

V. Attacks on nuclear installations in Ukraine and the response missions of the International Atomic Energy Agency

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Ukraine has 15 operable nuclear reactors at four nuclear power plants (NPP), which together generate about half of its electricity. In 2022 all four NPPs, as well as other nuclear installations, were subject to military attacks, including shelling and missile strikes, while two NPPs were occupied by Russian military forces.¹ This situation presented extraordinary nuclear safety, security and safeguards challenges for the facilities' personnel, the Ukrainian authorities and the International Atomic Energy Agency (IAEA).²

Attacks on nuclear facilities and other installations in the nuclear fuel cycle have occurred previously, both during military conflicts and in peacetime (see box 8.1).³ However, the attacks on nuclear installations in Ukraine are unprecedented in many respects. Never before have large, operating nuclear power plants been attacked by shelling or missile strikes by state militaries. There has been no historical precedent for the occupation by military forces and subsequent annexation of a nuclear power plant.⁴ In addition, the attacks before 2022 typically aimed to avert alleged nuclear proliferation or impede illicit weapon programmes and normally involved facilities that were not subject to the IAEA's safeguards—the technical measures by which the IAEA verifies that nuclear materials and technology are used only for peaceful purposes.

This section first reviews the extraordinary challenges faced by Ukrainian nuclear installations in 2022. It then describes the response missions and other assistance that was provided by the IAEA.

Events at Ukrainian nuclear installations in 2022

Chornobyl Nuclear Power Plant and Exclusion Zone

The Chornobyl NPP (ChNPP) site contains six reactor units. Of the six, units 1–3 have been shut down, unit 4 was partially destroyed in the nuclear

¹ On other aspects of the war in Ukraine see chapter 1, section V, chapter 2, section I, and chapter 12, section III, in this volume.

² For a brief description and list of member states of the IAEA see annex B, section I, in this volume.

³ For definitions of nuclear facility, nuclear installation and nuclear fuel cycle see IAEA, *IAEA Nuclear Safety and Security Glossary: Terminology Used in Nuclear Safety, Nuclear Security, Radiation Protection and Emergency Preparedness and Response, 2022* (interim) edn (IAEA: Vienna, 2022), pp. 135–37.

⁴ On Russia's claimed annexation in 2014 of the IR-100 research reactor and subcritical uranium–water assembly located in at the Sevastopol National University of Nuclear Energy and Industry, Crimea, see Sergeyev, Yu., Permanent representative of Ukraine, Statement at the UN General Assembly meeting on the Report of the International Atomic Energy Agency, 17 Nov. 2015.

Box 8.1. Attacks on nuclear installations prior to 2022**Attacks during armed conflict**

During World War II, the Allies made multiple attempts between 1942 and 1944 to destroy the Norsk Hydro heavy water-production facility in Telemark, Norway.^a

In 1950, as part of the strategic bombing campaign during the 1950–53 Korean War, the United States Air Force destroyed the chemical complex at Hungnam, North Korea, that was reportedly processing monazite for the Soviet nuclear programme.^b Monazite is a naturally occurring mineral containing rare earth elements, thorium and uranium.

On 30 September 1980, during the 1980–88 Iran–Iraq War, Iranian fighter-bombers attacked the Osirak research reactor that was being built in Iraq, damaging ancillary buildings but missing the reactor itself.^c

Between 1984 and 1988 Iraq launched seven air attacks that eventually destroyed Iran's Bushehr NPP, which was in advanced stages of construction at the time.^d

During the 1990–91 Gulf War the USA destroyed multiple Iraqi nuclear facilities, four of which contained nuclear or other radioactive material.^e In 2000 the US government compiled a list of four nuclear facilities in Iraq that both had nuclear or other radioactive materials on site and were damaged during the Gulf War: Tuwaita nuclear research centre, Tarmiya uranium enrichment facility, Al Qaim superphosphate fertilizer plant and Mosul feed materials-production facility.^f

Attacks during peacetime

In 1981 an Israeli air raid destroyed the Osirak reactor in Iraq.^g

In 1993 the USA used cruise missiles to destroy two Iraqi nuclear installations that had not been destroyed in the Gulf War.^h

In September 2007 an Israeli air strike destroyed a suspected undeclared nuclear facility located at al-Kibar, in eastern Syria.ⁱ

^a Kreps, S. E. and Fuhrmann, M., 'Attacking the atom: Does bombing nuclear facilities affect proliferation?', *Journal of Strategic Studies*, vol. 34, no. 2 (Apr. 2011), pp. 175–76.

^b Futrell, R. F., *The United States Air Force in Korea, 1950–1953* (US Air Force, Office of Air Force History: Washington, DC, 1983), pp. 186, 190.

^c US Director of Central Intelligence, 'National intelligence daily', 1 Oct. 1980, p. 1; and 'The ghosts that hit Osirak', *The Economist*, 18 Oct. 1980, p. 54.

^d Spector, L. S., *Nuclear Ambitions: The Spread of Nuclear Weapons 1989–1990* (Westview Press: Boulder, CA, 1990), pp. 190, 208–209.

^e Kreps and Fuhrmann (note a), pp. 177–78.

^f US Defense Health Agency, 'Intelligence related to possible sources of radioactive contamination during the Persian Gulf War', July 2000.

^g Feldman, S., 'The bombing of Osirak—Revisited', *International Security*, vol. 7, no. 2 (fall 1982), p. 114.

^h Kreps and Fuhrmann (note a), p. 178.

ⁱ Kile, S. N., 'Nuclear arms control and non-proliferation', *SIPRI Yearbook 2010*, p. 393.

accident of 26 April 1986 and is currently covered by the New Safe Confinement (NSC) shelter facility, and units 5 and 6 were never operational.⁵ The site also includes two spent fuel storage facilities: the wet spent fuel storage

⁵ On the 1986 nuclear accident see Blix, H., 'The Chernobyl reactor accident: The international significance and results', *SIPRI Yearbook 1987*, 425–32.

facility ISF-1 and the dry spent fuel storage facility ISF-2, which was opened in 2021 to replace ISF-1. In addition, there are multiple radioactive waste management and disposal facilities at the ChNPP site and in the wider Chornobyl Exclusion Zone.⁶

At 6.41 a.m. CET on 24 February 2022 the State Nuclear Regulatory Inspectorate of Ukraine (SNRIU), serving in its capacity of a national competent authority under the Convention on Early Notification of a Nuclear Accident, informed the emergency response manager at the IAEA's Incident and Emergency Centre (IEC) that 'Russian troops were at the site' of the ChNPP, and that Ukraine had imposed martial law on its territory.⁷ In the evening of the same day, the SNRIU reported that, as a result of a military attack, all facilities at the ChNPP site had been taken over by the Russian military.⁸

On 25 February the SNRIU reported to the IAEA that the automated radiation-measurement systems installed at the ChNPP site indicated higher than normal levels of background radiation, which was most likely caused by 'heavy military vehicles stirring up soil still contaminated from the 1986 accident'.⁹ The IAEA assessed that the readings reported by the SNRIU (of up to 9.46 microsieverts per hour) did not pose any danger to the public.¹⁰

Normally, the Ukrainian personnel at the ChNPP would work in regularly rotating shifts. After the Russian military took control of the site, the rotation of personnel stopped, and the work shift that began on 23 February 2022 was made to keep working for several weeks, in violation of normal plant procedures and the IAEA's nuclear safety and nuclear security guidance. Rotation of the on-site personnel was only allowed to partially resume on 21 March 2022.¹¹

On 31 March 2022 the Russian forces transferred control of the ChNPP to Ukrainian personnel and retreated.¹²

During the period of occupation, the ChNPP site experienced interruptions in off-site power supply and communications with the SNRIU, and the provision of radiation-monitoring data from the site to the IAEA's International Radiation Monitoring Information System (IRMIS) was cut off. These issues were remedied after the withdrawal of the Russian forces.¹³

⁶ IAEA, 'Nuclear safety, security and safeguards in Ukraine, 24 February–28 April 2022', Summary report by the director general, 28 Apr. 2022, p. 8.

⁷ IAEA, Summary report (note 6), pp. 3, 5; and Convention on Early Notification of a Nuclear Accident, opened for signature 26 Sep. 1986, entered into force 27 Oct. 1986, IAEA INFCIRC/335, 18 Nov. 1986.

⁸ State Nuclear Regulatory Inspectorate of Ukraine (SNRIU), 'Про ситуацію на Чорнобильській АЕС та стан безпеки інших ядерних установках' [On the situation at the Chornobyl NPP and the safety status of other nuclear facilities], 24 Feb. 2022; and IAEA, Summary report (note 6), p. 8.

⁹ IAEA, 'Update 1—IAEA director general statement on situation in Ukraine', Press release 10/2022, 25 Feb. 2022.

¹⁰ IAEA, 'Update 1' (note 9).

¹¹ IAEA, 'Update 27—IAEA director general statement on situation in Ukraine', Press release 40/2022, 20 Mar. 2022.

¹² Nuclear Energy Agency (NEA), 'Ukraine: Current status of nuclear power installations', 5 Dec. 2022.

¹³ IAEA, Summary report (note 6), pp. 8–12.

Zaporizhzhia Nuclear Power Plant

Zaporizhzhia NPP (ZNPP) is home to 6 of Ukraine's 15 nuclear power reactors, with an energy capacity of nearly 6 gigawatts electric (GWe).¹⁴ It is the largest NPP in Europe.

On 1 March 2022 the Russian Permanent Mission to the IAEA stated in an official letter to the agency that Russian military forces had taken control of the territory around the ZNPP. On the same day the SNRIU requested the IAEA 'to provide immediate assistance in coordinating activities in relation to the safety of the Chornobyl NPP and other nuclear facilities'.¹⁵

On 4 March 2022 Ukraine informed the IAEA that the site of the ZNPP 'had been shelled overnight', but 'a fire at the site had not affected "essential" equipment'.¹⁶ This constituted the first ever direct military attack on a large operational nuclear power plant anywhere in the world. Five hours later Ukraine reported to the IAEA that the ZNPP site was under the control of Russian military forces, but the regular staff continued to operate the plant and no release of radioactive material had taken place.¹⁷ By 5 March only two of the ZNPP's six reactors—units 2 and 4—were producing electricity, and the remaining four were in low-power mode, under maintenance or had been shut down.¹⁸

From 4 March 2022 the ZNPP was operated by regular management and staff, but under the control of Russian military forces. The shelling of the site continued throughout 2022, with both Russia and Ukraine accused each other of the shelling.¹⁹ One consequence of this, as the IAEA was repeatedly informed by the SNRIU, was that 'the personnel at the ZNPP were working under unbelievable pressure' and the 'morale and the emotional state' of staff at the ZNPP were 'very low'.²⁰ Another consequence was that the last operating reactor at ZNPP was shut down on 10 September 2022.²¹

Shelling of the ZNPP site and its vicinity also led to repeated damage to various power lines connected to the site. The ZNPP's connection to off-site

¹⁴ Nuclear Energy Agency (note 12).

¹⁵ IAEA, 'Update 6—IAEA director general statement on situation in Ukraine', Press release 15/2022, 2 Mar. 2022.

¹⁶ IAEA, 'Update 10—IAEA director general statement on situation in Ukraine', Press release 19/2022, 4 Mar. 2022.

¹⁷ IAEA, 'Update 11—IAEA director general statement on situation in Ukraine', Press release 20/2022, 4 Mar. 2022.

¹⁸ IAEA, 'Update 12—IAEA director general statement on situation in Ukraine', Press release 21/2022, 5 Mar. 2022.

¹⁹ Hunder, M., 'Russia and Ukraine accuse each other in shelling around Zaporizhzhia nuclear plant', Reuters, 28 Aug. 2022; and Bigg, M. M., 'Russia and Ukraine again trade blame for shelling at the Zaporizhzhia nuclear plant', *New York Times*, 20 Nov. 2022.

²⁰ IAEA, 'Nuclear safety, security and safeguards in Ukraine: 28 April–5 September 2022', 2nd summary report by the director general, 6 Sep. 2022, p. 14. On the increased likelihood of human error undermining the safe and secure operation of a facility when staff work under duress see Schnieder, M. et al., *World Nuclear Industry: Status Report 2022* (Mykle Schneider Consulting: Paris, Oct. 2022), pp. 257–58.

²¹ IAEA, Board of Governors, 'Nuclear safety, security and safeguards in Ukraine', Report by the director general, GOV/2022/66, 10 Nov. 2022, para. 42.

power was interrupted multiple times in 2022, triggering the emergency diesel generators.²² Off-site power lines are necessary not only for the ZNPP to provide power into the Ukrainian electricity grid, but also to provide the plant with the power required for its safety functions. Even if a nuclear power plant were to be shut down, it needs external power and water for an extended period in order to cool down the nuclear fuel in the core and in the spent fuel pools. For example, immediately after shutdown, the nuclear fuel in a reactor of the size of those installed at the ZNPP will still be producing about 200 megawatts (MW) from decay heat.²³ The loss of off-site power or the ultimate heat sink (e.g. water from a river or an ocean) can potentially lead to consequences similar to those that took place during the Fukushima Daiichi nuclear accident in 2011.²⁴

On 4 October 2022 Russian President Vladimir Putin signed laws purporting to annex the Ukrainian oblasts of Donetsk, Kherson, Luhansk and Zaporizhzhia to the Russian Federation.²⁵ Although the annexations were widely condemned and only recognized internationally by North Korea, this led Putin to sign a further decree designating the ZNPP as Russia's 'federal property'.²⁶ This action was denounced by the vast majority of United Nations member states as an illegal seizure.²⁷

Hostilities around the ZNPP site continued throughout 2022, leading to further damage to its infrastructure, repeated interruptions in its electricity supply, and reported psychological and physical pressure on the plant's personnel, including torture.²⁸

Other nuclear facilities and installations

The other three NPPs—Khmelnysky, Rivne and South Ukraine—remained under Ukrainian control. As a result of Russian missile strikes on 15 and

²² Nuclear Energy Agency (note 12).

²³ See Schnieder et al. (note 20), p. 245.

²⁴ For a definition of 'ultimate heat sink' see IAEA, *Design of the Reactor Coolant System and Associated Systems for Nuclear Power Plants, Specific Safety Guide*, IAEA Safety Standards Series no. SSG-56 (IAEA: Vienna, 2020), p. 5. On the Fukushima Daiichi accident see IAEA, *The Fukushima Daiichi Accident*, Technical vol. 1/5, Description and Context of the Accident (IAEA: Vienna, Aug. 2015), pp. 2–32.

²⁵ 'Ukraine updates: Putin signs law "annexing" 4 regions', Deutsche Welle, 5 Oct. 2022; and Russian Federal Constitutional Laws nos 5–8 of 2022, 4 Oct. 2022, *Rossiiskaya Gazeta*, 6 Oct. 2022.

²⁶ Указ № 711 «Об особенностях правового регулирования в области использования атомной энергии на территории Запорожской области» [Decree no. 711 'On the specifics of legal regulation of the use of nuclear energy in the territory of Zaporizhzhia oblast'], signed 5 Oct. 2022. See also 'Putin asserts control over Ukraine nuclear plant, Kyiv disagrees', Reuters, 5 Oct. 2022; and Shin, H., 'N. Korea backs Russia's proclaimed annexations, criticises US "double standards"', Reuters, 4 Oct. 2022. Operational and personnel issues caused by the annexation are discussed below.

²⁷ UN General Assembly Resolution ES-11/4, 'Territorial integrity of Ukraine: Defending the principles of the Charter of the United Nation', 12 Oct. 2022.

²⁸ Nuclear Energy Agency (note 12); Parkinson, J. and Hinshaw, D., "'The hole': Gruesome accounts of Russian occupation emerge from Ukrainian nuclear plant', *Wall Street Journal*, 18 Nov. 2022; and Tirone, J., 'Russia's atomic grab in Ukraine corners IAEA monitors', Bloomberg, 11 Oct. 2022.

23 November 2022, they all lost connection to the Ukrainian power grid, switching to emergency diesel generator power.²⁹

The Kharkiv Institute of Physics and Technology (KIPT) hosts a subcritical neutron source installation for research and production of radioisotopes.³⁰ Depending on the usage scenario, it has about 40 fuel assemblies each containing 41.7 grams of low-enriched uranium.³¹ On 24 February the installation was shut down as a precaution in response to the beginning of hostilities.³² On 6 March and 25 June the installation was damaged by shelling, and the external power supply was cut off due to ongoing fighting. Despite the damage, the IAEA concluded that ‘measurements showed no increase in radiation and the shelling had no significant impact on safety’.³³ On 10 November an IAEA mission to KIPT found that it had been heavily damaged by shelling but concluded that there was no indication of radioactive material release or diversion of nuclear material.³⁴

The State Specialized Enterprise (SSE) ‘Radon’ manages radioactive waste originating from medical, industrial and research facilities in Ukraine. It has five facilities for the interim storage of such waste, located in Dnipro, Kharkiv, Kyiv, Lviv and Odesa.³⁵ On 26 February 2022 the SNRIU reported that the Kharkiv branch had suffered some damage due to hostilities.³⁶ On 27 February the Kyiv branch of SSE ‘Radon’ sustained minor damage due to a missile strike. In both cases, no radioactive release was reported.³⁷

The IAEA response and its assistance missions to Ukraine

On 2 March 2022 the IAEA Board of Governors held a meeting to discuss the ‘nuclear safety, security and safeguards implications of the conflict in Ukraine as a result of the Russian Federation’s military operation that began on 24 February’.³⁸ In his introductory remarks the IAEA director general, Rafael Mariano Grossi, summarized the Russian military’s attacks on the Ukrainian

²⁹ Nuclear Energy Agency (note 12).

³⁰ IAEA, Summary report (note 6), p. 16.

³¹ Zhong, Z. and Gohar, Y., *Passive Safety Features Evaluation of KIPT Neutron Source Facility*, ANL-16/15 (Argonne National Laboratory: Argonne, IL, June 2016), p. 2; and Konoplev, K. A. et al., ‘LEU WWR-M2 fuel qualification’, Paper presented at the 24th International Meeting on Reduced Enrichment for Research and Test Reactors (RERTR), San Carlos de Bariloche, 3–8 Nov. 2002.

³² Stone, R., ‘Hero city’, *Science*, vol. 378, no. 6624 (9 Dec. 2022), p. 1038.

³³ IAEA, 2nd summary report (note 20), p. 32.

³⁴ IAEA, ‘Update 125—IAEA director general statement on situation in Ukraine’, Press release 186/2022, 11 Nov. 2022.

³⁵ IAEA, 2nd summary report (note 20), p. 32.

³⁶ IAEA, ‘Update 2—IAEA director general statement on situation in Ukraine’, Press release 11/2022, 26 Feb. 2022.

³⁷ IAEA, ‘Update 3—IAEA director general statement on situation in Ukraine’, Press release 12/2022, 27 Feb. 2022.

³⁸ Grossi, R. M., IAEA director general, Introductory statement to the IAEA Board of Governors, 2 Mar. 2022.

Box 8.2. IAEA General Conference resolutions and decisions on attacks against nuclear installations, 1983–2009

The General Conference is the main policymaking organ of the International Atomic Energy Agency (IAEA). Between 1983 and 2009 it issued five policy declarations concerning attacks on nuclear installations.

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| 9 Nov. 1983 | The General Conference declared that ‘all armed attacks against nuclear installations devoted to peaceful purposes should be explicitly prohibited’. ^a |
| 27 Sep. 1985 | The General Conference stated that it considered ‘any armed attack on and threat against nuclear facilities devoted to peaceful purposes constitutes a violation of the principles of the United Nations Charter, international law and the Statute of the Agency’. ^b |
| 5 Oct. 1987 | The General Conference authorized the IAEA director general to assist the United Nations Conference on Disarmament in development of an international convention prohibiting armed attacks on nuclear installations. ^c |
| 21 Sep. 1990 | The General Conference ‘recognized’ that ‘attacks or threats of attack on nuclear facilities devoted to peaceful purposes could jeopardize the development of nuclear energy’, and that such attacks ‘on a safeguarded nuclear facility, in operation or under construction, would create a situation in which the United Nations Security Council would have to act immediately in accordance with the provisions of the United Nations Charter’. ^d |
| 18 Sep. 2009 | The General Conference adopted a decision that referenced and essentially reconfirmed the resolutions of 1985 and 1990. ^e |

^aIAEA, General Conference, ‘Protection of nuclear installations devoted to peaceful purposes against armed attacks’, Resolution GC(XXVII)/RES/407, 14 Oct. 1983, para. 1.

^bIAEA, General Conference, ‘Protection of nuclear installations devoted to peaceful purposes against armed attacks’, Resolution GC(XXIX)/RES/444, 27 Sep. 1985, para. 2.

^cIAEA, General Conference, ‘Protection of nuclear installations against armed attacks’, Resolution GC(XXXI)/RES/475, 5 Oct. 1987, para. 2. For a brief description of the Conference on Disarmament see annex B, section I, in this volume.

^dIAEA, General Conference, ‘Prohibition of all armed attacks against nuclear installations devoted to peaceful purposes whether under construction or in operation’, Resolution GC(XXXIV)/RES/533, 21 Sep. 1990, paras 1, 3.

^eIAEA, General Conference, ‘Prohibition of armed attack or threat of attack against nuclear installations, during operation or under construction’, Decision GC(53)/DEC/13, 18 Sep. 2009.

nuclear infrastructure that had been reported to date. He noted that, despite the extraordinary circumstances, the nuclear facilities continued to operate ‘normally’ in a technical sense, but he emphasized that ‘there is nothing normal about the circumstances under which the professionals at Ukraine’s four Nuclear Power Plants are managing to keep the reactors that produce half of Ukraine’s electricity working’.³⁹

Grossi also reminded ‘all States, without exception’ about an obligation that they had agreed to in 1985, 1990 and 2009 concerning armed attacks on nuclear installations (see box 8.2). This asserts that ‘any armed attack on and threat against nuclear facilities devoted to peaceful purposes constitutes a

³⁹ Grossi (note 38).

violation of the principles of the United Nations Charter, international law and the Statute of the Agency’.⁴⁰

The ‘seven indispensable pillars of nuclear safety and security’

In the same remarks on 2 March 2022, Grossi put forward what later became known as the IAEA director general’s ‘seven indispensable pillars of nuclear safety and security’ framework. These seven principles, which were derived from the existing IAEA nuclear safety standards and nuclear security guidance documents, are as follows:

1. The physical integrity of the facilities—whether it is the reactors, fuel ponds or radioactive waste stores—must be maintained.
2. All safety and security systems and equipment must be fully functional at all times.
3. The operating staff must be able to fulfil their safety and security duties and have the capacity to make decisions free of undue pressure.
4. There must be secure off-site power supply from the grid for all nuclear sites.
5. There must be uninterrupted logistical supply chains and transportation to and from the sites.
6. There must be effective on-site and off-site radiation monitoring systems and emergency preparedness and response measures.
7. There must be reliable communications with the regulator and others.⁴¹

The seven pillars were widely endorsed by the international community.⁴²

On 26–30 September 2022, the 66th regular session of the IAEA General Conference also considered the nuclear and radiation safety, security and safeguards situation in Ukraine at length. Its general resolutions on all three of these topics discuss attacks on nuclear installations. Both the resolution on nuclear and radiation safety and the resolution on nuclear security call upon all IAEA member states ‘to be mindful of the importance of nuclear safety and security regarding peaceful nuclear facilities and materials in all circumstances’.⁴³ The safeguards resolution urges all member states ‘to refrain from

⁴⁰ IAEA, General Conference, ‘Protection of nuclear installations devoted to peaceful purposes against armed attacks’, Resolution GC(XXIX)/RES/444, 27 Sep. 1985, para. 2.

⁴¹ Grossi (note 38).

⁴² World Nuclear Association, Statement on the IAEA framework for the safety and security of Ukraine’s nuclear power plants, 10 Mar. 2022; and Joint statement on the High-level Meeting on the Safety and Security of Civil Nuclear Facilities in Armed Conflicts, US Department of State, 23 Sep. 2022. See also Fedchenko, V., ‘Nuclear security during armed conflict: Lessons from Ukraine’, SIPRI Research Policy Paper, Mar. 2022, section IV.

⁴³ IAEA, General Conference, ‘Nuclear and radiation safety’, Resolution GC(66)/RES/6, 30 Sep. 2022, para. 36; and IAEA, General Conference, ‘Nuclear security’, Resolution GC(66)/RES/7, 30 Sep. 2022, para. 26.

attacks or threats of attacks on, against or in the vicinity of nuclear facilities devoted to peaceful purposes in order to ensure that the Agency is able to conduct safeguards activities in accordance with relevant safeguards agreements'.⁴⁴

IAEA missions to Ukraine

On 3 March 2022 the IAEA Board of Governors condemned Russia's actions in Ukraine and requested that the director general and the IAEA Secretariat continue to closely monitor the situation.⁴⁵ In response to the Russian military's capture of the ZNPP and the SNRIU's request for assistance of 1 March and to the board's resolution of 3 March, Grossi announced on 4 March his intention to travel to Ukraine to 'to secure the commitment to the safety and security of all Ukraine's nuclear power plants from the parties of the conflict in the country'.⁴⁶

The urgency of this proposed visit was emphasized by the fact that several of the seven pillars were being violated at the ChNPP and ZNPP sites and elsewhere in Ukraine. For example, shortly after the Russian military takeover of the ZNPP, the plant personnel could not fulfil their duties without the approval of the Russian commander (in violation of pillar 3), and the Russian forces cut off almost all communication with the plant (in violation of pillar 7).⁴⁷ At the ChNPP, the staff of 211 technical and security personnel were unable to rotate from the site and effectively lived there for weeks with intermittent external electrical supply and communications with their families and the national authorities. The situation at ChNPP was in violation, at a minimum, of pillars 1, 3, 4, 5 and 7.⁴⁸ Later in the year, the IAEA Board of Governors assessed that 'all of the Director General's "seven indispensable pillars for nuclear safety and security" have been compromised' at the ZNPP.⁴⁹

As a result, Grossi led multiple missions of technical experts to Ukraine in 2022.⁵⁰ The first took place on 29–31 March to assist the South Ukraine NPP, Mykolaiv oblast, to reduce the risk of a major nuclear accident. The second mission took place on 25–28 April and comprised a high-level delegation and

⁴⁴ IAEA, General Conference, 'Strengthening the effectiveness and improving the efficiency of Agency safeguards', Resolution GC(66)/RES/10, 30 Sep. 2022, para. 3.

⁴⁵ IAEA, Board of Governors, 'The safety, security and safeguards implications of the situation in Ukraine', Resolution GOV/2022/17, 3 Mar. 2022, paras 1, 4.

⁴⁶ IAEA, 'IAEA director general Grossi's initiative to travel to Ukraine', Press release 21/2022, 4 Mar. 2022.

⁴⁷ IAEA, 'Update 13—IAEA director general statement on situation in Ukraine', Press release 22/2022, 6 Mar. 2022.

⁴⁸ IAEA, 'Update 20—IAEA director general statement on situation in Ukraine', Press release 32/2022, 13 Mar. 2022.

⁴⁹ IAEA, Board of Governors, 'The safety, security and safeguards implications of the situation in Ukraine', Resolution GOV/2022/58, 15 Sep. 2022, p. 1.

⁵⁰ IAEA, Board of Governors, 'Nuclear safety, security and safeguards in Ukraine', Report by the director general, GOV/2022/52, 9 Sep. 2022, paras 10–13.

technical experts to assess the safety and security at Ukrainian nuclear facilities in general, assess the situation at the ChNPP now that it had returned to Ukrainian control, and deliver radiation monitoring and personal protective equipment requested by Ukraine. The third mission was conducted at the ChNPP site and its exclusion zone from 30 May to 4 June. It assessed radiation protection, the safety of spent fuel and radioactive waste, and the nuclear security situation.

The fourth mission, the high-profile IAEA Support and Assistance Mission to Zaporizhzhya (ISAMZ), took place from 29 August to 3 September 2022 and aimed ‘to help stabilize the nuclear safety and security situation at the ZNPP site’.⁵¹ ISAMZ was agreed after several months of high-level diplomatic negotiations between the IAEA, Russia and Ukraine, with the participation of France.⁵² It was led by the IAEA director general and comprised a senior delegation and a technical team. This mission stood out because it took place at an NPP operated by Ukrainian personnel under Russian military control, with ongoing hostilities in the vicinity.

In connection with the arrival of ISAMZ, the IAEA reached an agreement with Ukraine and Russia to set up a permanent presence of IAEA inspectors at the ZNPP.⁵³ They would stay at the station and be replaced in regular rotations. During rotations, the IAEA teams had to reach the ZNPP from the territory controlled by the Ukrainian government, because the IAEA formally recognizes the ZNPP as Ukrainian.⁵⁴ From 29 August the IAEA began to post four-person shifts of experts at ZNPP to monitor nuclear safety and the security situation, improve communication, identify priority needs for assistance, and provide technical advice.⁵⁵

After ISAMZ, the IAEA missions to Ukraine became more routine, with the aim of assessing nuclear safety and security and providing the technical support and assistance required. In November and December 2022, the IAEA sent such missions to KIPT and SSE ‘Radon’ in Kharkiv, the ChNPP site, and the rest of the Ukrainian nuclear power plants.⁵⁶ On 13 December 2022 the IAEA and Ukraine agreed to also establish a ‘continuous presence of nuclear safety and security experts’ at the other three nuclear power plants—Khmelnitsky, Rivne and South Ukraine—as well as the ChNPP site.⁵⁷

⁵¹ IAEA, GOV/2022/52 (note 50), para. 14.

⁵² ‘IAEA seeks to visit Ukraine nuclear plant amid concerns’, Al Jazeera, 26 Aug. 2022; and ‘IAEA team “on its way” to Ukraine’s Zaporizhzhia nuclear plant’, Al Jazeera, 29 Aug. 2022.

⁵³ ‘IAEA team “on its way” to Ukraine’s Zaporizhzhia nuclear plant’ (note 52).

⁵⁴ ‘IAEA monitoring mission blocked from Zaporizhzhia NPP’, *Nuclear Engineering International*, 23 Feb. 2023.

⁵⁵ IAEA, GOV/2022/66 (note 21), paras 9–13.

⁵⁶ IAEA, GOV/2022/66 (note 21), paras 15–16; and IAEA, ‘Update 134—IAEA director general statement on situation in Ukraine’, Press release 201/2022, 2 Dec. 2022.

⁵⁷ IAEA, ‘Update 136—IAEA director general statement on situation in Ukraine’, Press release 207/2022, 13 Dec. 2022.

The ZNPP protection zone

The IAEA has consistently called for the cessation of shelling of the ZNPP site and its vicinity to avoid further damage to the plant and to ensure the safety of the staff. The shelling and other military activities in the vicinity of the ZNPP have often resulted in the loss of electricity and water supplies to the plant, forcing the reactors to shut down.

On 6 September 2022 the IAEA director general briefed the UN Security Council about the findings and recommendations of ISAMZ and proposed the establishment of a 'nuclear safety and security protection zone' around the ZNPP site.⁵⁸ He subsequently launched a broad diplomatic effort seeking support for and implementation of such a zone, which included bilateral meetings with Ukrainian President Volodymyr Zelensky in Kyiv on 6 October and with Russian President Vladimir Putin in St Petersburg on 11 October.⁵⁹ On 2 December Grossi expressed optimism that the negotiations establishing the security zone could be concluded 'in the near future'.⁶⁰ However, it did not happen in 2022. On 4 January 2023 Petro Kotin, head of the Ukrainian nuclear utility company Energoatom, dismissed the prospects for establishing such a zone, considering it is unrealistic under current conditions.⁶¹

Conclusions

In 2022 a large share of Ukraine's nuclear facilities, including all of its nuclear power plants, were subject to military attacks, while two were occupied by the Russian armed forces. Nuclear facilities have been attacked elsewhere in the past in dedicated strikes, but an assault of the scale that took place in Ukraine is unique.

These attacks presented unprecedented nuclear safety, security and radiation protection challenges. In response, the IAEA put forward a conceptual framework for addressing the safety and security challenges to nuclear installations in wartime: the 'seven indispensable pillars of nuclear safety and security'. The seven pillars concept is a significant innovation that is likely to have an impact on the fields of nuclear safety, nuclear security and emergency response well after 2022. This concept can be seen as a harbinger of an adjustment of the international nuclear security framework to face a new, previously largely unaddressed, set of scenarios: operation of national nuclear security regimes during attacks and disruption caused by states,

⁵⁸ IAEA, GOV/2022/52 (note 50), para. 6.

⁵⁹ IAEA, GOV/2022/66 (note 21), paras 18–20; and Tirone (note 28).

⁶⁰ Tirone, J., 'Nuclear monitors near accord on Ukraine security zone at Zaporizhzhia plant', Bloomberg, 2 Dec. 2022.

⁶¹ Tirone, J., 'Ukraine plant must be seized from Russia, nuclear chief says', Bloomberg, 4 Jan. 2023; and 'Idea of creating security zone around Zaporizhzhia NPP seized by Russia is unrealistic—Energoatom head', Interfax-Ukraine, 5 Jan. 2023.

rather than by non-state actors. Even during an international armed conflict, nuclear security itself is concerned with the malicious actions of individuals and non-state groups, not the actions of the armed forces of a state. However, the events of 2022 demonstrated that, in case of an international armed conflict or other such extraordinary circumstance, the nuclear security framework must continue to function, and this requires some adaptation, including through strengthening the links with the nuclear safety and emergency response frameworks.⁶²

The IAEA also conducted multiple missions to Ukrainian nuclear facilities and established a permanent presence there to monitor the situation. ISAMZ is of particular significance, because it established an IAEA presence at the ZNPP—the largest nuclear power plant in Europe, controlled by Russia. The IAEA presence contributed to nuclear safety, nuclear security and the security of the nuclear facility personnel at the ZNPP.

The IAEA director general launched a broad diplomatic effort in an attempt to establish a nuclear safety and security protection zone around Ukrainian nuclear installations. That effort did not return any tangible results in 2022 and there were few signs that year that such a zone will be established in 2023. Similarly, the conflict between the *de facto* and *de jure* control over the ZNPP has only deepened since October 2022.

⁶² Fedchenko (note 42).