

**Ukraine's Nuclear Shadow:**  
*National Security Implications for NATO and the UK*

**By Dr Bahram Ghiassaei**



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## About the Henry Jackson Society

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## About the Russia and Eurasia Studies Centre

The **Russia and Eurasia Studies Centre** undertakes in-depth, analytically-focused research into domestic and foreign policy issues in Russia and other post-Soviet states. Established in 2010 as the Russia Studies Centre, the programme's geographical scope has widened since 2014, mirroring the high level of importance attached to the region.

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**The Centre on Radicalisation and Terrorism (CRT)** at the Henry Jackson Society is unique in addressing violent and non-violent extremism. By coupling high-quality, in-depth research with targeted and impactful policy recommendations, we aim to combat the threat of radicalisation and terrorism in our society.

## Executive Summary

This research paper addresses the national security implications of the potential and actual nuclear and radiological events in Ukraine for the UK and the European members of NATO.

The armed conflict, over the past 20 months, has had significant humanitarian, economic, and environmental impacts in Ukraine, and profound energy security and national security implications for the country, NATO, and the UK.

The conflict, from the very outset, has been fought under the long shadow of nuclear weapons. The prolongation and escalation of the conflict, the supply of advanced weapons systems by the West, and the failure of the Kremlin to achieve its military objectives might be used as justification by Russia to deploy its 'battlefield' tactical nuclear weapons, with catastrophic consequences. In this context, the paper discusses the risks posed.

The paper also assesses the unprecedented aerial attacks by Russian forces on nuclear and radiological facilities, and their occupation, which have severely undermined safety and security at these facilities. Moreover, the paper examines the impact of Russian attacks on the physical integrity of these facilities, and the significant increase in risks associated with nuclear accidents, loss of proliferation-sensitive nuclear materials, and unauthorised access to radioactive substances which could be used for malicious purposes.

The paper reiterates that a major nuclear accident could have significant implications for Ukraine, Europe, and the UK. The paper also notes that equally alarming is the prospect of non-State actors – including proxy groups acting for hostile States, terrorists, and organised crime syndicates – acquiring small quantities of radioactive substances. Such materials could be the subject of illicit transnational trafficking, and be used to construct radiological "dirty bombs", thus presenting a significant risk to major cities across Europe, the UK, and the Middle East & North Africa (MENA) region.

The research paper advocates a number of policy recommendations, as noted below:

1. The UK and NATO to utilise the diplomatic and political conduits available to de-escalate the dangerous nuclear rhetoric, the spectre of which is looming over Europe.
2. The UK and NATO to lend their diplomatic, political, and financial support to the IAEA in establishing a 'nuclear safety and security protection zone' around the NPPs in Ukraine.
3. The land and maritime borders and crossings in the UK and Europe be strengthened, and radiation detection devices be deployed widely, to prevent illicit transnational trafficking of radioactive substances and sources, and mitigate risks posed by radiological terrorism.
4. A re-assessment of national security policies & strategies in relation to prevention, detection, emergency preparedness, and response to nuclear and radiological events be implemented.
5. The UK and NATO to initiate the drafting and adoption of an international legal instrument in relation to the safety and security of nuclear and radiological facilities during armed conflict.

## Glossary

1. **BWR** - Boiling Water Reactor
2. **ChNPP** - Chernobyl Nuclear Power Plant
3. **CSFSF** - Centralised Spent Fuel Storage Facility
4. **CTBT** - Comprehensive Nuclear-Test-Ban Treaty
5. **CTBTO** - Comprehensive Nuclear-Test-Ban Treaty Organization
6. **IAEA** - International Atomic Energy Agency
7. **ISF-1** - Intermediate Wet Spent Fuel Storage Facility at the Chernobyl Site
8. **ISF-2** - Intermediate Dry Spent Fuel Storage Facility at the Chernobyl Site
9. **KhNPP** - Khmel'nitsky Nuclear Power Plant
10. **MENA** - Middle East and North Africa
11. **NATO** - North Atlantic Treaty Organisation
12. **NPT** - Treaty on the Non-Proliferation of Nuclear Weapons
13. **NWS** - Nuclear-Weapon States
14. **NNWS** - Non-Nuclear-Weapon States
15. **NPP** - Nuclear Power Plant
16. **NTI** - Nuclear Threat Initiative
17. **PWR** - Pressurised Water Reactor
18. **RDD** - Radiological Dispersal Device
19. **RNPP** - Rivne Nuclear Power Plant
20. **SIPRI** - Stockholm International Peace Research Institute
21. **SNRIU** - State Nuclear Regulatory Inspectorate of Ukraine
22. **START** - New Strategic Arms Reduction Treaty
23. **SUNPP** - South Ukraine Nuclear Power Plant
24. **Uatom** - Information website of the State Nuclear Regulatory Inspectorate of Ukraine
25. **UAV** - Unmanned Aerial Vehicle (Drone)
26. **UNGA** - United Nations General Assembly
27. **UNSC** - United Nations Security Council
28. **WNA** - World Nuclear Association
29. **WNN** - World Nuclear News
30. **ZNPP** - Zaporizhzhia Nuclear Power Plant



## Chapter 1. Introduction

This research paper assesses the national security implications of the potential and actual nuclear and radiological events in Ukraine for the UK and the European members of NATO.

The armed conflict in Ukraine over the past 20 months has had significant societal, economic and environmental impacts in the country, and profound energy security and national security implications for Ukraine, and the European members of NATO, including the UK.

The conflict, from the very outset, has been fought under the long shadow of nuclear weapons, the escalation of which could lead to the deployment of tactical nuclear weapons, with devastating implications for the national security of Ukraine, the neighbouring countries, the UK and the European members of NATO. As Mr Guterres, the UN Secretary-General, has noted: “The prospect of nuclear conflict, once unthinkable, is now back within the realm of possibility.”<sup>1</sup>

Unprecedented aerial attacks on nuclear facilities have severely undermined the nuclear safety and nuclear security at the facilities. Attacks have also significantly increased the risk of nuclear accidents, the loss of proliferation-sensitive nuclear material, and unauthorised access to radioactive substances which could be used for malicious purposes.

The Russian seizure of the Chernobyl nuclear power plant (ChNPP) on 24 February 2022 re-awakened the fears and anxieties experienced by millions of people across Europe, following the Chernobyl nuclear accident in 1986. A repeat of the accident is impossible, as none of the four nuclear reactors are operational; however, large quantities of spent (used) nuclear fuel and radioactive waste are stored at the site, and in the 2,800km<sup>2</sup> Exclusion Zone around the ChNPP.

In view of their vulnerability to shelling, missile strikes, drone (Unmanned Aerial Vehicle, UAV) attacks, and mine explosions, the facilities are posing significant humanitarian, economic, environmental, and nuclear proliferation risks.

The aerial attacks and subsequent Russian occupation of the Zaporizhzhia NPP, the largest NPP in Europe with six reactors, has created a precarious nuclear safety and security situation, and a major concern for the International Atomic Energy Agency (IAEA). In addition to the six reactors, the site contains a number of facilities for the storage of spent fuel, and storage of radioactive waste.

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<sup>1</sup> UN, ‘Secretary-General’s remarks to the Press on the war in Ukraine’, 14 March 2022, <https://www.un.org/sg/en/content/sg/press-encounter/2022-03-14/secretary-generals-remarks-the-press-the-war-ukraine-delivered>

Alarming, in excess of 3,000 spent nuclear fuel rods, containing highly radioactive substances and plutonium, are stored inside metal casks within towering concrete structures, and thus highly vulnerable to aerial attacks.<sup>2</sup>

Moreover, aerial attacks and other military operations have affected the integrity of some of the radiological facilities, and resulted in the loss of radioactive substances. More than 5,000 radioactive sources are used in medical, research and industrial applications in Ukraine, and thousands of disused radioactive sources are stored in interim storage facilities across the country.

Further damage to the physical integrity of these facilities could lead to the illicit acquisition of these sources by proxy groups acting for hostile States, fundamentalist terrorists, international crime syndicates, and other non-State actors. Indeed, during the military occupation of ChNPP, in February 2022, looters raided one of the laboratories where radioactive sources and other radioactive materials were being used.<sup>3</sup>

Gramme-quantities of radioactive substances, including radioactive sources used in medical applications, may be used for the simple construction of radiological dispersal devices<sup>4</sup> (RDDs), or mixed with conventional explosives to construct 'dirty bombs'<sup>5</sup>. State-sponsored terrorists, proxy groups, and other non-State actors may acquire radioactive substances, and illicitly traffic them across national boundaries. Such materials could end up in major European cities, the UK, and the Middle East and North Africa (MENA) region, posing a significant threat to national and regional security.

Such devices could be used in attacks on critical infrastructure, crowded public events, and transport hubs in London and other major cities. The geographical extent of radioactive contamination, the cost of decontamination, which could exceed a billion pounds, and the disruption to daily activities in the affected areas would be immense.<sup>6</sup>

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<sup>2</sup> Arthur Neslen, 'Nuclear waste stored in "shocking" way 120 miles from Ukrainian front line', *The Guardian*, 13 May 2015, <https://www.theguardian.com/environment/2015/may/06/nuclear-waste-stored-in-shocking-way-120-miles-from-ukraine-front-line>

<sup>3</sup> Richard Stone, 'Dirty bomb ingredients go missing from Chernobyl lab', *Science*, Vol. 376 No. 6588, 1 April 2022, pp.12-13, <https://www.science.org/doi/epdf/10.1126/science.abq2800>

<sup>4</sup> U.S. Department of Health & Human Services, 'Radiological Dispersal Devices (RDDs)', Radiation Emergency Medical Management, (REMM), updated 8 November 2023, <https://remm.hhs.gov/rdd.htm>

<sup>5</sup> U.S. Nuclear Regulatory Commission, 'Backgrounder on Dirty Bombs', updated 23 February 2022, <https://www.nrc.gov/reading-rm/doc-collections/fact-sheets/fs-dirty-bombs.html>

<sup>6</sup> Bahram Ghiassee, 'Radiological Terrorism – A Global Policy Challenge in Need of Urgent Action', HJS, July 2022, p.18, <https://henryjacksonsociety.org/wp-content/uploads/2022/08/HJS-Radiological-Terrorism-Report-web.pdf>

Radiological terrorism constitutes a significant asymmetric threat to the national security of the UK and other NATO countries, noting the potential humanitarian, economic, and environment risks associated with the malicious use of radioactive substances.

Alarmingly, in March 2022, Ukraine informed the UN that it was no longer able to fulfil its international legal obligations under the International Convention on the Suppression of Acts of Nuclear Terrorism, which criminalises the unlawful acquisition of nuclear and radiological materials by non-State actors for malicious purposes.<sup>7, 8</sup>

In October 2022, the Russian Defence Minister alleged that Ukraine was developing a ‘dirty bomb’, with a view to detonating it in its own territory, and then “accusing Russia of launching a tactical nuclear weapon attack”. In a letter to the president of the United Nations Security Council (UNSC) the following day, Moscow reiterated its allegations, and placed “its forces on alert for a possible biological, chemical or nuclear attack”. A number of UNSC members have expressed their concern that Russia’s allegations could, indeed, be a pretext for escalation of the military conflict, and the actual deployment of a ‘dirty bomb’ by Moscow in Ukraine.<sup>9, 10</sup>

The IAEA has deplored the Russian Federation’s actions in Ukraine, and has expressed “grave concern” regarding the implications for nuclear safety, nuclear security, and nuclear safeguards in the country.<sup>11</sup> The IAEA has repeatedly briefed the United Nations General Assembly (UNGA), the UNSC, and other international organisations of the precarious nuclear safety and security situation in Ukraine.<sup>12</sup>

The UNGA has also strongly deplored the Russian aggression against Ukraine, in violation of Article 2(4) of the UN Charter. It has, moreover, condemned Russia’s declaration, on 24 February 2022, of a

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<sup>7</sup> NTI Nuclear Security Index, ‘Falling Short in a Dangerous World’, July 2023, p.46; footnote 5, [https://www.ntiindex.org/wp-content/uploads/2023/07/2023\\_NTI-Index\\_Report.pdf](https://www.ntiindex.org/wp-content/uploads/2023/07/2023_NTI-Index_Report.pdf)

<sup>8</sup> UN, ‘International Convention for the Suppression of Acts Of Nuclear Terrorism, Ukraine: Communication’, 4 March 2022, <https://treaties.un.org/doc/Publication/CN/2022/CN.72.2022-Eng.pdf>

<sup>9</sup> Security Council Report, ‘Ukraine: Meetings under the “Threats to International Peace and Security” Agenda Item’, 27 October 2022, <https://www.securitycouncilreport.org/whatsinblue/2022/10/ukraine-meetings-under-the-threats-to-international-peace-and-security-agenda-item.php>

<sup>10</sup> François Diaz-Maurin and Dan Drollette Jr, ‘Russia says Ukraine is preparing a “dirty bomb.” Is it true, and what does it mean?’, Bulletin of the Atomic Scientists, 27 October 2022, <https://thebulletin.org/2022/10/russia-says-ukraine-is-preparing-a-dirty-bomb-is-it-true-and-what-does-it-mean/#post-heading>

<sup>11</sup> IAEA, ‘The safety, security and safeguards implications of the situation in Ukraine’, GOV/2022/17, 3 March 2022, <https://www.iaea.org/sites/default/files/22/03/gov2022-17.pdf>

<sup>12</sup> IAEA, ‘Nuclear Safety and Security in Ukraine, Update 192 – IAEA Director General Statement on Situation in Ukraine’, 3 November 2023, <https://www.iaea.org/nuclear-safety-and-security-in-ukraine>

“special military operation” in Ukraine and, equally, the decision to heighten the readiness of its nuclear forces.<sup>13</sup>

Moreover, the international community considers attacks on nuclear power plants and associated facilities as a violation of the provisions of the 1977 Protocol I (article 56) and Protocol II (article 15) of the 1949 Geneva Convention.<sup>14,15</sup> It is argued that the Russian Federation is in contravention of its international legal obligations, as it is party to Protocol II of the Convention. In addition, the rules of International Humanitarian Law, specifically Rule 42, apply to attacks on nuclear facilities.<sup>16</sup> Again, Russia is regarded as being in violation of its legal obligations under international law, as it has incorporated Rule 42 in its military guidelines. Notwithstanding the existing legal framework, adoption of an international legal instrument specifically prohibiting attacks on civilian nuclear and radiological facilities during armed conflict would enhance and strengthen the applicable international legal regime.

The UK Government has, indeed, indicated that “The most pressing national security and foreign policy priority in the short-to-medium term is to address the threat posed by Russia to European security.”<sup>17</sup>

The methodology adopted in the preparation of this research report was based on a detailed review of the open literature in the public domain, and open-source reports and documents encompassing a number of specific issues relevant to this research report: (i) The nuclear arsenal of the Russian Federation, including ‘tactical nuclear weapons’; (ii) The status of the NPPs and associated facilities in Ukraine; (iii) The status of the Nuclear Research Centres under the jurisdiction of Ukraine; (iv) Radioactive sources used in medical, research and industrial applications, and associated facilities; and (v) The vulnerability of infrastructure (utilities) serving nuclear and radiological facilities, including external power supplies and cooling water systems.

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<sup>13</sup> UNGA, ‘Resolution adopted by the General Assembly on 2 March 2022 - Aggression against Ukraine’, A/RES/ES-11/1, 18 March 2022, [https://digitallibrary.un.org/record/3965290/files/A\\_RES\\_ES-11\\_1-EN.pdf?withWatermark=0&withMetadata=0&version=1&registerDownload=1](https://digitallibrary.un.org/record/3965290/files/A_RES_ES-11_1-EN.pdf?withWatermark=0&withMetadata=0&version=1&registerDownload=1)

<sup>14</sup> Vitaly Fedchenko, ‘Nuclear Security During Armed Conflict: Lessons From Ukraine’, SIPRI Research Policy Paper, March 2023, p.5, [https://www.sipri.org/sites/default/files/2023-03/rpp\\_2303\\_ukraine\\_intl\\_security\\_0.pdf](https://www.sipri.org/sites/default/files/2023-03/rpp_2303_ukraine_intl_security_0.pdf)

<sup>15</sup> George M Moore, ‘How international law applies to attacks on nuclear and associated facilities in Ukraine’, Bulletin of the Atomic Scientists, 6 March 2022, <https://thebulletin.org/2022/03/how-international-law-applies-to-attacks-on-nuclear-and-associated-facilities-in-ukraine/>

<sup>16</sup> Ibid.

<sup>17</sup> HM Government, ‘Integrated Review Refresh 2023: Responding to a more contested and volatile world’, CP 811, March 2023, p.11, [https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment\\_data/file/1145586/11857435\\_NS\\_IR\\_Refresh\\_2023\\_Supply\\_AllPages\\_Revision\\_7\\_WEB\\_PDF.pdf](https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1145586/11857435_NS_IR_Refresh_2023_Supply_AllPages_Revision_7_WEB_PDF.pdf)

A critical assessment of the potential use of tactical nuclear weapons, and the threats posed to the safety and security of nuclear facilities and radiological facilities, was then carried out to ascertain the national security implications for the UK and European members of NATO. Information disseminated by a number of entities was found to be of specific value in the context of this research report, inter alia, the Bulletin of the Atomic Scientists; IAEA; Nuclear Threat Initiative (NTI); Stimson Center; Stockholm International Peace Research Institute (SIPRI); 'Uatom' (the information website of the State Nuclear Regulatory Inspectorate of Ukraine, SNRIU); and the World Nuclear Association (WNA).

In addressing and assessing the national security implications for the UK and European NATO members, this report is structured into six chapters. Following this introduction, Chapter 2 assesses the potential deployment of tactical nuclear weapons, and the implications for the national security of the UK and NATO. Chapter 3 reviews the recent attacks on nuclear sites and facilities in Ukraine, and their implications for the UK and NATO. Chapter 4 assesses the attacks on radiological facilities, and their implications. Chapter 5 examines damage to infrastructure (utilities) serving the nuclear and radiological facilities. Finally, Chapter 6 presents the concluding remarks and policy recommendations.

## Chapter 2. Deployments of Tactical Nuclear Weapons, and Their Implications

Almost eight decades after their deployment, and 55 years after the adoption of the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) in 1968, nuclear weapons continue to pose the most alarming threat to regional and global security. The spectre of nuclear weapons is now looming over Europe. The atomic (nuclear) bombs dropped on Hiroshima and Nagasaki should, however, serve as a stark reminder to the belligerents in the armed conflict in Ukraine, and other European countries, of the devastating powers of such weapons, and their economic, humanitarian, environmental, and national security implications.

Indeed, the armed conflict in Ukraine has been fought under the long shadow of nuclear weapons from the very outset, notwithstanding the threats which nuclear weapons pose to regional and global security.<sup>18</sup> As the UN Secretary-General, Mr Guterres, noted in the early months of the war, “The prospect of nuclear conflict, once unthinkable, is now back within the realm of possibility.”<sup>19</sup>

Moscow’s alarming rhetoric and repeated threats to use tactical nuclear weapons in Ukraine are posing major global security challenges. The Kremlin’s evolving nuclear posture is undermining the global nuclear non-proliferation architecture; weakening the already fragile ‘Nuclear Arms Control’ regime; eroding the foundations of nuclear disarmament; and heightening the risk of a nuclear confrontation in Europe, involving NATO.

The Russian President, on the very first day of the invasion, on 24 February 2022, made veiled threats regarding the use of nuclear weapons, and a few days later placed Russia’s nuclear forces on “high alert”, noting that: aggressive “statements” from NATO had prompted him to do so.<sup>20</sup> The Kremlin’s threat of using nuclear weapons is designed to deter the West’s support and intervention.<sup>21</sup>

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<sup>18</sup> Giles David Arceneaux, ‘Whether to worry: Nuclear weapons in the Russia-Ukraine war’, *Contemporary Security Policy*, Vol.44 No.4, 2023, p.561,

<https://www.tandfonline.com/doi/epdf/10.1080/13523260.2023.2260175?needAccess=true>

<sup>19</sup> UN, ‘Secretary-General’s remarks to the Press on the war in Ukraine’

<sup>20</sup> Hans M. Kristensen, Matt Korda and Eliana Johns, ‘Nuclear Notebook: Russian nuclear weapons, 2023’, *Bulletin of the Atomic Scientists*, Vol.79 No.3, 9 May 2023, p.180, <https://thebulletin.org/premium/2023-05/nuclear-notebook-russian-nuclear-weapons-2023/>

<sup>21</sup> Heather Williams, ‘Russia Suspends New START and Increases Nuclear Risks’, Center for Strategic & International Studies (CSIS), 23 February 2023, <https://www.csis.org/analysis/russia-suspends-new-start-and-increases-nuclear-risks>

In his 'Address to the Nation' on 21 September 2022, President Putin announced the partial mobilisation of the country's military, and also made an indirect threat of use of nuclear weapons. In his speech, Mr Putin accused the US and its allies of engaging in "nuclear blackmail", noting that Russia has different types of weapons, some of which are more modern than the NATO weapons. He further reiterated that in the event of a threat to the territorial integrity of the country and its people, Russia would make use of all its weapons systems.<sup>22, 23, 24</sup>

Later, in October 2022, Mr Putin reiterated and compounded his previous implicit threats, declaring explicitly that nuclear weapons would be used, should the territorial integrity of Russia come under threat. As a result, the threshold for using nuclear weapons in response to a conventional attack has been lowered from an 'existential threat' to the 'threat to territorial integrity' of Russia.<sup>25</sup> It is understood that, in this context, territorial integrity encompasses the annexed regions of Ukraine.

Given Russia's annexation of Crimea in 2014, and its annexation of the four Eastern regions of Ukraine in 2022 – and despite the UNGA having dismissed both claims as illegitimate and illegal – its evolving nuclear doctrine increases the prospect of a nuclear conflict.

The Kremlin's nuclear rhetoric has been compounded by a number of nuclear policy decisions which have further heightened the risk of nuclear confrontation in Europe. As noted previously, Moscow, in October 2022, alleged that Ukraine was intending to use a 'dirty bomb', and then claim that Russia had launched a tactical nuclear weapon.<sup>26</sup> The allegations were construed by some Western analysts as another crude effort by the Russian Federation to create a pretext for nuclear escalation.<sup>27</sup>

Moreover, on 21 February 2023, the Kremlin suspended its participation in the 2010 New Strategic Arms Reduction Treaty (New START), the last remaining strategic 'Nuclear Arms Control' treaty between Russia and the US. The Russia Federation was arguing that it needed to have a clear idea as

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<sup>22</sup> The Kremlin, 'Address by the President of the Russian Federation', 21 September 2022, <http://en.kremlin.ru/events/president/news/69390>

<sup>23</sup> Francois Diaz-Maurin, "'Not a bluff:' Losing ground in Ukraine, Putin raises nuclear threats', Bulletin of the Atomic Scientists, 21 September 2022, <https://thebulletin.org/2022/09/not-a-bluff-losing-ground-in-ukraine-putin-raises-nuclear-threats/>

<sup>24</sup> Stephen J. Cimbala and Lawrence J. Korb, 'Putin's "bluff": a cautionary note about underestimating the possibility of nuclear escalation in Ukraine', The Bulletin of Atomic Scientists, 2 October 2023, <https://thebulletin.org/2023/10/putins-bluff-a-cautionary-note-about-underestimating-the-possibility-of-nuclear-escalation-in-ukraine/#post-heading>

<sup>25</sup> Arceneaux, 'Whether to worry', p. 569.

<sup>26</sup> Security Council Report, 27 October 2022

<sup>27</sup> Nigel Gould-Davies, 'Russia's "dirty bomb" diplomacy', The International Institute for Strategic Studies (IISS), 26 October 2022, <https://www.iiiss.org/online-analysis/online-analysis//2022/10/russias-dirty-bomb-diplomacy>

to the combined strategic arsenal of the Alliance, including “NATO countries such as France or Great Britain”.<sup>28</sup>

The Kremlin was reacting to an earlier statement by the US State Department, on 31 January 2023, that Russia was in violation of the New START. The Treaty, signed by Russia and the US in Prague on 8 April 2010, has played an effective role in ensuring transparency in the reduction of ‘strategic nuclear weapons’ by both parties.

The uncertainty created by Russia suspending its participation could lead to further tension between the world’s two nuclear superpowers, and their respective allies. It could also weaken the nuclear non-proliferation regime.<sup>29</sup> Indeed, Nuclear-Weapon States (NWS) might decide to resume testing, or accelerate the pace of the modernisation of their nuclear arsenals. Non-Nuclear-Weapon States (NNWS), on the other hand, may construe the revival of the nuclear arms race as yet another failure of the NWS in meeting their international legal obligations, under the NPT, to work towards nuclear disarmament. They might, thus, decide, as North Korea did, to withdraw from the NPT and embark on nuclear weapons programmes.

Moscow’s suspension of its participation in the New START, coupled with its ‘Nuclear Sharing’ with Belarus, and lowering the threshold for the use of nuclear weapons, have further exacerbated the precarious nuclear dimension of the conflict. It may, thus, prompt NATO to reassess its nuclear posture, in response to Russia’s evolving nuclear doctrine.

Following the collapse of the Soviet Union, President Alexander Lukashenko, in the 1990s, agreed to the full removal of Soviet nuclear weapons from Belarus, and also the destruction of the delivery vehicles.<sup>30</sup> However, this was reversed by President Putin’s announcement in March 2023 that the construction of a “special storage facility for tactical nuclear weapons” in Belarus will be completed by July 2023. The actual number of nuclear weapons transferred to the territory of Belarus is yet to be ascertained.<sup>31, 32, 33</sup>

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<sup>28</sup> Kristensen, ‘Nuclear Notebook: Russian nuclear’, p.179.

<sup>29</sup> Dan Smith, ‘Statement by Dan Smith, SIPRI Director: Suspending the New START treaty benefits nobody’, SIPRI, 22 February 2023, <https://www.sipri.org/media/press-release/2023/statement-dan-smith-sipri-director-suspending-new-start-treaty-benefits-nobody>

<sup>30</sup> William Courtney, ‘Countering Russia’s Nuclear Threat in Europe’, Rand Corporation, 20 April 2023, <https://www.rand.org/blog/2023/04/countering-russias-nuclear-threat-in-europe.html>

<sup>31</sup> Kristensen, ‘Nuclear Notebook: Russian nuclear’, p.181.

<sup>32</sup> BBC News, ‘Ukraine war: Putin confirms first nuclear weapons moved to Belarus’, 17 June 2023, <https://www.bbc.co.uk/news/world-europe-65932700>

<sup>33</sup>UN, ‘Deployment of Nuclear Weapons to Belarus Debated in First Committee, as Delegates Rethink Global Security’, GA/DIS/3712, 5 October 2023, <https://press.un.org/en/2023/gadis3712.doc.htm>



More recently, the decision by the State Duma (Russian Parliament), on 18 October 2023, to revoke the ratification of the 1996 Comprehensive Nuclear-Test-Ban Treaty (CTBT) is construed as the latest warning to the US and European members of NATO. The Kremlin is arguing that the decision to withdraw from the CTBT is premised on the notion that 23 years after it ratified the treaty, the US has failed to reciprocate.<sup>34</sup> Russia is also arguing that the US has signalled the resumption of nuclear testing, to enhance its nuclear capabilities.<sup>35</sup> There is, however, no independent corroboration of Russia's stance on this issue.

Notwithstanding, Moscow is to retain its cooperation with the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO), and the Treaty's verification system.<sup>36</sup> The CTBT is to enter into force, pending ratification by China, Egypt, the Islamic Republic of Iran, India, Israel, Pakistan, North Korea, and the US.

Arms control experts in the West have argued that President Putin's intention is not to initiate a nuclear arms race, but to generate alarm and uncertainty amongst States supporting Ukraine, as it did with the suspension of New START, earlier in February 2023.<sup>37</sup>

The Kremlin's continual threat of nuclear escalation may also be regarded as the creation of a shield behind which it can conduct its conventional war against Ukraine, while deterring the direct involvement of other countries, in particular NATO members.<sup>38</sup>

To further deter NATO, and signal its resolve to create a nuclear dimension to the war, the Russian Federation could threaten, as it has done previously, to deploy 'Intermediate-Range Missiles' (500 to 5,500km) capable of carrying nuclear weapons.<sup>39</sup> There is, however, uncertainty regarding the numbers and readiness of these weapons. The unilateral withdrawal of the US from the

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<sup>34</sup> CTBTO Preparatory Commission, 'Status of Signature and Ratification', 2023, <https://www.ctbto.org/our-mission/states-signatories>

<sup>35</sup> Hugh Chalmers, 'Commentary on De-Ratification of the CTBT by Russia', Verification Research, Training and Information Centre (VERTIC), 20 October 2023, <https://www.vertic.org/2023/10/commentary-on-de-ratification-of-the-ctbt-by-russia/>

<sup>36</sup> ICAN, 'Russia revokes ratification of nuclear test ban treaty (CTBT)', 18 October 2023, [https://www.icanw.org/russia\\_revokes\\_ratification\\_of\\_nuclear\\_test\\_ban\\_treaty\\_ctbt](https://www.icanw.org/russia_revokes_ratification_of_nuclear_test_ban_treaty_ctbt)

<sup>37</sup> Dan Smith, Wilfred Wan and Matthew Bunn, 'Russia's potential withdrawal from the Comprehensive Nuclear-Test-Ban Treaty underlines the urgent arms control problem', SIPRI, 17 October 2023, <https://www.sipri.org/commentary/expert-comment/2023/russias-potential-withdrawal-comprehensive-nuclear-test-ban-treaty-underlines-urgent-arms-control#:~:text=Russia%20has%20suspended%20its%20participation,cent%20of%20all%20nuclear%20weapons>

<sup>38</sup> Arceneaux, 'Whether to worry', p.567.

<sup>39</sup> Ibid., p.568.

Intermediate-Range Nuclear Forces (INF) Treaty, in 2019, put an end to the monitoring and verification of this class of nuclear-armed missiles.

Russia's strategic calculus may not be sustainable, as the prolongation of the armed conflict, the supply of advanced weapons systems by the West, and the gradual escalation of the war coupled with increased Russian losses, could lead to the Russian Federation deploying its 'battlefield' tactical nuclear weapons. The Kremlin's arsenal of 5,889 nuclear weapons includes 1,816 low-yield short-range tactical nuclear weapons.<sup>40</sup>

Russia, according to its Defence Minister, Sergei Shoigu, has recently carried out exercises that involved "delivering a massive nuclear strike by strategic offensive forces in response to an enemy nuclear strike".<sup>41</sup>

A nuclear attack on Ukraine, using low-yield tactical weapons, could affect a number of NATO members, in particular Hungary, Poland, Romania and Slovakia, due to the transboundary impact of the radioactive fallout, and other radioactive particles. It could, thus, be construed as a radiological weapon attack against NATO allies, invoking the provisions of Article 5 of the 1949 North Atlantic Treaty (Washington Treaty) and warranting a collective response by NATO.<sup>42</sup>

Reciprocal action by NATO, including deploying tactical nuclear weapons, could ensue. The US, in line with NATO's 'Nuclear Deterrence Policy', has some 100 tactical nuclear gravity bombs (B-61) stationed in Belgium, Germany, Italy, the Netherlands and Türkiye.<sup>43</sup>

The UK Government has noted that "NATO is the foundation of collective security in the Euro-Atlantic, and our commitment to Article 5 of the North Atlantic Treaty is our most powerful deterrent." The UK Government has also stated, as a matter of policy, that "We would consider using our nuclear weapons only in extreme circumstances of self-defence, including the defence of our NATO allies." The direct involvement of France and the UK, deploying their advanced nuclear missiles, under the auspices of NATO, could lead to a major nuclear confrontation in Europe.<sup>44</sup>

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<sup>40</sup> Kristensen, 'Nuclear Notebook: Russian nuclear'.

<sup>41</sup> George Wright, 'Russia says it rehearsed "massive" nuclear strike', BBC News, 25 October 2023, [www.bbc.com/news/world-europe-6722213](https://www.bbc.com/news/world-europe-6722213)

<sup>42</sup> NATO, 'Collective defence and Article 5', 4 July 2023, [https://www.nato.int/cps/en/natohq/topics\\_110496.htm#:~:text=Article%205%20provides%20that%20if,to%20assist%20the%20Ally%20attacked](https://www.nato.int/cps/en/natohq/topics_110496.htm#:~:text=Article%205%20provides%20that%20if,to%20assist%20the%20Ally%20attacked)

<sup>43</sup> Center for Arms Control and Non-Proliferation, 'Fact Sheet: U.S. Nuclear Weapons in Europe', 18 August 2021, <https://armscontrolcenter.org/fact-sheet-u-s-nuclear-weapons-in-europe/>

<sup>44</sup> 'Integrated Review Refresh', pp.33 & 41.

Moreover, the US, as a nuclear superpower and a key member of NATO, may get involved, deploying its long-range strategic nuclear weapons, thus escalating the nuclear conflict beyond Europe's borders. Indeed, on 25 September 2022, the US National Security Adviser stated that the US and its allies would take decisive action with "catastrophic consequences", should Russia use tactical nuclear weapons in Ukraine.<sup>45</sup>

Nuclear confrontation, even if limited to the territory of Ukraine, would have severe humanitarian, economic and ecological ramifications for Ukraine and other countries in Europe. Equally, the impact on critical infrastructure, public health, food security, and energy security would have profound implications for the national security of the UK and other European members of NATO. The 2,000 or so atomic (nuclear) tests conducted by China, France, the UK, USSR and US, and the atomic (nuclear) bombs dropped on Hiroshima and Nagasaki, are testaments to the destructive powers of nuclear weapons, the devastation they cause, and their long-term impact.

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<sup>45</sup> Edward Helmore, 'Jake Sullivan: US will act "decisively" if Russia uses nuclear weapons in Ukraine', *The Guardian*, 25 September 2022, <https://www.theguardian.com/us-news/2022/sep/25/us-russia-ukraine-war-nuclear-weapons-jake-sullivan#:~:text=We%20have%20communicated%20directly%2C%20privately,Sullivan%20told%20CBS%27s%20Face%20the>

## Chapter 3. Attacks on Nuclear Sites and Facilities, and Their Implications

Ukraine's nuclear power programme spans over half a century, starting with the construction of the Chernobyl Nuclear Power Plant (ChNPP) in 1970, the first reactor unit of which came into operation in 1977. Reactor unit 4, which started generating electricity in 1983, was destroyed in the 1986 nuclear accident, releasing radioactivity which reached Western European countries, including the UK.<sup>46</sup>

The country operates 15 nuclear reactors at four NPPs: Khmelnytsky (KNPP) in the west with two reactors; Rivne (RNPP) in the north-west with four reactors; South Ukraine (SUNPP) with three reactors; and Zaporizhzhia (ZNPP) with six reactors, in the currently occupied region of Zaporizhzhia in the south-east of the country. All 15 reactors are based on the Russian VVER design – water cooled and water moderated – and are similar to the Pressurised Water Reactor (PWR) design in the West. All 15 reactors are fundamentally different to the Chernobyl reactors and, hence, much safer. Prior to the start of the armed conflict, the NPPs generated 51% of Ukraine's electricity.<sup>47</sup>

All nuclear facilities, nuclear operations, and activities related to the use of radioactive sources in medical, research, and industrial applications are regulated by the State Nuclear Regulatory Inspectorate of Ukraine (SNRIU). However, the armed conflict has created challenges for the management and regulatory control of nuclear facilities located in the regions annexed by Russia, and also the facilities which Russian forces have occupied, including ZNPP, the largest nuclear power plant in Europe.

Attacks on NPPs, spent nuclear fuel storage facilities, radioactive waste treatment plants, and radioactive waste storage areas could result in the release of large quantities of radioactive substances, with profound transnational ramifications for public health, the economy, and the environment. Japan is still grappling with the environmental and economic legacies of the 2011 Fukushima Daiichi nuclear accident. China and South Korea have also been concerned with the release of radioactivity into the Pacific Ocean, and the impacts it is having on, inter alia, their fishing industry, and the people living in coastal areas. The security implications for Ukraine, the UK, and European NATO members would be equally alarming.

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<sup>46</sup> WNA, 'Nuclear Power in Ukraine', updated May 2023, <https://world-nuclear.org/information-library/country-profiles/countries-t-z/ukraine.aspx>

<sup>47</sup> Ibid.

As noted previously, physical damage to the structure of these facilities also poses the risk of radioactive substances being illicitly acquired by proxy groups, terrorists, organised criminal gangs, and other non-State actors for the construction of 'dirty bombs'. These radioactive substances could also be illicitly trafficked across national borders, thus posing significant security threats to Ukraine, and countries beyond its borders, including the UK.

Drones may be effectively used to transport radioactive substances, and may also be used by proxy groups, and other non-State actors, to illicitly transport small quantities of high-activity radioactive substances across borders for malicious activities. 'Drone Delivery Canada Corporation' was recently granted authorisation to transport medical radioisotopes using drones.<sup>48</sup>

Indeed, the 2023 arrest by the UK Counter-Terrorism Police of Bulgarian nationals who were acting as Russian spies<sup>49</sup>, and the assassination of Alexander Litvinenko in 2008 by Russian Secret Agents, using micro-gramme quantities of highly radioactive Polonium-210, demonstrate the national security threats posed to the UK and European countries, as discussed in detail below.

### **3.1 Chernobyl Nuclear Power Plant Site, and the Chernobyl Exclusion Zone**

The Chernobyl nuclear power plant site and the 2,800km<sup>2</sup> Chernobyl Exclusion Zone were occupied on the first day of the Russian invasion, and were under Russian control for a period of five weeks, from 24 February to 31 March 2022.

As noted previously, in 1986, ChNPP was the site of the worst nuclear accident in the history of commercial nuclear power plant operations, the radioactive release of which reached as far as the UK and Iceland. The site consists of six reactor units, of which units 1, 2 and 3 are permanently shut down, and units 5 and 6 were never commissioned. The partially destroyed reactor unit 4 was initially covered with a shelter facility, and is now protected by the 'New Safe Confinement', costing €1.5 billion.<sup>50</sup>

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<sup>48</sup> WNN, 'Canadian approvals milestone for drone delivery of radioisotopes', 16 June 2023, <https://world-nuclear-news.org/Articles/Canadian-approvals-mark-milestone-for-drone-delive>

<sup>49</sup> Dan Sabbagh, Five Bulgarians living in UK charged with spying for Russia, *The Guardian*, 21 September 2023, [https://www.theguardian.com/uk-news/2023/sep/21/uk-prosecutors-authorise-charges-against-five-people-suspected-of-spying-for-](https://www.theguardian.com/uk-news/2023/sep/21/uk-prosecutors-authorise-charges-against-five-people-suspected-of-spying-for-russia#:~:text=Nick%20Price%2C%20the%20head%20of,an%20enemy%20for%20a%20purpose)

<sup>50</sup> IAEA, Nuclear Safety, 'Security and Safeguards In Ukraine: Summary Report by the Director General, 24 February – 28 April', April 2022, p.8, <https://www.iaea.org/sites/default/files/22/04/ukraine-report.pdf>

The large quantities of highly radioactive ruptured fuel elements, which melted at the time of the accident, due to excessive heat, pose significant environmental and security risks. There are also proliferation concerns, as they contain plutonium. The atomic (nuclear) bomb dropped on Nagasaki in 1945 contained just 6.2kg of plutonium.<sup>51</sup>

The ChNPP site also houses a wet spent fuel Interim Storage Facility (ISF-1), where most of the highly radioactive spent fuel assemblies are stored under water. Spent nuclear fuel is also stored in ponds at units 1 and 2. The ponds require a regular supply of cooling water, and also a reliable source of electricity to circulate the water. Loss of water could result in overheating, melting of the spent nuclear fuel rods, hydrogen generation, explosions, and the release of radioactivity into the environment. A dry spent fuel Interim Storage Facility (ISF-2) is also present at the ChNPP site, designed for storage of spent fuel from reactors 1, 2 and 3 for a 100-year period. Both ISF-1 and ISF-2 remain in operation.<sup>52, 53</sup>

In addition, the ChNPP site houses a 'Liquid Radioactive Waste Treatment Plant' and a 'Solid Radioactive Waste Management Facility' which were commissioned to treat the significant quantities of liquid and solid radioactive waste which accumulated over the many years of operation of ChNPP, the 1986 nuclear accident, and emergency response activities to the nuclear accident.<sup>54</sup>

Moreover, a centralised spent nuclear fuel storage facility (CSFSF) was built by the US-based Holtec International in the Exclusion Zone, to receive spent nuclear fuel from the Rivne, Khmelnytsky and South Ukraine NPPs for dry storage. The CSFSF is also to receive and store vitrified (solid) high-level radioactive waste from the reprocessing of Ukrainian nuclear fuel which is to be returned from Russia.<sup>55</sup>

In addition to the facilities noted above, numerous 'Radioactive Waste Management Facilities' are located in the Chornobyl Exclusion Zone for the processing and disposal of radioactive waste in the Zone. These include, inter alia, the Vector site; the three main radioactive waste disposal points; the

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<sup>51</sup> Christoph Wirz and Emmanuel Egger, 'Use of nuclear and radiological weapons by terrorists?', *International Review of the Red Cross*, Vol.87 No.859, September 2005, <https://international-review.icrc.org/sites/default/files/S1816383100184358a.pdf>

<sup>52</sup> IAEA, 'Nuclear Safety, Security and Safeguards in Ukraine', GOV/2023/30, 31 May 2023, <https://www.iaea.org/sites/default/files/23/06/gov2023-30.pdf>

<sup>53</sup> Uatom, 'Spent Fuel Management at the Chornobyl NPP', 2019, <https://www.uatom.org/en/operating-dsfsf-at-zaporizhzhya-npp/spent-fuel-management-at-the-chornobyl-npp>

<sup>54</sup> Uatom, 'The Main Facilities at Chornobyl NPP Industrial Site', 2019, <https://www.uatom.org/en/exclusion-zone-development>

<sup>55</sup> WNA, Ukraine, May 2023.

nine temporary radioactive waste confinement sites; and the centralised long-term storage facility (CLTSF), designed to store 500,000 disused radiation sources for up to 50 years.<sup>56</sup>

During the Russian military occupation of the Chernobyl site and the Exclusion Zone, higher than usual levels of radioactivity were detected in the environment. However, drone attacks and missile strikes would not give rise to a repeat of the 1986 nuclear accident, as none of the six reactors are operational. Notwithstanding, damage to off-site (external) power supplies and water-coolant systems could have severe consequences. The spent nuclear fuel ponds containing some 8,500 tonnes of used fuel rods require a regular supply of cooling water, and also a reliable source of electricity to circulate and replenish the water.<sup>57</sup>

Loss of electricity or water could result in the spent fuel rods overheating and melting, excessive hydrogen generation, explosions, and massive quantities of radioactivity released into the environment. Off-site electricity is also required for the ventilation system to remove the hydrogen gas, and prevent it from building up during normal operation of the ponds.

Moreover, aerial attacks and mine explosions could damage the dry storage facilities and radioactive waste storage sites in the Exclusion Zone, resulting in the release of significant quantities of radioactivity, with transboundary implications.

As noted in the preceding sections, damage to the physical integrity of the facilities could result in unauthorised access to or theft of radioactive materials by non-State actors, and its use in RDD devices, including 'dirty bombs', and illicit trafficking beyond Ukraine's borders, thus posing risks to the national security of Ukraine, the UK and European members of NATO. It is rather alarming that looters raided a radiation monitoring laboratory in the Chernobyl village, removing radioactive isotopes used for the calibration of instruments and also pieces of highly radioactive waste material.<sup>58, 59</sup>

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<sup>56</sup> Uatom, 'The Main Radioactive Waste Management Facilities in the Exclusion Zone', 2019, <https://www.uatom.org/en/the-main-radioactive-waste-management-facilities-in-the-exclusion-zone>

<sup>57</sup> Stone, 'Dirty bomb', pp.12-13.

<sup>58</sup> Ibid.

<sup>59</sup> Diaz-Maurin, 'Russia says'

### 3.2 Zaporizhzhia NPP (ZNPP)

ZNPP is the largest nuclear power plant in Europe, housing six reactor units. Since the start of the conflict, all six reactors have been progressively shut down, impacting energy security for Ukraine, and the European countries which were importing electricity from Ukraine. In addition to the reactors, ZNPP has fresh nuclear fuel storage facilities, spent nuclear fuel storage ponds, a dry spent nuclear fuel storage facility, and a solid radioactive waste storage facility.<sup>60</sup>

Being close to the conflict zone, ZNPP and its vicinity have been the target of frequent Russian shelling, missile strikes, and drone attacks. Landmine explosions and fire have also damaged buildings near the reactor units. An explosion on 12 April 2023, which damaged the windows of reactor unit 4, was attributed to a drone attack by Ukrainian forces.<sup>61</sup>

The off-site (external) electricity generators, power lines, and switchyards have been attacked by Russian forces on a number of occasions, resulting in the loss of power supply to the ZNPP, and reliance on back-up diesel generators for limited periods. Water supplies to the ZNPP and associated facilities have also been affected by the conflict. Following the destruction of the Nova Kakhovka dam in June 2023, water levels at the Kakhovka reservoir which provides cooling water for ZNPP had fallen significantly.

It is noteworthy that direct shelling, drone attacks, or missile strikes on the six reactor units will not lead to an accident similar to Chernobyl or Fukushima, due to their design characteristics. Firstly, the reactors are based on the VVR design, which is very similar to Pressurised Water Reactors (PWR) in the West. Secondly, a 'Containment Structure', a one-metre thick dome-shaped structure made of steel-reinforced concrete, houses each reactor. The containment structure is designed to protect the public and the environment from accidental releases of radioactivity, and also to protect the reactor from external threats. Thirdly, the reactors are water cooled and water moderated, and contain no graphite which catches fire at elevated temperatures, as was the case in the Chernobyl nuclear accident. All six reactor units are currently shut down.

However, attacks on coolant water systems, or simultaneous attacks on external (off-site) power supplies and diesel fuel storage tanks could lead to a nuclear accident similar to Fukushima in 2011,

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<sup>60</sup> WNA, 'Ukraine: Russia-Ukraine War and Nuclear Energy', updated 16 October 2023, <https://world-nuclear.org/information-library/country-profiles/countries-t-z/ukraine-russia-war-and-nuclear-energy.aspx>

<sup>61</sup> IAEA, 'Nuclear Safety', GOV/2023/30, 2023, p.10.



notwithstanding that the reactors at Fukushima were based on the less safe Boiling Water Reactor (BWR) design. Loss of coolant water could eventually result in the overheating and melting of the spent fuel inside the reactors; the generation and accumulation of hydrogen gas; hydrogen explosions; and disruption of the containment structure. This could release large quantities of radioactive particles and gases into the atmosphere which would contaminate vast areas of Ukraine, and across Europe.

This scenario is similar to the chain of events that in 2011 destroyed the Fukushima NPP. The same scenario applies to the spent nuclear fuel storage ponds located inside the containment structure of the reactors. Moreover, interruption to the supply of electricity would impact on the normal functioning of the control systems, radiation monitoring instruments, and the ventilation systems which prevent the build-up of hydrogen gas and radioactive gases inside the containment structures.

A massive 'Dry Spent Fuel Storage Facility' is located adjacent to ZNPP, the towering concrete structures of which hold thousands of spent (used) nuclear fuel elements. They contain high-activity radioactive substances, and weapon-usable plutonium. These concrete structures are highly vulnerable to aerial attacks. Physical damage could lead to extensive contamination of the environment, and public exposure. As noted previously, proxy groups, terrorists, criminal gangs, and other non-State actors may illicitly acquire the radioactive substances, with malicious intent. Also, they could be the subject of illicit transnational trafficking and used in the construction of 'dirty bombs' or other RDDs.

The IAEA has expressed concern that the nuclear safety and security situation at ZNPP continues to be fragile and potentially dangerous, and states that "We are fortunate that a nuclear accident has not yet happened."<sup>62</sup> The IAEA has also noted that the international community must do everything in its power, including the implementation of a "nuclear safety and security protection zone" to reduce the risk of a nuclear accident at ZNPP.<sup>63</sup>

The IAEA has acknowledged that the continued presence of the Agency's staff at ZNPP, and also the immediate establishment of a protection zone around ZNPP, are essential in preventing the occurrence of a nuclear accident.<sup>64</sup>

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<sup>62</sup> IAEA, 'IAEA Director General Statement to United Nations Security Council', 30 May 2023,

<https://www.iaea.org/newscenter/statements/iaea-director-general-statement-to-united-nations-security-council>

<sup>63</sup> IAEA, 'Nuclear Safety, Security and Safeguards in Ukraine, February 2022–February 2023', February 2023, <https://www.iaea.org/sites/default/files/23/02/nuclear-safety-security-and-safeguards-in-ukraine-feb-2023.pdf>

<sup>64</sup> IAEA, 'Nuclear Safety, Security and Safeguards in Ukraine', GOV/2022/66, 10 November 2022, p.7,

To assure the IAEA, President Zelenskiy has pledged that Ukrainian forces will not attack ZNPP in their counter-offensive operations to recapture the NPP, and surrounding areas.<sup>65</sup> It is noteworthy that ZNPP has been the target of aerial attacks by both belligerents.

### 3.3 Khmelnytsky, Rivne, and South Ukraine NPPs

Unlike ZNPP, Khmelnytsky, Rivne and South Ukraine NPPs have not been the targets of direct missile attacks, or drone strikes. Notwithstanding, they have all been impacted by the armed conflict. Aerial attacks in their vicinity, and also attacks on critical infrastructure – conventional power plants and the national electricity grids – have affected their normal operation and electricity generation.

In November 2022, all three NPPs suffered a complete and simultaneous loss of off-site power, thus demonstrating the precariousness of the nuclear safety and security situation in Ukraine.<sup>66</sup>

As regards SUNPP, in September 2022, an explosion some 300 metres away had caused interruption to the off-site (external) power lines.<sup>67</sup> Also, in March 2023, a cruise missile had flown close to SUNPP. In the same month, two external high-voltage electricity lines were disconnected from the NPP, as a result of shelling.<sup>68</sup>

Notwithstanding the presence of IAEA staff at all the NPPs, in a communique on 25 October 2023, the IAEA reported that powerful explosions overnight had shaken an area near the Khmelnytsky NPP, shattering many windows at the nuclear site, and also temporarily cutting power to some of the off-site radiation monitoring systems. The incident, according to the IAEA, had once

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<https://www.iaea.org/sites/default/files/22/11/gov2022-66.pdf>

<sup>65</sup> Dan Sabbagh, 'Zelenskiy pledged not to attack nuclear plant in Zaporizhzhia, says IAEA chief', *The Guardian*, 10 October 2023, <https://www.theguardian.com/world/2023/oct/10/zelenskiy-promises-not-to-attack-zaporizhzhia-nuclear-plant-says-iaea-chief#:~:text=Zelenskiy%20pledged%20not%20to%20attack%20nuclear%20plant%20in%20Zaporizhzhia%2C%20says%20IAEA%20chief,-Rafael%20Grossi%20says&text=Rafael%20Grossi%2C%20the%20head%20of,of%20its%20counteroffensive%20against%20Russia>

<sup>66</sup> IAEA, 'Nuclear Safety', February 2023.

<sup>67</sup> IAEA, 'Nuclear Safety', November 2022, p.23.

<sup>68</sup> IAEA, 'Nuclear Safety', GOV/2023/30, p.33.

again underlined the precarious situation, and the risks posed to nuclear facilities during the ongoing military conflict.<sup>69, 70</sup>

The Ukrainian authorities attributed the explosions to two Russian drones which they had shot down at distances of 5km and 20km from the nuclear site. President Zelenskiy stated that the Russian drone attacks, which had shattered windows at the plant and injured 20 people, were probably targeting the area's nuclear power station.<sup>71</sup>

### 3.4 Nuclear Research Centres

There are a number of nuclear research centres in Ukraine, some of which have been the target of aerial attacks by Russian forces.

The Kharkiv Institute of Physics and Technology (KIPT), which operates a 'subcritical neutron source' installation that is used for research and development and for radioisotope production for medical and industrial applications, has been the target of aerial attacks. On 6 March 2022, it came under significant shelling, resulting in damage to the electrical substation, the main building of the installation, cables of the cooling and ventilation systems, and the shattering of windows. According to the IAEA, the damage to the physical integrity of the installation contravenes the IAEA's first pillar of the seven pillars of nuclear safety and security in relation to the armed conflict in Ukraine.<sup>72</sup>

A later attack on the installation, in June 2022, damaged, inter alia, the main building, the cooling system, and the diesel generator building. No radiological consequences were, however, reported.<sup>73,</sup>

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The Kyiv Nuclear Research Institute of the National Academy of Sciences of Ukraine, which operates a small 10MW light-water research reactor, has, to date, not been directly affected.

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<sup>69</sup> IAEA, 'Update 190 - IAEA Director General Statement on Situation in Ukraine', 25 October 2023, <https://www.iaea.org/newscenter/pressreleases/update-190-iaea-director-general-statement-on-situation-in-ukraine>

<sup>70</sup> IAEA, 'Update 191 - IAEA Director General Statement on Situation in Ukraine', 27 October 2023, <https://www.iaea.org/newscenter/pressreleases/update-191-iaea-director-general-statement-on-situation-in-ukraine>

<sup>71</sup> Reuters, 'Zelenskiy says Russia probably targeted nuclear plant with drones', 26 October 2023, [www.reuters.com/world/europe/ukraine-says-drone-debris-damages-critical-facility-west-2023-10-25/](http://www.reuters.com/world/europe/ukraine-says-drone-debris-damages-critical-facility-west-2023-10-25/)

<sup>72</sup> IAEA, 'Nuclear Safety, Security and Safeguards in Ukraine - Summary Report by the Director General, 24 February - 28 April 2022', April 2022, pp.5 & 16, <https://www.iaea.org/sites/default/files/22/04/ukraine-report.pdf>

<sup>73</sup> IAEA, 'Nuclear Safety, Security and Safeguards in Ukraine: 2nd Summary Report by the Director General, 28 April - 5 September 2022', September 2022, p.32, [https://www.iaea.org/sites/default/files/22/09/ukraine-2ndsummaryreport\\_sept2022.pdf](https://www.iaea.org/sites/default/files/22/09/ukraine-2ndsummaryreport_sept2022.pdf)

<sup>74</sup> WNA, 'Russia-Ukraine War', October 2023.

The Sevastapol National University of Nuclear Energy and Industry operates a small research reactor. However, following Russia's annexation of the Crimea Peninsula in 2014, it is no longer under the regulatory control of the SNRIU.

## Chapter 4. Attacks on Radiological Facilities, and Their Implications

Radioactive sources are extensively used across Ukraine in medical, research, and industrial applications. In addition, a number of facilities store disused radioactive sources on an interim basis, with a view to final disposal. According to the IAEA, there are currently approximately 5,000 radioactive sources in Ukraine, a fraction of which are high-activity dangerous sources.<sup>75</sup>

In 2015, Ukraine was in possession of 9,654 radioactive sources. However, as a result of the conflict in the Donbas region, it lost regulatory control over 1,200 radioactive sources; 65 facilities using radioactive sources, including eight institutions; a number of radioactive waste management enterprises; and 142 radioactive sources belonging to two mining companies in the Donbas region. It also lost regulatory control over 277 radioactive sources, and 53 radiation sources containing radionuclides.<sup>76</sup>

There are also a number of interim radioactive waste management facilities in the country, where thousands of disused radioactive sources are stored. They are managed by the RADON Association, and are located in the cities of Dnipro, Kharkiv, Kyiv, Lviv, and Odessa.<sup>77</sup>

On February 2022, a missile strike damaged the off-site radiation monitoring system at RADON Kyiv. On the same day, following an aerial attack, an electrical transformer was damaged at RADON Kharkiv.<sup>78,79</sup> Also, in March 2022, video connections to the surveillance system of the nuclear regulator SNRIU were lost due to damage to the communication cables of RADON Dnipro.<sup>80</sup>

Loss of regulatory control over radioactive sources could lead to their theft, unauthorised acquisition, and smuggling, and their use by proxy groups, terrorists, and organised crime groups for malicious purposes, within Ukraine and beyond its borders. As gramme-quantities are needed for

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<sup>75</sup> IAEA, 'Nuclear Safety', 10 November 2022, p.13.

<sup>76</sup> Dmytro Chumak, 'The Implications of the Ukraine Conflict for National Nuclear Security Policy', *EU Non-Proliferation Consortium Non-Proliferation Papers*, No.53, November 2016, p.3,

<https://www.sipri.org/sites/default/files/Implications-Ukraine-conflict-national-nuclear-security-policy.pdf>

<sup>77</sup> Ukraine, 'National Report on Compliance with Obligations under the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management', KYIV, 2020, pp.33, 103, 134 & 135,

<https://www.iaea.org/sites/default/files/ukraine-7rm.pdf>

<sup>78</sup> IAEA, 'Update 3 – IAEA Director General Statement on Situation in Ukraine', 27 February 2022,

<https://www.iaea.org/newscenter/pressreleases/update-3-iaea-director-general-statement-on-situation-in-ukraine>

<sup>79</sup> Jim Green, 'Nuclear facilities targeted in Russia's war on Ukraine', Campaign for Nuclear Disarmament, 14 March 2022, <https://cnduk.org/nuclear-facilities-targeted-in-russias-war-on-ukraine/>

<sup>80</sup> IAEA, 'Nuclear Safety, Security, and Safeguards in Ukraine - 2nd Summary Report by the Director General, 28 April - 5 September 2022', p.32, [https://www.iaea.org/sites/default/files/22/09/ukraine-2ndsummaryreport\\_sept2022.pdf](https://www.iaea.org/sites/default/files/22/09/ukraine-2ndsummaryreport_sept2022.pdf)

‘dirty bombs’ and other RDDs, they pose a significant risk to the national security of European countries, including the UK. As noted in the preceding sections, ‘dirty bomb’ ingredients went missing from one of Chernobyl’s radiation monitoring laboratories when it was looted in February 2022.<sup>81</sup>

The IAEA has acknowledged that it needs to work closely with the Ukrainian authorities to account for and locate radioactive sources over which regulatory control has been lost. The IAEA has expressed its concern that these radioactive sources might end up in the hands of unauthorised persons.<sup>82</sup>

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<sup>81</sup> Stone, ‘Dirty bomb’, 2022, pp.12-13.

<sup>82</sup> IAEA, ‘Nuclear Safety’, 28 April 2022, p.26.

## Chapter 5. Attacks on Infrastructure (Utilities), and Their Implications

From the very outset of the armed conflict, critical infrastructure, including conventional power plants, the national electricity grid, and water treatment plants, have been the targets of shelling, missile strikes and drone attacks, with devastating humanitarian, economic, and environmental consequences.

Utilities, or ancillary facilities, providing external (off-site) electricity, cooling water, and steam, are critical to nuclear safety and security, and at the same time highly vulnerable to sabotage and aerial attacks. They are regarded as soft targets.

Explosion of mines and direct aerial attacks on off-site power supplies and cooling systems have repeatedly undermined the safety and security of nuclear and radiological facilities in Ukraine.<sup>83</sup> As noted previously, off-site electricity supply is essential for instrumentation and control systems, even when nuclear reactors are shut down, or in cases of emergency, where a nuclear or radiological accident occurs. Off-site electricity is also required for pumping coolant water to NPPs, spent (used) nuclear fuel ponds, and some of the nuclear waste storage facilities.

The Kakhovka dam, which supplies water to the ZNPP water reservoirs, was destroyed in June 2023 by Russian forces, limiting the supply of cooling water for the reactors, spent fuel storage ponds, and other facilities at the ZNNP site.

As noted previously in relation to the Fukushima Daiichi NPP, lack of off-site (external) electricity supply, and the failure to supply coolant water to the four nuclear reactors, and the 'Spent Fuel Storage Ponds', were the main causes of the nuclear accident in 2011. More than a decade later, Japan is still dealing with the environmental, societal, and economic impacts of the accident.

Accidents at nuclear facilities, in particular spent nuclear storage facilities and radioactive waste storage facilities, as noted earlier, could lead to illicit acquisition of proliferation-sensitive nuclear material, and also other radioactive materials which may be used by proxy groups, terrorists, and other non-State actors for illicit transboundary trafficking, or the simple construction of a 'dirty bomb'.

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<sup>83</sup> IAEA, GOV/2023/30, 31 May 2023, p.33.

## Chapter 6. Concluding Remarks and Recommendations

The events involving nuclear and radiological facilities in Ukraine are posing significant transnational security threats to the UK and European NATO members. The dangerous nuclear rhetoric, and the recent policy decisions which Russia has instituted are increasing the prospect of the deployment of tactical nuclear weapons in Ukraine.

The war in Ukraine has demonstrated the inadequacy of the international legal framework governing nuclear and radiological security during armed conflict. The international community, thus, needs to address the pressing requirements of increasing nuclear safety, security, and safeguards, and, equally, to take collaborative action to deter Russia's potential deployment of tactical nuclear weapons in Ukraine. This could mitigate the risks associated with (i) the safety and security of these facilities; (ii) unauthorised acquisition of nuclear and other radioactive materials; (iii) sabotage and illicit transnational trafficking; and (iv) proliferation of nuclear materials, and their acquisition by rogue States. Failure to do so would adversely impact on the public, the economy, and the environment. It would, moreover, have grave implications for energy security and the national security of countries with nuclear facilities, including the UK.

Based on the foregoing discussions and findings of this report, a number of policy recommendations may be advocated, the implementation of which could enhance the security of the UK and its allies in NATO.

The UK, in conjunction with France and the US (the permanent members of the UNSC) and other NATO countries, should utilise the diplomatic and political conduits available to them to de-escalate the dangerous nuclear rhetoric, the spectre of which has been looming over Europe since the very outset of the armed conflict in Ukraine.

The UK and other NATO members should lend their diplomatic, political and financial support to the IAEA, to accelerate its efforts to establish a 'nuclear safety and security protection zone' around the NPPs in Ukraine, in particular the Zaporizhzhia NPP. The UNGA, the UNSC and the IAEA Board of Governors meetings could be considered as suitable fora, in this context.

The radiological threats posed to the national security of the UK by proxy groups acting for hostile States, fundamentalist terrorist groups, international organised crime groups, and other non-State



actors need to be reassessed, in order to reduce the risks posed to public health and the environment, and, equally, to protect critical infrastructure in the UK.

The land and maritime borders and crossings in the UK and European NATO countries need to be strengthened to mitigate and prevent illicit transnational trafficking of radioactive substances and radioactive sources, thus protecting the national security of the UK and NATO countries. Noting that 45,000 migrants entered the UK illegally in 2022,<sup>84</sup> it is plausible that gramme-quantities of radioactive substances could easily be smuggled into the UK for malicious activities, including assassinations, construction of ‘dirty bombs’ and damage to critical infrastructure, including key transport hubs in London and other major cities in the UK.

Radiation detectors are currently deployed at airports, border crossings, and maritime crossings. However, their deployment at other geographical locations needs to be considered, in order to enhance the efficacy of preventing and detecting the illicit trafficking of radioactive substances.

Use of small commercial drones, equipped with aerial radiation detectors, should also be considered to monitor and protect crowded places and urban spaces.

A re-examination of national security policies and strategies in relation to the prevention, detection, emergency preparedness, and response to nuclear and radiological events may be required. This is to enhance resilience; counter radiological terrorism; prevent illicit trafficking of radioactive substances; and mitigate the humanitarian, economic, and environmental impacts.

In view of the recent developments in the Russia–Ukraine war, and the transnational challenges posed to the national security of the UK, a reassessment of the UK’s security policy strategies, as articulated in the ‘2021 Integrated Review of Security, Defence, Development and Foreign Policy’<sup>85</sup> and also the ‘Integrated Review Refresh, 2023’, may be warranted.

The UK, as a member of the UNSC, the G7 and the G20, and a major contributor to the IAEA Nuclear Security Fund, could play a significant role, in conjunction with other NATO members, in drafting and

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<sup>84</sup> ‘Integrated Review Refresh’, p.41.

<sup>85</sup> HM Government, ‘Global Britain in a competitive age - The Integrated Review of Security, Defence, Development and Foreign Policy’, March 2021, CP 403, [https://assets.publishing.service.gov.uk/media/60644e4bd3bf7f0c91eababd/Global\\_Britain\\_in\\_a\\_Competitive\\_Age\\_the\\_Integrated\\_Review\\_of\\_Security\\_Defence\\_Development\\_and\\_Foreign\\_Policy.pdf](https://assets.publishing.service.gov.uk/media/60644e4bd3bf7f0c91eababd/Global_Britain_in_a_Competitive_Age_the_Integrated_Review_of_Security_Defence_Development_and_Foreign_Policy.pdf)

adopting the requisite international legal instruments, with a view to enhancing the safety and security of nuclear and radiological facilities during armed conflict.





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