclear Program”, *The Nonproliferation Review*, vol. 26, no. 3–4 (2019): 1746–66, <https://doi.org/10.1080/10736700.2019.1630094>.

⁹⁴ Yury Yudin, “Multilateralization of the Nuclear Fuel Cycle: The Need to Build Trust”, (New York and Geneva: UNIDIR, 2010), <https://unidir.org/publication/multilateralization-of-the-nuclear-fuel-cycle-the-need-to-build-trust/>.

⁹⁵ Daniel Shats, “China–Russia Nuclear Industry Cooperation”, (Montgomery, AL: China Aerospace Studies Institute, 2024), https://www.airuniversity.af.edu/Portals/10/CASI/documents/Research/Infrastructure/2024-01-16_China-Russia_Nuclear_Cooperation.pdf.



LEU cylinders transferred from the Orano Cycle facility in France to storage at the IAEA LEU Bank. January 2020. Credit: Katy Laffan / IAEA.

technology was manufactured and installed by the supplier, without the participation of recipient personnel. Operators in the host countries did not see internal components or detailed design information during assembly. Only the information required to safely and legally operate the plant was shared, and the facilities were under IAEA voluntary safeguards. These restrictions were defined in the cooperation agreements, which may include provisions allowing regulatory bodies (as in the US case) access to safety or licensing-related technologies.⁹⁶

4.2. The viability and effectiveness of black box technology transfer

The logic of black box transfer is that the recipient is denied access to sensitive technologies. This may include blueprints for key components (e.g., centrifuge rotors, bearings and magnets) and sensitive operational data (e.g., cascade sequencing, enrichment-stage ratios, flow rates, material throughput and separative work efficiency). Conditions of supply usually include prohibitions on reconfiguring cascades, modifying pipelines, manipulating enrichment levels, or having unsupervised access to control systems, software or operational parameters codes to prevent misuse. These protections could include information barriers (e.g., casing, sealing and isolating sensitive components), restricting access during installation, and incorporating tamper-resistant features to prevent unauthorised access or modification without detection or causing a malfunction. These barriers may also restrict core manufacturing blueprints, so that

⁹⁶ US Congress, Congressional Research Service, “Nuclear Energy Cooperation with Foreign Countries: Issues for Congress”, 9 April 2026, <https://www.congress.gov/crs-product/R41910>.

even if internal components are compromised, the manufacturing and optimisation techniques remain secret, ensuring that the core technology remains protected.⁹⁷

The effectiveness of the black box model in preventing proliferation is unclear. In general, certain levels of operational knowledge may remain accessible to recipient operators and, over time, contribute to their understanding of the technology's design and principles or to filling gaps in efforts to localise it. The host state may require access to some technical information to meet its regulatory oversight requirements for the facility. For instance, it is unclear to what extent China's indigenous enrichment capabilities were informed by Russian-supplied technology, despite the black box transfer of the technology.⁹⁸ Technology may also have an impact on the effectiveness of the black box model. For example, certain centrifuge technologies that have been designed for greater operational flexibility may allow easier alteration and bypassing of safeguards.

These vulnerabilities could be addressed, for example, if the facility were operated in the recipient country while the host country had no ownership of, or access to, the facility, technology or operational details. Such arrangements could reduce the likelihood of misuse and diversion while also addressing supply assurance and national sovereignty needs.

4.3. Safeguards considerations for nuclear fuel technology transfer

Several factors shape how safeguards are applied when sharing nuclear fuel technology, particularly uranium enrichment, with a non-nuclear-weapon state (NNWS). Due to the high inherent risks of enrichment technology, including replication or diversion of technology and know-how, technology sharing involving the indigenisation or the operation of enrichment plants may entail higher verification requirements than those for nuclear fuel supply.

A key factor would be the cooperation arrangements and ownership of enrichment operations, particularly under the "black box" model, where access to certain areas and operations that are subject to safeguards may be restricted. In such cases, traditional safeguard approaches may need to be revisited and complemented based on the design of the enrichment facility and ownership arrangements. Ownership and jurisdiction are key because safeguard obligations differ between NNWS and NWS. In an NWS, enrichment facilities are typically subject to voluntary offered agreements, and safeguards are applied only to facilities designated as civilian and selected by the IAEA from a list offered by the state. The practice does not establish

⁹⁷ Alexander Glaser, "Internationalization of the Nuclear Fuel Cycle: Goals, Strategies, and Challenges", 2009, ICNND Research Paper No. 9. Princeton: Program on Science and Global Security, Princeton University, https://www.princeton.edu/~aglaser/2009aglaser_icnnd.pdf.

⁹⁸ Jeffrey Lewis, "China's New Centrifuge Plants", Arms Control Wonk, 17 September 2013, <https://www.arms-controlwonk.com/archive/206826/chinas-new-centrifuge-plants/>, and Hui Zhang, "China's Uranium Enrichment Capacity: Rapid Expansion to Meet Commercial Needs", (Cambridge, MA: Project on Managing the Atom, Belfer Center for Science and International Affairs, Harvard Kennedy School, 2015), https://www.belfercenter.org/sites/default/files/pantheon_files/files/publication/chinasuraniumenrichmentcapacity.pdf.

a uniform obligation for submitting design information during the planning phase. In practice, safeguards have often been applied to facilities that were constructed prior to the IAEA CSA safeguards regime. In contrast, all NNWS are obliged to declare and subject any enrichment facility and submit design information before construction to enable safeguards to be integrated from the outset.

Given that there is no precedent for a black box model in an NNWS, a standard safeguards model would need to be developed. The model can be informed by IAEA safeguards experience in regular enrichment facilities, including past efforts under the Tripartite Enrichment Project (a collaboration between the IAEA, Russia and China to develop specialised safeguards for uranium enrichment plants utilising Russian-supplied centrifuge technology), as well as past black box models.

It is also important to consider commercial and private sector factors. For instance, an exporting business may be reluctant to accept intensive safeguards that may compromise its intellectual property or to incur higher costs by designing safeguards to address such concerns, especially if its technology is already deployed elsewhere with inferior safeguards.

Another issue is that the IAEA's general safeguards objectives under a CSA are broad enough to address various forms of misuse and diversion. However, in practice, safeguards are primarily designed to detect the diversion of material, rather than the replication, diversion of technology and know-how, or a parallel program. This matters in black box cooperation models because the central rationale is to prevent recipient states from replicating or indigenising the technology. While measures under the CSA remain essential, detecting clandestine nuclear fuel cycle activities or the diversion of expertise, equipment, or materials is more feasible when an AP is in force. For that reason, cooperation with an NNWS would benefit significantly from implementing the AP or, at least, equivalent provisions.

Finally, even the most robust safeguard systems cannot entirely eliminate all risks, such as violations related to proprietary technology or attempts to replicate certain components through parallel domestic efforts. These risks could be mitigated through bilateral legal instruments to deter and penalise such non-compliance scenarios. For example, cooperation agreements can condition continued cooperation on full compliance with the NPT and IAEA safeguards, prohibit nationalisation, and restrict domestic manufacturing of enrichment components without the supplier's prior consent. Agreements may also include enforcement measures in the event of violations, including withdrawal of technology, suspension of cooperation (e.g., material supply and maintenance) and, if necessary, sanctions, as in the case of Euratom.



5. Cooperative approaches to risk mitigation

Barakah Nuclear Power Plant. Credit: Extracted from publicly released video by Emirates Nuclear Energy Corporation (ENEC).

A potential expansion of nuclear energy programmes in the Middle East will have implications for engagement on mitigating nuclear risks and on regional civil nuclear cooperation. Nuclear energy ambitions are likely to increase incentives for regional coordination, as interests in safety and security risk mitigation and in realising the economic and development benefits of peaceful uses increasingly converge. This creates opportunities to advance cooperation between states in the region in managing shared risks, pooling resources, reducing duplication, and addressing long-standing gaps in technical capacity and political constraints that have historically held back progress.

These dynamics are likely to surface in, and also potentially shape, ongoing discussions and proposals related to long-standing regional initiatives, including the establishment of a WMD-Free Zone and a regional nuclear energy consortium. This section examines these implications and outlines potential cooperative approaches and risk-mitigation measures that may emerge, including the political and technical considerations that govern the negotiation and adoption of these arrangements.

5.1. Implications for the Middle East WMD-Free Zone

As technical capacity grows through new programmes, states may more credibly envision and commit to new regional cooperation frameworks, including joint ventures for new nuclear power plants and fuel production. This trend will accelerate as successful programmes build confidence in the technology and regional capacity and encourage other states in the Middle East to invest in cooperation initiatives.



The fourth session of the Conference on the Establishment of a Middle East Zone Free of Nuclear Weapons and Other Weapons of Mass Destruction, New York, 2023. Credit: Almutaser Albalawi / UNIDIR.

States in the region may also value creating technical interdependence through regional cooperation to enhance transparency and reinforce the legitimacy of regional nuclear energy activities. Some states may also seek to promote regional cooperation in order to claim scientific leadership and position themselves to shape future regional cooperation arrangements (including a possible nuclear energy consortium or technical verification expertise hub) for both political assurance and economic benefits.

The potential deployment of SMRs and other advanced Gen IV designs, in which fuel types and supply chains differ from traditional LEU fuel, may prompt states in the Middle East to consider establishing new fuel-supply assurance arrangements. This could include a regional fuel consortium or representation in a future international advanced-fuel consortium.

All of these aspects could shape ongoing discussions about establishing a WMD-Free Zone in the region, including at the annual United Nations General Assembly-mandated conference. States may go beyond preambular paragraphs that promote peaceful cooperation and assistance and may include a dedicated regional body to facilitate regional cooperation initiatives, along the lines of the African Commission on Nuclear Energy (AFCONE) under the Treaty of Pelindaba.

Given the regional context and the possible emergence of nuclear energy cooperation that may involve bilateral safeguards standards or proliferation-sensitive technology (e.g., enrichment), states may explore building confidence and enhancing trust in verification arrangements under the future Zone treaty. These would complement IAEA safeguards with bilateral and regional mechanisms inspired by precedents such as Euratom, the Brazilian–Argentine Agency for

Accounting and Control of Nuclear Materials (ABACC) under the Treaty of Tlatelolco, and the adoption of the AP under the Central Asian Nuclear Weapon-Free Zone (NWFZ).

Middle Eastern states may need to discuss whether certain fuel cycle activities pose such a heightened proliferation risk that, with no clear peaceful justification, they warrant consideration of possible control measures under the future WMDFZ treaty. This would affect, for instance, how the region's states balance their NPT rights to enrichment and reprocessing while reassuring one another of their programme's peaceful nature.

Other aspects that states will have to consider in the context of the Middle East WMDFZ are threats from non-state actors and the potential consequences of nuclear accidents in neighbouring territories. This will include considering whether to include provisions on nuclear security, safety and physical protection in the future Zone treaty, as addressed in some of the established NWFZ treaties. These provisions may also include adherence to key international instruments, including measures aligned with those outlined in the Convention on Physical Protection of Nuclear Material and Nuclear Facilities, the Convention on Early Notification of a Nuclear Accident, and the Convention on Assistance in the Case of a Nuclear Accident, while affirming the primacy of national sovereignty.

Additional cooperative measures that states may consider, beyond general references to compliance with international standards and guidelines, are explicit standards for the review of planning and siting for new nuclear energy plants and for technology selection, aligned with IAEA standards.

5.2. Managing dual-use risks of nuclear technology

The dual-use nature of nuclear technologies creates the dilemma of how to balance the right to peaceful uses, including strategic and technological benefits of fuel cycle technologies, while managing associated proliferation risks.

In general, the key risk-mitigation principle should be that exporting states engage in open dialogue with states interested in fuel cycle technologies to address their strategic and sovereign concerns while mitigating proliferation risks. This could include redirecting cooperation towards advanced nuclear reactor technology and other less sensitive aspects of the fuel cycle that would still elevate the recipient state's industry and R&D scientific base (e.g., mining, conversion and fuel fabrication), along with credible fuel-supply assurances. Cooperating states may also explore the idea of a voluntary moratorium on developing certain aspects of fuel cycle capabilities for as long as these arrangements remain reliable and meet legitimate economic needs.

Revisiting the adequacy of existing international fuel-supply assurance tools, including the IAEA LEU Bank, is a necessary starting point. Alternative mechanisms include multilateral fuel cycle centres and strengthened bilateral supply guarantees, and other approaches to mitigate political tensions and economic disruptions, including an international advanced-fuel assurance mechanism that goes beyond the IAEA LEU Bank's scope to include HALEU and

fuel fabrication. These could significantly enhance the reliability of supply assurances and reduce the strategic rationale for costly and politically contentious domestic fuel cycle capabilities.

The widespread deployment of advanced reactors and fuel will also affect how IAEA safeguards are implemented. The agency has considerable flexibility to adapt within the existing safeguard mandate; however, adopting these technologies may still require safeguards to adapt to how and where diversion and misuse risks arise, thereby increasing the need for stronger verification systems. Accordingly, discussions on nuclear energy and fuel cycle cooperation should be accompanied by parallel dialogue at the regional and international levels on verification standards for advanced nuclear reactor systems and novel nuclear fuel.

The regional risk to the physical protection and resilience of civilian nuclear infrastructure against conventional military strikes is unique and pressing. This also warrants a global dialogue on reinforcing international norms that prohibit targeting civilian nuclear facilities and on ways to enhance safety and emergency preparedness. Revisiting the credibility of international assistance mechanisms, including those for maintenance and emergencies, would ease concerns about operational disruptions and emergency response. Additionally, regional non-attack agreements or understandings that commit states not to target civilian nuclear facilities, even during armed conflicts – including an explicit definition of the conditions and a list of the protected facilities (similar to elements of the 1988 agreement between Pakistan and India) – can be promoted as a regional confidence-building or risk-reduction measure to address these risks.

The particular regional dynamics of the Middle East, where nuclear energy expansion intersects with a legacy of clandestine nuclear weapon programmes and persisting security dilemmas, suggest that ad hoc approaches that address individual cases may not be effective or sustainable. A broader regional approach embedded in cooperative frameworks could better address legitimate needs and security concerns while advancing long-term regional non-proliferation and disarmament goals, including the establishment of the WMDfZ.

Regional approaches have proven more resilient than ad hoc and bilateral arrangements, particularly when designed to withstand conflicts and political crises. SESAME has been the Middle East's flagship example of sustained regional cooperation amid severe conflicts and political tensions. The SESAME experience demonstrates the region's willingness to engage in civilian settings and formats, especially on scientific cooperation issues, which can make it easier to secure the political buy-in for their establishment and can engage policy communities on technical questions.

Similar approaches could be adopted to address the dual-use dilemma posed by nuclear energy and sensitive fuel cycle technologies while still addressing national concerns. Long-standing proposals for a regional nuclear energy consortium that includes a regional fuel cycle centre have been a frequent idea in expert and official discussions, including recently during the United States–Iran negotiations. While the details of the specific proposals discussed vary,



the core principle is the establishment of agreed-upon regional facilities in a host territory or across different host territories.⁹⁹ The consortium will be governed through a joint venture involving interested states in the region and cooperating exporting states. Enrichment and other fuel cycle aspects within such a framework would operate under strict international monitoring, with safeguards and access restrictions agreed upon by states, designed to prevent the spread of sensitive proliferation knowledge.

From an economic perspective, the consortium could help pool regional resources and expertise. It would be less costly for states to individually join a regional consortium than to build and operate a national one. Wide regional participation also increases demand, strengthening the consortium's economic case.

One plausible operational design is a black box approach in which the supplier prefabricates, constructs and operates the enrichment units on the agreed host territory. The agreement would specify access limitations and roles for personnel of the host states and of other states in the region, potentially including non-sensitive operational roles such as maintenance, operating

⁹⁹ For further reading on regional nuclear energy arrangements in the Middle East, see Mohamed Ibrahim Shaker, "Regionalizing Nuclear Energy in the Middle East", *Global Governance*, vol. 20, no. 4 (2014): 517–28, <http://www.jstor.org/stable/24526322>; IAEA, "Multilateral Approaches to the Nuclear Fuel Cycle", Report of an Expert Group Submitted to the Director General, 2005, <http://www.iaea.org/publications/7281/multilateral-approaches-to-the-nuclear-fuel-cycle>; Giorgio Franceschini and Daniel Müller, "Peaceful Uses of Nuclear Energy in the Middle East: Multilateral Approaches", (Frankfurt: Peace Research Institute Frankfurt, 2011), https://www.prif.org/fileadmin/Daten/Downloads/Projekt-Downloads/EU_Consortium_Peaceful_uses_of_nuclear_energy.pdf; Frank von Hippel, Alexander Glaser, Zia Mian and Seyed Hossein Mousavian, "A Nuclear Consortium in the Persian Gulf as a Basis for a New Nuclear Deal between the United States and Iran", *Bulletin of the Atomic Scientists*, 2 June, 2025, <https://thebulletin.org/2025/06/a-nuclear-consortium-in-the-persian-gulf-as-a-basis-for-a-new-nuclear-deal-between-the-united-states-and-iran/>, and Mohammad Javad Zarif, "Keynote Speech", 63rd Pugwash Conference on Science and World Affairs, 3 November, 2025, <https://pugwash.org/wp-content/uploads/2025/11/251103-mjz-pugwash-hiroshima.pdf>.

outer and auxiliary systems (e.g., piping and cooling), loading and unloading feed material, and monitoring non-sensitive processes. Sealed prefabricated centrifuges would be installed in restricted-access areas with physical barriers, with monitoring systems managed by the supplier to prevent replication or unauthorised access.

Over time, the consortium could offer interested Middle Eastern states a sequenced, gradual path towards deeper involvement, subject to strict verification measures and contingent on sustained compliance and confidence-building (mirroring Japan's gradual enrichment development under close US oversight). The initial phase could involve a full black box operation under the exporter's full ownership and control. In the medium term, personnel from states in the region might engage in supervised R&D or training focused on non-sensitive aspects of enrichment operations. In the long term, personnel of states with a strong compliance track record verified by the IAEA could assume operational responsibilities.

The framework would require a robust governing agreement with strict conditions. These conditions would include prohibitions on independent operation without the consortium's consent, limits on unauthorised transfer of technology or knowledge, full compliance with international safeguards, and enforcement measures for disputes and violations. This framework

offers significant non-proliferation benefits and reduced incentives for domestic enrichment operations and stockpiling beyond economic needs. It also lowers the risk of disruption and politicisation of international monitoring during periods of political tension. It could foster gradual confidence-building among participating states, because ownership and operations are not controlled by and concentrated in a single state, and regional fuel cycle activities become transparent and institutionalised. Furthermore, fewer national

facilities resulting from an agreed regionalised fuel cycle would, in principle, reduce verification efforts and costs.

For these proposals to materialise and receive serious consideration from policymakers, sustained attention to technical and political details is essential. Discussions could be held not only at the bilateral level but also regionally, especially through the General Assembly-mandated WMD-Free Zone conference process, including during the informal meetings of the conference's working committee. Intergovernmental and specialised institutions (e.g., United Nations bodies) and dedicated programmes (e.g., UNIDIR's Middle East WMD-Free Zone Project) could facilitate capacity-building and sustain the dialogue, including through convening regional experts and officials in a Track-1.5 setting.



For cooperative proposals such as the regional consortium to materialise and receive serious consideration from policymakers, sustained attention to technical and political details is essential.

Sustaining dialogue on proposals such as the regional nuclear energy and fuel cycle consortium can also open the door to broader cooperation. Over time, the consortium could expand to encompass the regional scientific community and the private sector, as well as nuclear fusion energy, and non-power applications of nuclear science (e.g., food and water security, medicine, and agriculture) that align with shared regional priorities. Broadening the regional cooperation agenda could strengthen its value, increase public support for regional cooperation and provide incentives for political buy-in.



Sustaining dialogue on proposals such as the regional nuclear energy and fuel cycle consortium can also open the door to broader regional cooperation.

Navigating a New Era for Nuclear Energy in the Middle East

Interest in nuclear energy across the Middle East is gaining renewed momentum amid a global push for energy security and economic growth. However, if the expansion of nuclear activities – particularly uranium enrichment – is not reasonably justified, then it could heighten risks and tensions.

This publication examines the current drivers for pursuing nuclear energy in the Middle East and how they may evolve in the near and medium terms. In particular, it examines how regional policy discourses and assumptions about security, climate change, energy, nuclear, and AI technologies shape interest in nuclear energy and influence decision-making. Understanding these drivers, together with the political and technical frameworks governing nuclear energy cooperation, is crucial for assessing risks and informing effective risk mitigation and regional cooperation.

The publication closes by examining the potential implications for the Middle East WMD-Free Zone initiative and identifying effective risk-mitigation models and partnership strategies to address proliferation threats and strengthen peaceful cooperation in the Middle East.



Palais des Nations
1211 Geneva, Switzerland

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