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Radiological Risks and Regional Readiness: Analyzing the GCC's Nuclear Incident Response Framework

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ABSTRACT

Nuclear security is defined as the ability for a state to fulfill requirements including ensuring nuclear weapons and technologies are secured, detecting and deterring nuclear proliferation, mitigating the consequences of a nuclear incident, and providing nuclear-related education. Nuclear incident response is a critical part of nuclear security, and has four steps: detection, training, response, and consequence management. This paper seeks to 1) identify the current capabilities of the Gulf Cooperation Council (GCC) with regards to nuclear and radiological incident response; 2) identify both technical and non-technical gaps in current GCC incident response efforts; and 3) suggest recommendations for improved regional incident response. When analyzing the current capabilities of the GCC, we reviewed each country's involvement in existing international and regional organizations, as well as each state's current nuclear infrastructure and capabilities. This research elucidated technical, political, and workforce-focused gaps within the GCC. These gaps lay the groundwork for the recommendations for the GCC in the future, which include development of independent state nuclear regulatory authorities, implementing a nuclear security-focused information sharing agreement, remedying issues within existing GCC nuclear security education, and solidifying incident response capabilities within the maritime and cyber domains. Increased cooperation within and outside of the GCC, remaining in the greater Persian Gulf region, is repeatedly emphasized throughout this paper, because as GCC states continue to develop nuclear technology and become more significant global players, the risk of radiological and nuclear incidents and emergencies grows as well.

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ACRONYMS AND DEFINITIONS

Abbreviation	Definition
CBRN	Chemical, Biological, Radiological, Nuclear
COE-ME	EU Center of Excellent, Middle East Secretariat
EMC	GCC's Emergency Management Center
EU	European Union
FANR	UAE's Federal Authority for Nuclear Regulation
GCC	Gulf Cooperation Council
IAEA	International Atomic Energy Agency
IEC	IAEA's Incident and Emergency Center
IMO	International Maritime Organization
JRODOS	Java Real-time Online Decisi-On Support
KIN	Kuwait Information Network
MEMAC	Marine Emergency Mutual Aid Center
NEET	Not Employed, in Education, or Training
NNSA	National Nuclear Security Administration
NORM	Naturally Occurring Radioactive Material
NRRC	Saudi Arabia's Nuclear and Radiological Regulatory Commission
NSA	Naval Support Activity (Bahrain)
NSDD	Nuclear Smuggling Detection and Deterrence
RN	Radiological and Nuclear
ROPME	Regional Organization for the Protection of the Marine Environment
TENORM	Technologically Enhanced Naturally Occurring Radioactive Material
TTT	Train the Trainer
UAE	United Arab Emirates

1. INTRODUCTION

The Gulf Cooperation Council (GCC), established in 1981, is a political and economic alliance of six Arab countries that line the Persian Gulf: The United Arab Emirates (UAE), Bahrain, Saudi Arabia , Oman, Qatar, and Kuwait.[1] These six countries share common values like religion and politics, and foster some of the fastest growing economies in the world.[2] These shared interests facilitate collaboration on key issues facing the region – such as the growth of the nuclear and radiological sector, and the concerns that come with it.

Figure 1: GCC States

The GCC states are historically known for their enormous hydrocarbons industries but have acknowledged that hydrocarbons are highly likely to lose momentum within the next hundred years. In anticipation, some of the GCC members have identified nuclear power as a supplementary energy source and are looking to become leaders in the nuclear renaissance. Since the early 2000s, GCC members have devoted significant resources towards research and development of nuclear energy infrastructure. Nuclear energy development in the Gulf can assist these countries in diversifying their energy portfolios and fulfill various carbon emissions pledges that some GCC members have made.[3] Nuclear power may even power some near-term hydrocarbon extraction efforts in the GCC.

In general, a diversified energy sector that includes nuclear power creates new risk scenarios for both the nuclear operators and their neighbors. Nuclear-related risks can be either intentional (such as sabotage) or unintentional (malfunctions). Regardless of intent, the impact is still severe and can affect a significant region or population of people. For the Persian Gulf region, this was realized in June 2025, when Israel mistakenly announced that its military forces had attacked Iran's Bushehr Nuclear Power Plant.[4] The Bushehr Nuclear Power Plant is located on the coast of Iran, on the Persian Gulf. If it was compromised, radioactive materials would very quickly contaminate the Gulf, which is the primary water source for the Gulf states, and critical to life in the region. Radioactive materials, such as tritium (a radioactive hydrogen isotope) would render the water undrinkable, as the current desalination technologies in place would be unable to filter it out.[5] The Gulf is also a shallow body of water, with an average depth of 300 feet (90 meters) and limited water flow through

[1] "Primary Law." https://www.gcc-sg.org/en/AboutUs/Pages/PrimaryLaw.aspx.
[2] "Gulf_Cooperation_Council_MEA_Website." https://www.mea.gov.in/Portal/ForeignRelation/Gulf_Cooperation_Council_MEA_Website.pdf.
[3] "Ensure GCC's Energy Future by Reconsidering Joint Nuclear Plant Collaboration." *Issue Brief*, December 19, 2024. https://www.bakerinstitute.org/research/ensure-gccs-energy-future-reconsidering-joint-nuclear-plant-collaboration.
[4] "The Fallout Factor in Targeting Iran's Nuclear Program." https://www.csis.org/analysis/fallout-factor-targeting-irans-nuclear-program.
[5] arabtimes. "What If A Nuclear Missile Lands In Arabian Gulf Waters?" arabtimes, June 22, 2025. https://www.arabtimesonline.com/news/what-if-a-nuclear-missile-lands-in-arabian-gulf-waters/.

the Strait of Hormuz into the Arabian Sea, therefore radionuclides resulting from contamination could remain in the Gulf for up to two years.[6]

Although Israel very quickly walked back their statement, the potential crisis highlighted just how detrimental any nuclear incident in the region would be - threatening the lives of over 60 million people. It would be very beneficial for the GCC alliance, during this time of cautious peace, to construct and solidify nuclear incident response architecture, minimizing the effects of a potential incident in the future. This paper will analyze 1) pre-existing regional organizations with nuclear response capabilities that the GCC (or its individual member states) belong to, 2) capabilities and cooperation efforts of the member states, 3) the gaps affecting incident response, and 4) will conclude with recommendations for the GCC, supported by technical means from the United States, specifically through Sandia National Laboratories (hereby known as Sandia).

[6] Maderich, Vladimir, Roman Bezhenar, Ivan Kovalets, Oleksandr Khalchenkov, and Igor Brovchenko. 2023. "Long-Term Contamination of the Arabian Gulf as a Result of Hypothetical Nuclear Power Plant Accidents." *Journal of Marine Science and Engineering* 11 (2): 2. https://doi.org/10.3390/jmse11020331.

2. UNDERSTANDING NUCLEAR SECURITY AND INCIDENT RESPONSE

The Institute for Nuclear Security defines nuclear security through a multipronged approach:

- Ensuring nuclear weapons and other technologies are secured, controlled, and monitored.
- Detecting, deterring, and discouraging proliferation of nuclear weapons and radiological threats.
- Preventing the diversion of nuclear or radiological materials for illicit or malicious use.
- Enhancing proliferation resistance through technologies that support the peaceful use of nuclear energy.
- Mitigating the consequences of radiological or nuclear (RN) incidents.
- Educating nuclear engineers and scientists in nonproliferation, fuel cycle management, and radiochemistry.[7]

One element of nuclear security is incident response. Proper nuclear incident response is critical across the world, not just for the GCC. The GCC, however, has a rapidly developing RN sector, plus neighbors with nuclear capabilities, underlining the significance of constructing solid incident response architecture. In the RN sector, incident response has four pillars:

1. **Detection (of an incident):** regards the systems, stations, and other technology used to detect an RN incident and alert the relevant agencies and governments. Detection also encompasses the intelligence-sharing agreements that various states have with each other to share information about RN incidents.
2. **Training (to recognize an incident):** Focuses on the training of emergency and first responders to identify an RN incident, contain it, and request the assistance of the proper agencies.
3. **Incident Response:** Defines what agencies respond to an RN incident and establishes a chain of command. During this aspect of incident response, a "home team" will be established, with responsibilities including communications, plume modelling, and executive decision-making.
4. **Incident Consequence Management:** The last aspect of RN incident response focuses on both the short- and long-term consequences of an incident and the response. This includes information and capability sharing following the successful mitigation of an incident.[8]

Across any country or region's RN incident response architecture, some challenges and weaknesses are repetitive. Questions about who has what authority, language barriers, and experience with RN are recurring non-technical weaknesses that are important to consider and discuss. Technical questions surrounding radiological calculation systems and what actions are to be taken at various radiological levels can also cause confusion and prevent a state from successfully mitigating an RN incident.[9]

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[7] "What Is Nuclear Security? | Institute for Nuclear Security." Accessed December 23, 2025. https://nuclear.utk.edu/what-is-nuclear-security/.
[8] Dr. Amir Mohagheghi, interview, November 20, 2025, Microsoft Teams.
[9] Arthur Shanks, "Radiation Emergency Response," December 10, 2025, Microsoft Teams.

3. ORGANIZATIONS THAT SUPPORT NUCLEAR INCIDENT RESPONSE IN THE PERSIAN GULF

There are various relevant pre-existing organizations that have nuclear incident response capabilities, both on the international level and within the Persian Gulf region. The International Atomic Energy Agency and the International Maritime Organization are global international organizations with relevant missions for nuclear and radiological emergency management in the Gulf. Within the Middle East, GCC states belong to the Regional Organization for the Protection of the Marine Environment and the CBRN Risk Mitigation Center of Excellence (Middle East). Finally, the GCC itself has its own incident response body, known as the Emergency Management Center.

3.1. The International Atomic Energy Agency

Every GCC state is a member of the International Atomic Energy Agency (IAEA), the world's central organization for international cooperation in the nuclear energy field.[10] The IAEA's incident response capabilities are found within the Department on Nuclear Safety and Security. This department is split into three divisions, each with different responsibilities that support nuclear incident response.

- **Division of Nuclear Installation Safety**: Supports Member States in establishing and maintaining safety infrastructure at nuclear sites.[11]
- **Division of Nuclear Security**: Focuses on preventing, detecting, and responding to threats and acts of nuclear terrorism. This division also offers training and technical advice to Member States.[12]
- **Division of Radiation, Transport and Waste Safety**: This division develops and assists in implementing safety standards surrounding radiation protection, radioactive waste, and transport.[13]

The Department on Nuclear Safety and Security is also responsible for the management of the Incident and Emergency Center (IEC).[14] Established in 2005, the IEC is the global touchpoint for international emergency preparedness, specializing in communication and response to nuclear emergencies across the world.[15]

In the Middle East, the IAEA has had significant success, especially recently, with facilitating nuclear cooperation efforts, especially through IAEA-supported workshops like the *Nuclear Workshop for Middle East: Raising Awareness about Nuclear Law in the Middle East*. This workshop took place at IAEA headquarters in Vienna, Austria, in January 2025. Representatives from the GCC states of Bahrain, Saudi Arabia, and the UAE attended, as well as non-GCC representatives from Iran, Iraq, Jordan,

[10] "List of Member States." Text. IAEA, June 8, 2016. https://www.iaea.org/about/governance/list-of-member-states.
[11] "Division of Nuclear Installation Safety." Text. IAEA, June 8, 2016. http://www.iaea.org/about/organizational-structure/department-of-nuclear-safety-and-security/division-of-nuclear-installation-safety.
[12] "Division of Nuclear Security." Text. IAEA, June 8, 2016. http://www.iaea.org/about/organizational-structure/department-of-nuclear-safety-and-security/division-of-nuclear-security.
[13] "Division of Radiation, Transport and Waste Safety." Text. IAEA, June 8, 2016. http://www.iaea.org/about/organizational-structure/department-of-nuclear-safety-and-security/division-of-radiation-transport-and-waste-safety.
[14] "Nuclear Safety and Security." Text. IAEA, June 8, 2016. https://www.iaea.org/topics/nuclear-safety-and-security.
[15] "Incident and Emergency Centre." Text. IAEA, June 8, 2016. https://www.iaea.org/about/organizational-structure/department-of-nuclear-safety-and-security/incident-and-emergency-centre.

and Yemen.[16] The purpose of the workshop was to increase the knowledge of participants about national and international nuclear law and to strengthen legal nuclear frameworks within member states. According to member states in attendance, the most beneficial aspects of the workshop were discussions, lectures, and case studies on nuclear safety and security, specifically emergency preparedness and response.[17]

In December 2025, the IAEA Conference on Nuclear and Radiological Emergencies took place in Riyadh, Saudi Arabia. The purpose of this conference was to "enhance global awareness of crucial emergency preparedness and response".[18] Participants from over 100 countries, such as experts, emergency responders, and technical specialists, attended. At the time of this writing, recaps of the conference have not yet been published, but the agenda for the conference anticipated covering coordination and cooperation in emergency preparedness and response, public communication, artificial intelligence applications for emergency management, decision-making under uncertainty, and emergency arrangements for floating and mobile reactors.[19]

3.2. The International Maritime Organization

The International Maritime Organization (IMO) is the United Nations organization responsible for the safety and security of shipping and prevention of marine pollution by ships.[20] While the IMO does not have a defined incident response capability, the organization is significant due to its role in setting global safety and security shipping codes. One of the most significant of these codes is the IMO's SOLAS (Safety of Life at Sea) Convention. Within SOLAS, chapter VII (Carriage of Dangerous Cargoes) contains regulations and requirements for the carriage of packaged irradiated nuclear fuel, plutonium, and high-level radioactive wastes.[21] Chapter VIII (Safety of Nuclear-fueled ships) contains basic requirements for nuclear-powered ships and radiation hazards. This chapter draws deeply from the Code of Safety for Nuclear Merchant Ships, addressing radiation safety (radiological protection design, protection of persons, and radioactive waste management).[22]

The IMO also sets standards for RN material transportation by sea, known as the "International Code for the Safe Carriage of Packaged Irradiated Nuclear Fuel, Plutonium, and High-Level Radioactive Waste on Board Ships". This code establishes safety standards for the design and construction of ships carrying RN material, specifies RN packaging requirements and operational procedures, and promotes international cooperation by ensuring consistent RN safety standards across the maritime domain.[23] The IMO also participated in the IAEA's Global Emergency

[16] "Nuclear Law Workshop for Middle East: Raising Awareness about Nuclear Law in the Middle East." Text. IAEA, February 14, 2025. https://www.iaea.org/newscenter/news/nuclear-law-workshop-for-middle-east-raising-awareness-about-nuclear-law-in-the-middle-east.
[17] Ibid.
[18] "IAEA Conference on Nuclear and Radiological Emergencies Opens in Riyadh." Text. IAEA, December 1, 2025. http://www.iaea.org/newscenter/news/iaea-conference-on-nuclear-and-radiological-emergencies-opens-in-riyadh.
[19] Ibid.
[20] "International Maritime Organization." Accessed August 26, 2025. https://www.imo.org/.
[21] "International Convention for the Safety of Life at Sea (SOLAS), 1974." Accessed February 20, 2026. https://www.imo.org/en/about/conventions/pages/international-convention-for-the-safety-of-life-at-sea-%28solas%29%2c-1974.aspx.
[22] "Code of Safety for Nuclear Merchant Ships." Accessed February 20, 2026. https://inis.iaea.org/records/f8s8q-za111.
[23] "International Code for the Safe Carriage of Packaged Irradiated Nuclear Fuel, Plutonium and High-Level Radioactive Wastes on Board Ships (INF Code)." Accessed December 11, 2025. https://www.imo.org/en/ourwork/safety/pages/inf-code.aspx.

Preparedness and Response Conference in October 2015, which discussed how international organizations would handle nuclear and radiological incidents. Throughout the conference, the IMO emphasized their independent research in maritime transportation of nuclear and radiological material.[24]

While the IMO sets the rules, it does not have an enforcement capability. Instead, IMO codes and standards are expected to be enforced by flag states (country that a ship is registered to) and port state control authorities.[25] Therefore, understanding and implementing the IMO's codes and regulations is an important aspect of nuclear security in the maritime. The IMO may not actively support RN incident response, but adhering to the organization's codes helps in deterring future maritime nuclear incidents.

3.3. The Regional Organization for the Protection of the Marine Environment

The Regional Organization for the Protection of the Marine Environment (ROPME) was founded in 1971 to coordinate the efforts of the GCC states, Iran, and Iraq to protect the marine and coastal environment of the ROPME Sea Area (Persian Gulf and Gulf of Oman) against marine pollution and other stressors.[26] ROPME does address RN contamination in its emergency response body, the Marine Emergency Mutual Aid Center (MEMAC). MEMAC has publicly available emergency response plans to combat possible incidents, including RN incidents (however they were last updated in 2012).[27] The RN plan for ROPME consists of four in-depth volumes:

- **Volume 1 – Planning:** Discusses the ROPME regional emergency response plan, defines the level of planning and preparedness required, protective actions (sheltering, evacuation, stable iodine administration, food ban and food control, and soft countermeasures), and more. Volume 1 also describes potential emergencies for the ROPME region, their possible impacts, and regional response requirements.[28]
- **Volume 2a – Operational Response Plan:** This volume defines operational organization – the command and control, on-scene control, mitigation, instructions to the public, recovery, and more. Volume 2a also lists ROPME's emergency response facilities and equipment.[29]
- **Volume 2b – Preparedness Plan:** Volume 2b continues with operational organization, focusing on the roles and responsibilities of the member states, ROPME as a regional organization, and the RN Emergency Preparedness Committee. It also goes through the review and feedback process, as well as logistics and administration.[30]
- **Volume 3 – Emergency Procedures**: The last volume of the ROPME RN emergency plan defines the responsibility, purpose, input, output, and identifying procedures for identifying,

[24] "WhatsNewNews." Accessed September 9, 2025. https://www.imo.org/en/mediacentre/pages/whatsnew-472.aspx.
[25] "What Is IMO? A Technical Guide for Maritime Operations." Accessed February 20, 2026. https://www.avsglobalsupply.com/blog-detail/imo.
[26] "About ROPME." *ROPME*, n.d. https://ropme.org/about-ropme/.
[27] "Regional Radiological/Nuclear Emergency Response Plan :: MEMAC." https://memac-rsa.org/en/regional_radiological_nuclear_emergency_response_plan.
[28] "Volume 1: PLANNING BASIS." Accessed January 2, 2026. https://memac-rsa.org/assets/fileManager/Volume_1_Planning_Basis.pdf.
[29] "Volume_2a_Operational_Response_Plan1." Accessed January 2, 2026. https://memac-rsa.org/assets/fileManager/Volume_2a_Operational_Response_Plan1.pdf.
[30] "Volume_2b_Preparedness_Plan1." Accessed January 2, 2026. https://memac-rsa.org/assets/fileManager/Volume_2b_Preparedness_Plan1.pdf.

notifying, and activating the plan. Volume 3 also highlights general procedures for on-scene response, casualty management, and protection of emergency workers.[31]

MEMAC has been active since 1982, with meetings and forums held roughly every two years.[32] MEMAC has also hosted tabletop and other wargaming exercises, both internally and with other international partners.[33] While MEMAC's focus is not nuclear, its RN incident response plan is incredibly thorough and well prepared, aligning closely with nuclear priorities.

3.4. CBRN Risk Mitigation Centers of Excellence (Middle East Regional Secretariat)

The European Union (EU) funds and implements a global initiative known as the "EU Chemical, Biological, Radiological, and Nuclear (CBRN) Risk Mitigation Centers of Excellence", which aims to reduce risks and strengthen an all-hazards security governance in partner countries.[34] The Center of Excellence in the Middle East region (CoE-ME) is located in the Kingdom of Jordan and supported by Lebanon and Iraq.[35] The CoE-ME priorities include:

- Tackling CBRN security threats
- CBRN critical infrastructure
- CBRN waste and transport
- CBRN education, training, and exercises

The CoE-ME boasts recent achievements including the mapping of CBRN capabilities, optimized resources, enhanced regional cooperation, and bolstered capacities in education, training, and infrastructure.[36]

3.5. The Gulf Cooperation Council's Emergency Management Center

The Gulf Cooperation Council has its own incident response body, located in its Security Affairs branch, known as the Emergency Management Center (EMC). The EMC is an information-sharing center – managing incident response plans, operating as a radiological data exchange platform, and functioning as an early warning system for the GCC.[37] The EMC has a growing partnership with the European Union focused specifically on the usage of "JRODOS" (Java Real-time Online Decisi-On Support). JRODOS is a modular software program intended for impact assessments of RN incidents at nuclear installations.[38] Specifically, JRODOS models the dispersion of radioactive

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[31] "Volume_3_Emergency_Procedures1." Accessed January 2, 2026. https://memac-rsa.org/assets/fileManager/Volume_3_Emergency_Procedures1.pdf.
[32] "Events :: MEMAC." https://memac-rsa.org/en/events.
[33] Ibid.
[34] "EU CBRN Centres of Excellence - Chemical, Biological, Radiological and Nuclear Risk Mitigation." November 5, 2025. https://cbrn-risk-mitigation.network.europa.eu/eu-cbrn-centres-excellence_en.
[35] "Middle East - Chemical, Biological, Radiological and Nuclear Risk Mitigation." November 5, 2025. https://cbrn-risk-mitigation.network.europa.eu/eu-cbrn-centres-excellence/network/middle-east_en.
[36] "CoE Middle East Fact Sheet." Accessed December 10, 2025. https://cbrn-risk-mitigation.network.europa.eu/document/download/6c7fc85c-dda0-4711-8244-0662bcec173e_en?filename=MIE_fact-sheet_2022.pdf.
[37] Amnah Ibraheem, "CMC Seminar Series Ft. Amnah Ibraheem on the GCC EMC," Microsoft Teams, December 2, 2025.
[38] "JRODOS For Nuclear Emergencies." Accessed August 13, 2025. https://harmo.org/Conferences/Proceedings/_Bologna/publishedSections/H18-198-VonArx.pdf.

contamination, involving outside data such as weather, radiation monitoring networks, and geographical information systems.[39] In 2020, the EU announced that they were actively funding and supporting the installation of JRODOS in the EMC, where it would be customized for GCC conditions and used to enhance regional incident response.[40] The EU also provided support to train indigenous personnel to operate the JRODOS.[41]

The EMC also recently coordinated with the United Nations Office of Counterterrorism to host a meeting focused on oil and gas infrastructure protection and crisis management against terrorist threats in July 2025.[42] While not specific to nuclear incident response, this successful, high-level meeting is a significant milestone in regional cooperation to protect critical energy infrastructure, and it is likely that future meetings could include nuclear energy as well.[43]

[39] Ibid.
[40] "The European Union Supports the Capabilities of the Gulf Cooperation Council's Emergency Management Centre in Preparedness for and Response to a Nuclear or Radiological Emergency | EEAS." https://www.eeas.europa.eu/delegations/kuwait/european-union-supports-capabilities-gulf-cooperation-council%E2%80%99s-emergency-management-centre_en?s=202.
[41] Ibid.
[42] "UNOCT and GCC EMC Conclude Expert Meeting on Oil and Gas Infrastructure Protection and Crisis Management against Terrorist Threats | Office of Counter-Terrorism." https://www.un.org/counterterrorism/events/unoct-and-gcc-emc-conclude-expert-meeting-oil-and-gas-infrastructure-protection-and-crisis.
[43] "UNOCT and GCC EMC Conclude Expert Meeting on Oil and Gas Infrastructure Protection and Crisis Management against Terrorist Threats | Office of Counter-Terrorism." https://www.un.org/counterterrorism/events/unoct-and-gcc-emc-conclude-expert-meeting-oil-and-gas-infrastructure-protection-and-crisis.

4. GCC MEMBER STATE CAPABILITIES

The following chart depicts the RN incident response capabilities of each GCC member (as of December 2025). Each state has technical radiation detection capabilities, in the form of monitoring stations and early warning stations, but that is where the similarities end. Training, Incident Response, and Consequence Management capabilities vary greatly between GCC states. Saudi Arabia and the UAE, for example, have established nuclear authorities - Nuclear and Radiological Regulatory Commission (NRRC) in Saudi Arabia, and Federal Authority for Nuclear Regulation (FANR) and the Abu Dhabi Police's Nuclear Security Division in the UAE - under which training, incident response, and consequence management capabilities all fall under. The NRRC and FANR are also aligned with both the IAEA and GCC Emergency Management Center.

It is important to acknowledge that Saudi Arabia and the UAE have nuclear facilities which make established, efficient infrastructure essential. However, other GCC states have a growing interest in nuclear energy to diversify their energy portfolios. This means that their nuclear incident response infrastructure must be organized and efficient. In Bahrain, Kuwait, Oman and Qatar, various incident response capabilities are spread across numerous state ministries like Health, Environment, Interior, Civil Defense, Emergency Management, and even military organizations. When collecting information to complete this chart, it was very difficult to understand what each ministry contributes to RN incident response infrastructure, and what their role would look like in an emergency.

The variety of ministries and agencies involved, as well as a lack of clarity in the open source on their capabilities demonstrates weaknesses and vulnerabilities in these individual state's nuclear security. Not having a single, designated nuclear body within a government almost guarantees that these components will not move smoothly in the case of a nuclear emergency, and is likely to slow civil nuclear energy development, should these countries decide to seek nuclear energy.

Table 1: RN Incident Response Capabilities of GCC States

Member State	Nuclear Technology	Detection	Training	Incident Response	Consequence Management
Bahrain	N/A	5 radiation early warning stations (one in each providence + one at the Supreme Council headquarters)[44]	The IAEA provides specialist training[45] Joint training exercises with US (NAVCENT and NSA)[46]	Ministry of the Interior Supreme Council for the Environment NSA Bahrain (specific to US installations in country)	National Civil Protection Platform

[44] *Radiation Monitoring In Bahrain – NBN*. Middle East. October 10, 2016. https://nbn.business/radiation-monitoring-barhain-2/.
[45] "Tc-Bahrain." Accessed December 16, 2025. https://www.iaea.org/sites/default/files/20/10/tc-bahrain.pdf.
[46] "Bahrain News: NSA Bahrain Holds Emergency Exercise to Enhance Readiness." December 5, 2017. https://www.gdnonline.com/Details/1347940.

Kuwait	N/A	29 land-based stations located across border areas, densely populated zones, and islands[47] 15 marine monitoring stations in Kuwait's territorial waters[48]	CBRN awareness for first responders' course (sponsored by NATO)[49] CBRN medical response training (sponsored by CoE-ME)[50]	Kuwait National Guard	Kuwait Information Network (KIN) Environment Portal (Beatona)
Oman	N/A	8 radiation monitoring stations, with more being constructed[51]	CBRN handling training (Ministry of Health)[52] CBRN medical response training (sponsored in part by the EU CoE Middle East)[53]	Ministry of Environment and Climate Affairs National Committee for Civil Defense Environmental Authority of Oman Public Authority for Civil Defense and Ambulance	Ministry of Health (Emergency Management Center) National Committee for Emergency Management (electronic emergency management platform)
Qatar	N/A	At least 50 monitoring stations, concentrated within Dukhan, Doha, and Al Khor[54]	IAEA Technical Cooperation Program[55] Emergency readiness training (Ministry of Environment and Climate Change)[56]	Ministry of the Environment and Climate Change Ministry of the Interior (Permanent Committee for Emergency) National Command Center	Ministry of the Environment and Climate Change

[47] Francis. "National Guard Reassures Public on Radiation, Chemical Safety; No Threat Detected." *Times Kuwait*, June 15, 2025. https://timeskuwait.com/national-guard-reassures-public-on-radiation-chemical-safety-no-threat-detected/.
[48] Francis. "National Guard Reassures Public on Radiation, Chemical Safety; No Threat Detected."
[49] "CBRN Awareness for First Responders Course in Kuwait City." *JCBRN Defence COE*, October 31, 2024. https://www.jcbrncoe.org/news/cbrn-awareness-for-first-responders-course-in-kuwait-city/.
[50] "Kuwait Strengthens Public Health and Safety with First-Ever Training Course on CBRN Medical Preparedness and Response - Chemical, Biological, Radiological and Nuclear Risk Mitigation." Accessed December 16, 2025. https://cbrn-risk-mitigation.network.europa.eu/news-1/kuwait-strengthens-public-health-and-safety-first-ever-training-course-cbrn-medical-preparedness-and-2025-02-17_en.
[51] "Oman_nr-7th-Rm." Accessed December 15, 2025. https://www.iaea.org/sites/default/files/oman_nr-7th-rm.pdf.
[52] "Oman: Training Course on Chemical, Biological, Radioactive, and Nuclear Incidents and Handling Mechanism of Hazardous Materials | International Committee of the Red Cross." December 23, 2020. https://www.icrc.org/en/document/Oman-training-course-chemical-biological-radioactive-and-nuclear-incidents-and-handling.
[53] "Oman Concludes National Workshop on Medical Handling and Responding to CBRN Incidents as Part of the European Union Centres of Excellence | UNICRI :: United Nations Interregional Crime and Justice Research Institute." Accessed December 16, 2025. https://unicri.org/index.php/News-EUCBRNCoE-Oman-National-Workshop-on-Medical-Handling-and-Responding-to-CBRN-Incidents.
[54] "MECC NIR Index." Accessed December 15, 2025. https://radmon.mecc.gov.qa/?lang=en.
[55] "Cns_national_report_qatar_joint_8th_and_9th_rm." Accessed December 16, 2025. https://www.iaea.org/sites/default/files/24/02/cns_national_report_qatar_joint_8th_and_9th_rm.pdf.
[56] Newspaper, The Peninsula. "Training for National Plan for Nuclear and Radiological Emergency Begins." June 3, 2024. https://thepeninsulaqatar.com/article/03/06/2024/training-for-national-plan-for-nuclear-and-radiological-emergency-begins.

Saudi Arabia	Low Power Nuclear Power Plant (research reactor; open-pool, low power, 100kW)	400 radiation monitoring stations[57]	The NRRC is "actively developing" more training aligned with IAEA standards[58]	Nuclear and Radiological Regulatory Commission (NRRC) – Nuclear Emergency Operations Center	NRRC
United Arab Emirates	Barakah Nuclear Power Plant (power plant; generates 5.6 GWe of electricity – ¼ of UAE's energy demand)	17 radiation monitoring states[59]	FANR Emergency Response Organization conducts 2 general trainings/year Abu Dhabi Police (Nuclear Security Division) is responsible for coordinating trainings[60]	FANR Emergency Operations Center (Incident Commander) Abu Dhabi Nuclear Security Division	Abu Dhabi Police (Nuclear Security Division)

[57] "International Radiation Monitoring Information System-IRMIS." Accessed December 15, 2025. https://nrrc.gov.sa/en/our-work/international-radiation-monitoring-information-system-irmis/.
[58] "Saudi_arabia-National-Report-8rm." Accessed December 16, 2025. https://www.iaea.org/sites/default/files/2025-08/saudi_arabia-national-report-8rm.pdf.
[59] "Eprev-Uae-120919_0." Accessed December 15, 2025. https://www.iaea.org/sites/default/files/documents/review-missions/eprev-uae-120919_0.pdf.
[60] Ibid.

5. REGIONAL COLLABORATION

The Middle East is a condensed, highly populated region where a nuclear incident would be highly likely to affect multiple countries. It is critical that the GCC can work together both within itself, and with other countries in the region, to fortify RN incident response efforts. To understand the ability for these countries to work together, it is important to highlight collaboration efforts both in and outside of the nuclear sector.

One of the best examples of regional defense cooperation in the GCC is Eagle Resolve. Eagle Resolve is a biennial joint military exercise between the GCC alliance and the United States.[61] While the 2025 Eagle Resolve exercise focused primarily on integrating air and missile defense, in the past it has also addressed security challenges such as cybersecurity, explosive ordnance disposal, maritime interdiction, counterterrorism operations, and CBRN incident response.[62] Eagle Resolve is highly praised for its efforts in strengthening military partnerships and advancing operational capabilities of GCC states.[63]

The GCC also collaborates on various technical capabilities. The first example of this is KIN, which is Kuwait's official government network for emergency and incident response. KIN connects the Kuwaiti government to private enterprises, but also to the GCC.[64] KIN allows for the Kuwaiti government to reliably communicate with the GCC and its other member states in times of crisis. Another example is the GCC Interconnection Authority. This organization is working to connect the power grids of the GCC Member States, with the objective of ensuring power security and economic benefits.[65] Uniting various power grids across multiple countries is a challenge, but also a great show of trust. This trust within the GCC is a great starting point for facilitating trust in the RN incident response area.

The GCC shares the Persian Gulf with two other countries - Iraq and Iran – and have worked to strengthen their relationships with both countries. ROPME is an excellent example of collaboration across all the Persian Gulf States, with the GCC, Iran, and Iraq coming together to address concerns over marine pollution in the ROPME Sea Area. The ROPME Sea Area is critical to the survival of all these countries, and this collaboration effort proves that the Persian Gulf region is willing to work together on significant issues.

With Iraq specifically, the GCC has focused on building strategic partnerships built on geographical proximity, religion, and language.[66] The GCC Secretary-General and the Iraqi Ministry of Foreign Affairs signed a memorandum of understanding in April of 2019 and a joint work plan (for 2019-2024) to strengthen GCC-Iraqi cooperation economically, and in security.[67] The joint work plan appeared to be successful, as Saudi Arabia and the UAE both invested $3 billion into Iraq's renewable energy sector in 2021. Another measurement of success is that the border between Saudi Arabia and Iraq was reopened in 2020, after 30 years of closure. Despite the progress, however, the

[61] U.S. Central Command. "Strengthening Regional Defense Cooperation." Accessed February 23, 2026. https://www.centcom.mil/MEDIA/NEWS-ARTICLES/News-Article-View/Article/4062096/strengthening-regional-defense-cooperation/.
[62] Ibid.
[63] Ibid.
[64] AlMansoury, Laialy Abdullah. *Kuwait Government Initiative for ICT Disaster Response*. n.d.
[65] *GCC Interconnection Authority*. n.d. Accessed December 16, 2025. https://gccia.com.sa/.
[66] "In His Speech before the Baghdad Conference for Cooperation and Partnership: GCC Secretary General Reiterates the Firm Stances of the Cooperation Council Towards Supporting Security, Stability and Development Effort in the Republic of Iraq." https://www.gcc-sg.org/en/MediaCenter/News/Pages/news2022-12-20-5.aspx.
[67] "62a9917b71502GCCIRAQLAYAL." https://www.grc.net/documents/62a9917b71502GCCIRAQLAYAL.pdf.

GCC remains unwilling to let Iraq join the organization due to fundamental political differences between Iraq and the GCC member states.[68]

The GCC also made significant efforts to ease tensions with Iran in the early 2020s. In 2023, representatives from Iran and Saudi Arabia met in Beijing, signing a deal to restore diplomatic ties between the two nations and reactivate a 2001 security cooperation agreement. This deal was widely viewed as a significant positive move towards diplomacy, especially after Iran reopened its embassy in Riyadh, and Saudi Arabia resumed diplomatic operations in Iran.[69] The UAE, Qatar, and Oman have also re-established economic relations with Iran, and there is a general increase in investment in Iran since 2023 by Gulf states as well.[70]

[68] Ibid.
[69] IISS. "Rebuilding GCC–Iran Relations in the Shadow of War." https://www.iiss.org/online-analysis/online-analysis/2025/07/rebuilding-gcciran-relations-in-the-shadow-of-war/.
[70] Matamis, Joaquin. "To Succeed, the GCC Requires Cooperation with Iran for Regional Security • Stimson Center." *Stimson Center*, April 29, 2024. https://www.stimson.org/2024/to-succeed-the-gcc-requires-cooperation-with-iran-for-regional-security/.

6. GCC RISK ASSESSMENT AND GAPS

To offer precise recommendations, it is essential to first identify the gaps in the GCC's incident response capabilities. Conducting open-source research on the GCC, in conjunction with relevant historical nuclear incidents, allows for the development of accurate risk scenarios and the identification of capability deficiencies within the GCC.

6.1. Nuclear Cybersecurity

In 2010, a highly complex digital malware was discovered within Iran's nuclear program. Called Stuxnet, it was a computer worm that physically damaged Iran's nuclear facilities by targeting the computer systems controlling the physical infrastructure like centrifuges and gas valves. It is estimated that Stuxnet was present within the program from at least 2007 to 2010 and is widely considered the world's first cyber weapon.[71] To date, no state has officially claimed accountability for the worm. Cyber-attacks can be used to compromise nuclear command and control systems and violate the integrity of nuclear materials and facility operations. The IAEA and most nuclear powers still do not yet have nuclear cybersecurity capabilities ready to combat a cyber threat like Stuxnet, or worse.[72] To put in perspective, it took Iran's engineers at least two years to completely purge Stuxnet from their nuclear systems, and set their nuclear program back by at least a year.[73] The ability to create cyber weapons, by both state and non-state actors, have increased greatly in the 15 years since Stuxnet was identified, only making nuclear cybersecurity a more urgent priority.

Table 2: GCC Cyber Threat Landscape

Country	Percentage of Threats	Primary Attack Types	Key Vulnerabilities
UAE	40%	Ransomware, DDoS, Data breaches	Smart city infrastructure, financial sector
Saudi Arabia	26%	Ransomware, APT attacks, Data theft	Energy sector, government institutions
Kuwait	15%	Phishing, Banking fraud, Ransomware	Financial services, government networks
Qatar	10%	Data leaks, Government breaches	Critical infrastructure, energy sector
Bahrain	6%	Financial fraud, Data breaches	Banking sector, telecommunications
Oman	3%	Infrastructure attacks, Data theft	Government services, energy facilities

[71] University, © Stanford, Stanford, and California 94305. "Stuxnet: The World's First Cyber Weapon." February 3, 2015. https://cisac.fsi.stanford.edu/news/stuxnet.
[72] "Addressing Cyber-Nuclear Security Threats." *The Nuclear Threat Initiative*, October 31, 2022. https://www.nti.org/about/programs-projects/project/addressing-cyber-nuclear-security-threats/.
[73] Hosenball, Mark. "Experts Say Iran Has 'Neutralized' Stuxnet Virus." Technology. *Reuters*, February 14, 2012. https://www.reuters.com/article/technology/experts-say-iran-has-neutralized-stuxnet-virus-idUSTRE81D24R/.

The cyber domain is arguably the biggest gap in the GCC. In 2025, the Middle Eastern region had an average data breach cost of $7.29 million USD, second only to the United States at $10.22 million USD.[74] Table 2 displays that in the GCC, the UAE is the most targeted nation (over 50,000 cyberattacks daily in 2024[75]), followed by Saudi Arabia.[76] Another significant detail emphasized in Table 2 is that critical infrastructure, energy, and government sectors are consistently targets of cyber attacks. Despite this, the GCC states have historically underinvested in cyber security.[77] This underinvestment in the cyber domain may be caused by inconsistencies in security priorities and organizational maturity.[78] The GCC has developed its cyber sector quite quickly in the last 20 years – security may not have been prioritized when it was a bigger objective to catch up to the rest of the developed world. Now, the GCC is facing severe financial and economic consequences:

Table 3: Financial & Economic Impacts of Cybercrime in Saudi Arabia (2024)

Cost Category	Amount (SAR)	Amount (USD)	Regional Impact
Average Data Breach	29.9 million	8.0 million	Highest in decade
Annual Cybercrime Losses	45+ billion	12+ billion	Regional estimate
Ransomware Recovery	25+ million	6.7 million	Per major incident
DDoS Attack Mitigation	5-15 million	1.3-4.0 million	Per sustained campaign

This gap in the cyber domain is not limited to financial and economic consequences, however. Regional security - and by extension nuclear incident response - is also affected. The GCC does not have an office or agency dedicated to cyber security and IT protection, highlighting a weakness in unity and collaboration on this issue. This is concerning, as not only is cyber a vital aspect of RN incident response, but it can also be used by adversaries to create an RN incident. A cyber-attack on any nuclear facility, regardless of their purpose, can be severe and not only physically affect the state and its population, but can also hurt their nuclear development and set it back years.

6.2. Nuclear Security Education

One of the most infamous nuclear accidents occurred in 1986 at the Chernobyl Nuclear Power Plant in Pripyat, Ukraine. Due to an unforeseen power outage, a maintenance test of the reactor cooling

[74] "Data Breach Statistics & Trends [Updated 2025]." Accessed January 13, 2026. https://www.varonis.com/blog/data-breach-statistics.
[75] *Gulf Cybersecurity Crisis: Threats, Vulnerabilities & Economic Impact (2024-2025)*. Cyber Threats. July 4, 2025. https://bluefire-redteam.com/gulf-countries-cybersecurity-crisis-comprehensive-analysis-of-digital-threats-regional-vulnerabilities-and-economic-impact-in-2024-2025/.
[76] Ibid.
[77] *2025 GCC Cybersecurity in Review: Key Insights from the SANS Threat Landscape Report – Intelligent CISO*. n.d. Accessed December 18, 2025. https://www.intelligentciso.com/2025/12/15/2025-gcc-cybersecurity-in-review-key-insights-from-the-sans-threat-landscape-report/.
[78] Ibid.

for Chernobyl's Unit 4 was delayed from the afternoon to after midnight to account for the evening peak energy needs; thus, leaving the test to be conducted by an operating crew that had not prepared the shutdown procedure.[79] Several operator errors combined with profound defects in the reactor's design resulted in an explosion equivalent to 60 metric tons of TNT.[80] Investigative reports conducted following the accident also contributed it to a lack of appropriate safety culture within the Soviet Union.[81] Chernobyl reminds the world of the importance of retaining educated and experienced nuclear professionals in the nuclear field.

In general, the Persian Gulf region lacks nuclear security education for their nuclear student base, arguably a cornerstone in facilitating a secure nuclear infrastructure. Even in nuclear energy states like Saudi Arabia and the UAE, nuclear security education is very limited (Naif Arab University for Security Sciences (Saudi Arabia) has a one-year program in nuclear security and Khalifa University (UAE) offers a one semester nuclear security program).[82] A lack of nuclear security education in these countries affects their ability to respond accurately to a nuclear incident.[83]

Several issues preventing the growth of nuclear security education in the Persian Gulf have been identified. The most significant is the lack of nuclear security material written in or translated into Arabic.[84] In many countries, nuclear security and safety-related literature are in English or translated from English. When documents are translated into Arabic from English, Modern Standard Arabic is typically used, which does not reflect information and knowledge from various Arabic dialects spoken across the Gulf.[85] In Arabic universities, English and Arabic are both used in class – English textbooks and Arabic lectures – which can also create confusion, especially if direct translations of English words into Arabic have multiple meanings or words (ex. The English words "safety" and "security" have multiple Arabic translations, such as *al'amn, 'amn, al'aman, salama*, etc).[86] A language barrier in a critical security field, further complicated with translations or foreign language textbooks that may not be so helpful, is a vulnerability that could prevent nuclear energy growth in Saudi Arabia and the UAE, and deter nuclear development in other Gulf countries.

6.3. Nuclear Security Infrastructure

In 2011, a magnitude 9 earthquake and resulting tsunami damaged the power supply and cooling capacity at the Fukushima Daiichi nuclear reactor in Japan.[87] Within the first three days, all three cores mostly melted, and resulted in high radioactive releases throughout days four through six.[88]

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[79] Mecklin, John. "Critical Underlying Factors in Three Major Nuclear Accidents." *Bulletin of the Atomic Scientists*, August 31, 2020. https://thebulletin.org/2020/08/critical-underlying-factors-in-three-major-nuclear-accidents/.
[80] Ibid.
[81] Ibid.
[82] Alanazi, Ahmed, and Mostafa Kofi. "Adapting Nuclear Security Education Programs in Arab Countries." *International Journal of Nuclear Security* 8, no. 1 (2024). https://doi.org/10.7290/ijns088315.
[83] Sarbaland, Faisal, and Taakaki Sakai. "Saudi Arabian Universities' Need for a Nuclear Security Educational Textbook: A Systematic Review." *International Journal of Nuclear Security* 9, no. 1 (2024). https://doi.org/10.7290/ijns09394512.

[84] "Adapting Nuclear Security Education Programs in Arab Countries."
[85] Homan, Zenobia. "The Language of Nuclear Security." Accessed March 3, 2026. https://resources.inmm.org/sites/default/files/2021-09/a281.pdf.
[86] Ibid.
[87] "Fukushima Daiichi Accident - World Nuclear Association." Accessed January 13, 2026. https://world-nuclear.org/information-library/safety-and-security/safety-of-plants/fukushima-daiichi-accident.
[88] Ibid.

The Japanese government was able to evacuate the population surrounding Daiichi, and no one died from the radioactive material released into the environment.

Fukushima Daiichi was constructed based on an assessment of the 1960 Chile Tsunami, as Japan is prone to earthquakes and tsunamis, however the plant was still severely damaged from the 2011 tsunami.[89] The blame for this falls on Japan's nuclear regulatory agency, which had reported estimates from local experts that Daiichi's 5.1 meter seawall was insufficient.[90] The regulatory agency also failed to meet basic safety requirements and emergency response plans.[91] Both the Japanese government and the nuclear regulator had no emergency response plans prepared and the chain of command for nuclear incident response was complex and confusing, traveling through multiple different departments within the government.[92] Having incident response capabilities that can be flexible and respond quickly throughout environmental disasters and resulting nuclear incidents is critical for the GCC states.

The IAEA emphasizes that an effective nuclear security infrastructure for a nuclear power program is essential for its success.[93] A complete nuclear security infrastructure must have legal, regulatory, and institutional frameworks, as well as a national nuclear security strategy. There must be measures in place for nuclear material, facilities, and activities.[94] A national nuclear security strategy must identify nuclear security measures for response to nuclear security events and identify and assign responsibilities to institutions within the state to establish and sustain nuclear security infrastructure for coordination and cooperation, among other things.[95]

This paper previously determined that only the GCC states with nuclear installations had agencies specifically for RN incident response. Non-nuclear GCC states have not specified RN incident response organizations and have instead distributed responsibilities for RN response across multiple departments or ministries; thus, leaving the potential for a large organizational gap and disrupts to the chain of command that needs to be established should an RN incident occur.[96] Confusion on who reports to whom, or who is responsible to respond, can cause a loss of valuable time during an emergency, as was seen in Japan. Establishing effective nuclear security infrastructure both as individual states and as a region is essential for GCC incident response.

6.4. RN Transport in the Maritime Domain

In 2023, a mining company was transporting capsules of Caesium-137 across western Australia, when it was discovered that a capsule had gone missing during transit.[97] The missing capsule measured about ¼ inch by 1/3 inch and took seven days to locate on Australia's Great Northern Highway.[98] Despite the miniscule size of the capsule, it had the potential to cause radiation burns or

[89] Ibid.
[90] Mecklin, John. "Critical Underlying Factors in Three Major Nuclear Accidents." *Bulletin of the Atomic Scientists*, August 31, 2020. https://thebulletin.org/2020/08/critical-underlying-factors-in-three-major-nuclear-accidents/.

[91] Ibid.
[92] Ibid.
[93] "STI/PUB/1591." Accessed January 13, 2026. https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1591_web.pdf.
[94] Ibid.
[95] Ibid.
[96] Arthur Shanks, "Radiation Emergency Response," December 10, 2025, Microsoft Teams.
[97] Hernandez, Joe. "A Tiny but Dangerous Radioactive Capsule Is Found in Western Australia." World. *NPR*, February 1, 2023. https://www.npr.org/2023/01/31/1152870649/australia-missing-radioactive-capsule.
[98] Ibid.

severe illness if a civilian happened upon it, making it critical to locate.[99] Transporting RN material, regardless of the mode of transport, generates risks that are not usually applicable to sedentary nuclear structures. When transporting RN material, it is important that external factors such as other vehicle operators, weather, security concerns, and package integrity are considered. Incident response includes preventative measures, and understanding nuclear transport and its risks can improve these preventative measures and overall incident response.

The biggest industries in the Middle East revolve around oil and gas, especially in the Persian Gulf region. In 2024, 20 million barrels of oil transited the Strait of Hormuz every day.[100] This is the equivalent of roughly 20% of global petroleum liquids consumption for 2024.[101] Oil and gas processes, especially extraction, typically come across naturally occurring radioactive material, known as NORM.[102] When NORM comes into contact with machinery and is brought to the surface it becomes technologically enhanced NORM, or TENORM.[103] This industry also intentionally utilizes RN materials throughout the processes, which can also be a safety hazard. For example, in 1996 a worker at the Gilan fossil fuel power plant in Iran became seriously injured after picking up an unshielded Iridium source used for industrial radiography.[104] While radiological incidents are a priority both in onshore and offshore oil and gas operations, they are especially concerning in the maritime environment due to the difficulty of containing exposed RN materials.

Currently, the responsibility for handling radioactive waste resulting from extraction processes lies with the oil and gas companies conducting the activities, who either have indigenous capabilities or outsource to consultants. Radioactive waste and equipment exposed to radiation are often brought to facilities to be processed for reuse and sometimes waste products like wastewater are intentionally reintroduced into the environment.[105]

Handling identified radioactive waste is not an issue for the Persian Gulf, however as the region begins to move towards incorporating nuclear power, there is a significant need for maritime radiation monitoring and detection capability, in order to handle RN material either not identified by oil and gas companies or coming from a different source.[106] Despite the significance of this body of water, and the pre-existing presence of NORM/TENORM, there is very little maritime RN detection and monitoring technology in place in the Persian Gulf. Kuwait and Bahrain are the only GCC states publicly stating their marine incident response capabilities: Kuwait has 15 radiation monitoring stations in their territorial waters, and Bahrain has conducted incident response training with the US Navy presence in country. The rest of the GCC, including the two nuclear countries (Saudi Arabia and UAE) do not have publicly known maritime monitoring mechanisms in place. Establishing capabilities to detect and monitor RN material in the Gulf could be an effective first step in countering this gap.

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[99] Ibid.
[100] "Amid Regional Conflict, the Strait of Hormuz Remains Critical Oil Chokepoint - U.S. Energy Information Administration (EIA)." Accessed February 24, 2026. https://www.eia.gov/todayinenergy/detail.php?id=65504.
[101] Ibid.
[102] US EPA, OAR. "Radioactive Waste Material From Oil and Gas Drilling." Overviews and Factsheets. November 30, 2018. https://www.epa.gov/radtown/radioactive-waste-material-oil-and-gas-drilling.
[103] Ibid.
[104] "Pub1123_scr." Accessed March 4, 2026. https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1123_scr.pdf.
[105] "Radioactive Material in the Oil and Gas Industry." July 21, 2021. https://www.nrdc.org/bio/bemnet-alemayehu/radioactive-material-oil-and-gas-industry.
[106] Uddin, S., S. W. Fowler, M. Behbehani, A. N. Al-Ghadban, P. W. Swarzenski, and N. Al-Awadhi. "A Review of Radioactivity in the Gulf Region." *Marine Pollution Bulletin* 159 (October 2020): 111481. https://doi.org/10.1016/j.marpolbul.2020.111481.

6.5. Nuclear Incidents versus GCC Strength

In June 2025, a brief war broke out between Israel and Iran, with Israel claiming that Iran was an imminent nuclear threat.[107] Despite the targeting of Iran's nuclear facilities by both the US and Israel, the IAEA reported that Iran still has enriched uranium, and that the country reneged an agreement with the IAEA to allow the organization to continue monitoring their nuclear activities.[108] Currently, Iran is experiencing severe domestic instability, with protests breaking out across the country in the last week of 2025. The protests have continued into 2026, despite a country-wide digital blackout, and Iran's foreign minister, Abbas Araghchi, has stated that Iran is "fully prepared for war" if threatened by its adversaries during this time of instability.[109]

Concern about a state-sponsored nuclear attack is not only a consistent concern for GCC states, but is also now beginning to appear on analyses for top global risks in 2026.[110] While Iran has not demonstrated any nuclear weapons capability, the cloudiness surrounding their nuclear program, plus isolation from their neighboring Arab countries, and historic instability in the region, a state-sponsored nuclear attack targeting Iran or in defense of Iran is a persistent worry. Even if GCC states are not directly involved in a conflict like this, having the incident response capabilities to handle the aftermath is crucial. Depending on the location of a nuclear explosion, the wind could carry toxic chemicals downwind into GCC states or severely affect the Persian Gulf water quality.

A state-sponsored nuclear attack requires the GCC to have a united front on not just nuclear incident response, but also on the global political stage. The GCC has struggled to act as a collective entity in the past, possibly because it lacks executive legislative mechanisms, preventing GCC-level policymaking, coordination, and incident response like what is seen in the EU or other regional organizations. The most obvious example resulting from a lack of executive coordination was the Arab-League coordinated blockade of Qatar from 2017 – 2021, when the GCC states of Saudi Arabia, Bahrain, and the UAE briefly embargoed Qatar.[111] Throughout the blockade, the GCC was never utilized as a mediation or negotiation platform, again lacking that executive function. Lack of proper executive mechanisms also pushes the GCC to become a public stage for rivalries between its member states.

Each GCC state has a "vision" document, which highlights their objectives within a bounded time horizon. These vision documents are excellent for understanding the goals of the GCC countries, but they also identify areas for competition and rivalry both within and outside of the GCC alliance. For example, the UAE has expressed wariness over Saudi Arabia's vision document, Saudi Vision 2030, worrying that economic reforms in Saudi Arabia will disrupt industries in the UAE.[112] This has exploded into a large economic rivalry between the two states, as Saudi Arabia and the UAE represent the two most populous and prosperous countries in the GCC and are becoming

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[107] "Q&A | Twelve Days That Shook the Region: Inside the Iran-Israel War | ACLED." July 25, 2025. https://acleddata.com/qa/qa-twelve-days-shook-region-inside-iran-israel-war.
[108] "Top Ten Global Risks for 2026" Stimson Center.
[109] "Tehran Talks Tough on Washington but Tests Diplomatic Off-Ramps." January 12, 2026. https://www.iranintl.com/en/202601125185.
[110] Matamis, Joaquin. "Top Ten Global Risks for 2026 • Stimson Center." *Stimson Center*, January 5, 2026. https://www.stimson.org/2026/top-ten-global-risks-for-2026/.
[111] ISPI. "GCC Struggles: Internal Rivalries, Fragmentation and Lost Opportunities." https://www.ispionline.it/en/publication/gcc-struggles-internal-rivalries-fragmentation-and-lost-opportunities-187279.
[112] "Competing Economic Visions in the Gulf." *The Cairo Review of Global Affairs*, March 20, 2022. https://www.thecairoreview.com/essays/competing-economic-visions-in-the-gulf/.

increasingly competitive in efforts to grow their energy sectors.[113] This sort of competition can signal how the GCC may struggle on nuclear incident response cooperation, especially if zero-sum economic competition occurs. This is obviously a serious issue if there are other state actors involved, as it exposes weaknesses in the alliance and can sow seeds of exploitation for adversaries to utilize.

[113] DC (ACW), Arab Center Washington. "The UAE-Saudi Arabia Rivalry Becomes a Rift." *Arab Center Washington DC* (blog), May 22, 2025. https://arabcenterdc.org/resource/the-uae-saudi-arabia-rivalry-becomes-a-rift/.

7. RECOMMENDATIONS

As the GCC invests in establishing a more robust nuclear security infrastructure in the next five to ten years, it is recommended that the GCC focus on closing gaps in technical areas where progress on RN incident response is achievable in the near-term. Focusing on solutions for technical issues will demonstrate the seriousness of the GCC in its pursuit of advanced technology and energy diversification. Increased collaboration between GCC states is also a priority as this will create solid RN incident response capabilities at the regional level.

Five recommendations for the GCC states to close gaps, both technical and non-technical, include:

1. Building a robust cybersecurity infrastructure to support RN incident response
2. Continued development of independent state nuclear regulators
3. Implementation of a nuclear security focused information sharing agreement for GCC states
4. Encouraging the creation of an Arabic-centric nuclear security curriculum to provide professional development options for nuclear security professionals in the Gulf
5. Solidifying maritime nuclear security infrastructure by implementing maritime radiation monitoring technology and assimilating GCC qualifying ports into the Mega Ports Initiative

7.1. Developing GCC Nuclear Cyber Security

To successfully utilize cyber resources for RN incident response, the GCC must first solidify cyber-specific incident response. Cybersecurity is a serious weakness across the GCC states, but this could also be an excellent technical area to increase regional cooperation. The development of a GCC-level cybersecurity office is one idea. Establishing a regional cyber office under the GCC would create guidance and leadership for cybersecurity and facilitate cooperation between GCC states on cyber. Strengthening GCC cybersecurity capabilities will inevitably lead to improved nuclear incident response capabilities as well; deterring adversaries from attacking nuclear facilities via the cyber domain.

An external option that GCC states may also take interest in is Sandia's TracerFIRE program. TracerFIRE is a program consisting of scenario-driven exercises where the participants learn to identify a cyber adversary, determine their entrance point, identify the adversary's target, and prevent recurring incidents. TracerFIRE is used primarily for cyber incident response and allows for participants to interact with malware and malicious actors in a secure environment.[114] This program, and others like it, could be very beneficial for cyber education and increased cyber security across the GCC states, which in turn will allow them to better rely on cyber infrastructure to respond to RN incidents.

7.2. Strengthening Nuclear Security through Independent Nuclear Regulators

Reflecting on the Fukushima Daiichi accident in 2011, it remains critical for the GCC states to address proper, effective nuclear security infrastructure. One option is to establish official, independent nuclear regulators within each Member State. Currently, the only GCC states that have independent nuclear regulators are the UAE (Federal Authority for Nuclear Regulation) and Saudi Arabia (Nuclear and Radiological Regulatory Commission). Bahrain, Kuwait, Oman, and Qatar do

[114] "Tracer FIRE Exercise Hosted at Georgia Tech to Improve Talent Pipeline | School of Electrical and Computer Engineering." Accessed February 25, 2026. https://ece.gatech.edu/news/2023/12/tracer-fire-exercise-hosted-georgia-tech-improve-talent-pipeline-0.

have nuclear emergency response capabilities; however, these capabilities are spread across multiple departments, or even multiple ministries, and are not as fully developed as the UAE and Saudi capabilities. Fully-functioning, independent nuclear regulators may not be necessary for those member states at this moment as they do not have nuclear facilities, however, developing independent nuclear regulators, or even an established point of contact specifically for nuclear incident response would demonstrate the seriousness of these states in diversifying their energy portfolios and mitigating RN risks in the region. A nuclear incident in the Gulf affects every Gulf State—it is critical that these states have the infrastructure to execute critical joint response.

Currently, the GCC EMC's operations center connects to each member state's Ministry of the Interior (except for Saudi Arabia and the UAE, whose nuclear regulatory authorities coordinate directly with the EMC); however, RN security is not a key mission for a Ministry of the Interior. A typical Ministry of the Interior oversees many responsibilities, including public security, law enforcement, immigration, local governments, and civil registration. If each member state were to establish nuclear regulators, connecting to the EMC directly, this could shorten incident identification and response times. This would increase cooperation between GCC states as well, as a chain of command for regional incidents could be established through these regulators, and each state would have a better understanding of the capabilities of the other members.

Establishing nuclear regulators in every GCC state would aid in incident response substantially; having an independent body with the sole focus of RN materials, its security and architecture would create a clear chain of command and concentrate all responsibilities and capabilities under one department. During an emergency where RN incident response is necessary, established, independent nuclear regulators will save precious time and eliminate confusion. Given that each member state already has workers who focus on nuclear incident response, we recognize that the primary hurdles to development will include funding, support, and independence.

7.3. Encouraging GCC Cooperation through Information-Sharing

Following the conflict between Iran and Israel in June 2025 and more recently in March 2026, the ability for the GCC to represent strength and unity in the face of conflict has become crucial. The GCC currently lacks critical executive functions to facilitate its legitimacy as an organization to its member states, as proven with the 2017 blockade of Qatar, and the use of the GCC by Saudi Arabia and the UAE to posture economically. Reforming this gap cannot be solved with just one solution, however one recommendation to begin this process is the establishment of a nuclear security information-sharing agreement. In 2025, the Persian Gulf region experienced a high level of turmoil: military altercations between Israel and Iran, Iran and the Gulf, an Israeli strike on Qatar, and more. Creating trust, especially regarding the security of nuclear infrastructure, is critical. Creating a comprehensive information-sharing agreement between the GCC states on RN incidents, facilitated by the GCC itself, may encourage trust between the member states and increase cooperation. Repairing internal struggles and tensions will also better the GCC's external-facing image, making the alliance more legitimate to both allies and adversaries. This could allow for increased collaboration with non-GCC states in the future, as well as deter adversaries from attacking individual GCC states.

7.4. Developing Nuclear Security Education

It is critical to acknowledge that globally, only half of the 230,000 people responsible for nuclear security have access to professional development programs, and the MENA region is especially

affected.[115] The lack of Arabic language materials that are relevant and written to accommodate various Arabic dialects is a significant gap that, if addressed, could greatly benefit not just the GCC states, but all Arabic countries seeking nuclear energy. As explained before, nuclear security textbooks written in Arabic should be written by proficient Arabic speakers with expert knowledge in nuclear security, an indigenous capability that Sandia may be able to assist with. Sandia offers nuclear security trainings for over 72 countries across the globe, with subjects ranging from the Design and Evaluation process, physical protection of nuclear materials and facilities, and uncrewed aircraft systems.[116] These trainings provide lectures and materials in the target language that can be utilized by the recipients long after the workshop concludes. Sandia also conducts train-the-trainer (TTT) events, specifically focusing on educating people who are responsible for educating others in their home countries. Both styles of technical assistance are helpful in creating an Arabic-centric nuclear security curriculum to benefit Arabic nuclear programs and reinforce nuclear security in the Persian Gulf region.

7.5. Protecting the Persian Gulf's Maritime Environment and Vessels

More than 30,000 vessels pass through the Strait of Hormuz every year, yet only two GCC countries have maritime RN monitoring and detection capabilities. If a nuclear event were to occur in the Persian Gulf, maritime traffic through the Strait of Hormuz be severely affected, directly influencing the flow of international supply chains, especially oil and gas trade. Two recommendations that the GCC could seek out include: 1) the Nuclear Smuggling Detection and Deterrence (NSDD) joint initiative between Sandia National Laboratories and the US National Nuclear Security Administration (NNSA), and 2) broader collaboration with Sandia and other DOE national laboratories on maritime radiation detector technology. While NSDD does have primary missions focused on nuclear smuggling, a sub-initiative more relevant to GCC states is the mega ports mission.[117] This initiative began in the late 1990s and early 2000s in countries across Eurasia, where the DOE and NNSA installed radiation detection monitors and other equipment in select mega ports.[118] Several GCC ports qualify as mega ports but have not taken advantage of this joint initiative to implement this radiation monitoring equipment. Taking part in this initiative could boost GCC maritime incident response, as this equipment can assist these countries in detecting and eliminating RN threats or incidents in the Persian Gulf.

The second recommendation is to collaborate with Sandia or other DOE national laboratories on maritime radiation detector technology. For example, since the early 2000s, Sandia's engineers have proposed a radiation detector in the form of a buoy.[119] The buoy can be used in coastal/shallow water environments to detect RN material in and on vessels.[120] This example monitoring technology can be ideally operated in shallow waters around the Gulf region and could assist GCC states in their maritime radiation detection and monitoring capabilities. Utilizing this technology, especially as these

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[115] "Saudi Arabian Universities' Need for a Nuclear Security Educational Textbook: A Systematic Review."
[116] Nuclear Security Technology Complex. "Training." Accessed March 3, 2026. https://www.sandia.gov/nstc/training/.
[117] *Read*. n.d. Accessed February 25, 2026. https://www.nationalacademies.org/read/27215/chapter/7.
[118] NNSA. "Megaports Initiative: Protecting the World's Shipping Network from Dangerous Cargo and Nuclear Materials." Homeland Security Digital Library, n.d. https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwjYmpD36PWSAxVpE1kFHRd8FfEQFnoECCYQAQ&url=https%3A%2F%2Fwww.hsdl.org%2Fc%2Fview%3Fdocid%3D473907&usg=AOvVaw1uOnyNumZ2bZxRdQHKQErg&opi=89978449.
[119] Aas, Christopher A., and Beck Lyle. *Detecting Nuclear and Radioactive Material in a Civilian Maritime Environment*. Nos. SAND2005-6845P. Sandia National Laboratories, 2005.
[120] Ibid.

states develop nuclear installations, will help in detecting and deterring possible incidents involving RN material during maritime transport.

8. CONCLUSION

The Persian Gulf is one of the fastest developing regions in the world, now intending to become a nuclear energy powerhouse. To accomplish this, the GCC must have strong RN incident response infrastructure that can handle any situation, regardless of intention or impact. The nuclear development of the GCC is already supported by numerous international and regional organizations, such as the IAEA, ROPME, CoE-ME and the GCC's EMC.

The work to address serious gaps, however, remains. A critical vulnerability identified within the GCC alliance is the lack of independent regulatory authorities – nuclear departments are instead confined within environmental safety or interior departments, when they should be their own entities.

Significant technical gaps weakening RN incident detection and response, both at state level, and at a regional level persist as well. These technical gaps include vulnerabilities in the cyber and maritime domains, as well as the overall nuclear security architecture. Non-technical gaps that are political in nature are preventing collaboration both within the GCC and externally. Internal rivalries, such as the one between Saudi Arabia and the UAE could prevent internal cooperation if there are financial tensions. The GCC as an organization lacks the executive mechanisms to diffuse internal rivalries, harming its legitimacy, especially on the international stage. Finally, gaps analyzed in the GCC workforce spotlight a severe lack of Arabic language materials for nuclear security education, which, combined with very few indigenous universities offering nuclear security degree programs, could also prevent nuclear industry growth in the Gulf region.

Therefore, it is recommended that the GCC focuses on regional collaboration before prioritizing national achievements.

Five different recommendations were put forward in this paper, however the opportunities for GCC collaboration are limitless. The first option addresses gaps in the cyber domain, suggesting the creation of a GCC-level cybersecurity office to promote cooperation on this issue. This option also references Sandia's TracerFIRE program to educate and train cyber professionals in the GCC region in cyber incident response, which would in turn help RN incident response.

The second option is the installation of independent state nuclear regulators. This would build on the incident response infrastructure that the GCC has established by standardizing nuclear regulatory authorities across the alliance. Establishing independent nuclear regulatory authorities would also benefit each state individually by increasing their own response capabilities and guaranteeing autonomous departments dedicated only to nuclear concerns.

The third recommendation suggests a nuclear security intelligence-sharing agreement, which could begin to solidify GCC legitimacy, both to its internal members, and to the outside world. An intelligence sharing agreement can create trust and cooperation among member states and could be used in the future as a stepping-stone to regional Persian Gulf cooperation.

The fourth recommendation is focused on closing gaps in the workforce by offering trainings and relevant materials to facilitate an Arabic-centric nuclear security curriculum. These trainings will provide the nuclear expertise to Arabic speakers and writers who can then write accurate and understandable materials.

The fifth and final option tackles maritime weaknesses by offering options for the GCC to collaborate with Sandia and the US National Nuclear Security Administration via the Nuclear Smuggling Detection and Deterrence "Mega Ports" initiative. This initiative installs radiation

detection monitors in mega ports. No GCC mega port has participated in "Mega Ports", but this initiative could be an excellent way to patch maritime vulnerabilities and reduce RN incidents in that domain. The second solution is to work specifically with Sandia to develop maritime radiation capabilities unique to the maritime environment, which would make already present operations in the Gulf encountering NORM/TENORM safer, as well as future incidents.

Working together on both nuclear and non-nuclear issues can bring this entire region closer together, reducing the possibility of nuclear incidents and increasing stability. The path toward establishing a robust nuclear energy infrastructure in the GCC hinges on the region's ability to foster collaboration among its member states. By prioritizing regional cooperation over individual national achievements, the GCC can effectively address critical vulnerabilities in regulatory frameworks, incident detection, and response capabilities. The establishment of independent nuclear regulatory authorities, the implementation of intelligence-sharing agreements, and the development of Arabic-centric curriculum are essential steps toward building a unified front in nuclear safety and security. Furthermore, collaborative initiatives, such as partnering with organizations like Sandia National Laboratories to enhance maritime and cyber defenses, will strengthen the GCC's incident response infrastructure in RN and beyond. By working together, the GCC states could overcome internal rivalries and create a cohesive strategy that ensures the safe and sustainable development of nuclear energy, ultimately benefiting the entire region and its future generations.

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