



King's Research Portal

Document Version
Peer reviewed version

[Link to publication record in King's Research Portal](#)

Citation for published version (APA):

Elbahtimy, H. (in press). Approaching Irreversibility in Global Nuclear Politics. *Journal for peace and nuclear disarmament*.

Citing this paper

Please note that where the full-text provided on King's Research Portal is the Author Accepted Manuscript or Post-Print version this may differ from the final Published version. If citing, it is advised that you check and use the publisher's definitive version for pagination, volume/issue, and date of publication details. And where the final published version is provided on the Research Portal, if citing you are again advised to check the publisher's website for any subsequent corrections.

General rights

Copyright and moral rights for the publications made accessible in the Research Portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognize and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the Research Portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the Research Portal

Take down policy

If you believe that this document breaches copyright please contact librarypure@kcl.ac.uk providing details, and we will remove access to the work immediately and investigate your claim.

Accepted Draft – Please consult final version available open-access in the Journal of Peace and Nuclear Disarmament

Approaching Irreversibility in Global Nuclear Politics

Hassan Elbahtimy

King's College London
London, United Kingdom

hassan.elbahtimy@kcl.ac.uk

Author ORCID: 0000-0002-1281-4269

Approaching Irreversibility in Global Nuclear Politics

Hassan Elbahtimy

Abstract

Despite growing interest in irreversibility, it remains one of the least-studied concepts in the nuclear disarmament and arms control literature. Scratch beneath the surface and it becomes clear that ‘irreversibility’ needs to be unpacked both conceptually and empirically. How can we meaningfully and productively address irreversibility in the context of global nuclear politics? Should irreversibility be seen as a distinct concept to be taken seriously or is it superfluous and unnecessary? Should consideration of irreversibility be deferred, and only opened once disarmament has been achieved? These, among other questions, highlight the importance of trying to pin down what is meant by irreversibility. The article starts by asking why we should care about irreversibility. It then examines how irreversibility has been used in disarmament and arms control politics. In doing so, it highlights how irreversibility has frequently meant different things to various actors and sometimes used in conflicting ways. The bulk of the article is dedicated to exploring how irreversibility can be defined and approached including proposed parameters for the concept. It ends by introducing the contributions to this special issue.

Keywords:

irreversibility; Global Nuclear Order; Nuclear Weapons; nuclear disarmament

Acknowledgements

I’d like to thank all members of the research consortium on irreversibility convened 2022-2023 as well as all experts and reviewers who contributed working papers, articles and provided valuable comments on drafts and presentations. These contributions enabled open and curious conversations about an under-studied concept and in the process significantly enriched the research published in this and next special issue. I’d also like to thank the Counter Proliferation and Arms Control Centre (CPACC) in the United Kingdom that provided funding to support this work and the complete freedom to shape the research agenda of the consortium and its outputs. I thank Niels Renssen and Amelie Stoetzel for their excellent research support they provided to me in writing this article. Finally, I’d like to thank Fumihiko Yoshida and Hibiki Yamaguchi for their excellent editorial support that was crucial to producing this special issue.

Introduction

If everything can be undone, what does it mean to speak about the irreversibility of nuclear disarmament? How can we constructively engage with the vision of a nuclear weapons free world when the potential for their return constantly hangs over our heads? Should irreversibility be seen as a distinct concept to be taken seriously or is it superfluous and unnecessary? This article seeks to engage with the concept of irreversibility in global nuclear politics through surveying its literature, examining the multiple meanings usually ascribed to it and finally examining how it can be approached in policy and research. In doing so, it provides a

framework for engagement with the concept as well as paves the way for other contributions in this special issue. The article starts by asking why we should care about irreversibility. It then examines the way in which irreversibility has been used in disarmament and arms control politics. In doing so, it highlights how irreversibility has frequently meant various things to various actors and used in conflicting ways. It then develops parameters for the concept aimed at introducing more clarity to the use of the term and ends with a section that introduces the articles in this special issue.

Multilateral nuclear diplomacy sometimes seems enamoured with irreversibility. It has long been acknowledged, within the context of the Nuclear Non-Proliferation Treaty (NPT), as one of the key features of nuclear disarmament. The term made its first formal appearance in an NPT consensus final document in 2000, when it was 5th of the 13 practical steps therein. Step 5 states that the ‘principle’ of irreversibility is ‘to apply to nuclear disarmament, nuclear and other related arms control and reduction measures’. Since then, irreversibility has featured regularly in agreed NPT outcome documents, including in the 64-point action plan agreed at the 2010 Review Conference (the last NPT RevCon to agree a consensus document). Various state groups within the NPT Review process have also affirmed their commitment to irreversibility, including the P5 states, Nuclear Proliferation and Disarmament initiative (NPDI), New Agenda Coalition (NAC) and the Non-aligned Movement (NAM), among many others. At least in principle, the concept appears to enjoy widespread support.

The concept is also used in other aspects of nuclear politics, suggesting wider relevance beyond just multilateral diplomacy and the NPT. For example, in September 2022, DPRK’s Kim Jong-un announced that his country’s nuclear status has become ‘irreversible’, adding that nuclear weapons represent the ‘dignity, body, and absolute power of the state’ (Seo, Register and Chen 2022). The purported irreversibility of DPRK’s nuclear status was became codified into North Korean national law; adding a legal seal on Kim Jung-un’s earlier commitment. The term has been frequently used in the context of nuclear negotiations with the DPRK; but in a completely different way. The term was used in various rounds of historical negotiations as an objective held by the United States or the international community in approaching the DPRK. The objective of such negotiations was sometimes referred to as complete, verifiable and irreversible denuclearization –CVID for short. As these examples show, there is no shortage in the rhetorical use of the term in international politics; even if sometimes employed towards conflicting aims.

Despite growing interest in the topic, irreversibility remains one of the least-studied concepts in the nuclear disarmament and arms control literature. Scratch beneath the surface and it becomes clear that ‘irreversibility’ needs to be unpacked conceptually and empirically. How can we meaningfully and productively address irreversibility in the context of the NPT and broader nuclear politics? Is it an added demand on an already long list of unfulfilled disarmament measures? Should consideration of irreversibility be deferred, and only opened once disarmament has been achieved, rather than discussing it now? These, among other questions, highlight the importance of trying to pin down what is meant by irreversibility.

This special issue, the first of two on this topic, is a product of a research consortium that was launched in 2022 to examine and scrutinize the concept and its uses in global nuclear politics.¹ The consortium was led by King's College London (KCL) and included four other research organisations: Centre for Strategic and International Studies (CSIS), The European Leadership Network (ELN), VERTIC and the University of York. Beyond these institutions, the consortium drew on a large network of researchers from the disarmament and arms control community who contributed discussion papers on the topic and were also called upon to review and comment on the papers produced under the project.² Many of the ideas contained in the papers in this special issue have emerged and been refined in productive discussions in regular consortium meetings, two KCL-held workshops and one Wilton Park Conference.³

The articles in this special issue build on a limited but expanding body of literature dedicated to the topic of irreversibility. VERTIC and SIPRI had produced two prominent studies in 2011 dedicated entirely to engaging with the concept. VERTIC's study broke new ground by highlighting the usefulness of considering irreversibility as a spectrum and developed illustrative models for various degrees of irreversibility (Cliff, Elbahtimy and Persbo 2011). SIPRI's study emphasized the normative and political character of irreversibility and the need to consider those alongside technical aspects (Anthony 2011). More recently, there has been growing research interest on the issue which is partly driven by the need to inform ongoing policy discussions on irreversibility. A food-for-thought paper was prepared and presented as part of the work the International Partnership for Nuclear Disarmament Verification (IPNDV) in 2018. The paper reviewed the state of knowledge on irreversibility of nuclear disarmament (IPNDV Working Group 1 2018). CSIS published a multi-essay edited report, providing useful insights into the topic across political, societal and technical domains while also reflecting on how multilateral nuclear diplomacy can incorporate irreversibility (Williams, Link and Rodgers 2023).

Why irreversibility?

With the disarmament and arms control agenda full of multiple challenging and intractable issues, why should we care about understanding and engaging with the concept of irreversibility? I provide here three arguments why doing so is important.

First, if we are to take the ambition of a world without nuclear weapons seriously, then we need to engage with questions about what that world might look like. This involves making crucial imaginative leaps to understand and address the kind of issues that would arise in a post-nuclear world. Much research and analysis has been directed towards understanding why

¹ The consortium was funded through a research grant offered by the UK government's Counter Proliferation and Arms Control Centre (CPACC). None of the papers produced in the research consortium was reviewed by the UK government before publication and the authors of the papers take sole responsibility for them.

² In addition to consortium members, the following experts provided invaluable contributions to whom I'm very grateful: Amy Woolf, Andreas Persbo, Anne Harrington, Dieter Fleck, Eliana Reynolds, Emiliano J. Buis, Joellen Pretorius, John Walker, Joseph Pilat, Kareem Haggag, Mark Hibbs, Matt Korda, Philipp Sauter, Sharon Squassoni, Stephen Herzog, Thomas Hajnoczi, Togzhan Kassenova and William Walker.

³ Two workshops were held at KCL in January and March 2023 and Wilton Park Conference held in March 2023.

we should or should not embrace nuclear abolition including why that would be irresponsible or, on the other side, necessary. Thinking about irreversibility can widen our scope of inquiry by allowing us to consider crucial questions about the dynamics, whether of reversal or sustainability, that would underpin a world without such weapons. Being able to imagine such a world and address some of the key questions it would raise is crucial for making realistic steps towards creating that world.

Second, there is a practical need to address irreversibility in a meaningful and productive way particularly in the context of the global nuclear disarmament and arms control regime. As will be shown in this article, the concept has been used frequently without that use being clearly defined or reflecting a basic common understanding of what irreversibility entails. It is sometimes blended with disarmament without much differentiation between the two concepts and sometimes is used interchangeably with verification. This lack of common understanding of the concept was recognized in the last NPT Review Conference. State parties included language in the draft text that recognized that ‘further work is required to ensure the irreversibility of nuclear disarmament’ and encouraged states to ‘to exchange information on the application of the principle of irreversibility in relation to the implementation of their Treaty obligations.’⁴ This gives a good indication of the growing need to engage with irreversibility within the international diplomatic community and consequently invites us to consider ways through which such an engagement can both productive and meaningful.

Finally, investigating irreversibility can provide a new and useful lens through which we can examine established practices of arms control and disarmament anew. For example, many arms control and disarmament agreements seem fragile. They frequently get frozen, withdrawn from or lapse. The most recent manifestation of that can be observed in the New START treaty; previously similar dynamics afflicted INF, Open Skies and the ABM treaty among others. While these treaties took countless hours to negotiate, adopt, implement and verify, their inability to endure poses questions about how to understand dynamics of reversibility and irreversibility in arms control and disarmament regimes. This can shed new light on elements of regime design and political drivers that can make some regimes more easily reversible than others. This invites us to consider how to introduce elements in regime design that would make such negotiated agreements stand a better chance of sticking and enduring. More broadly, understanding irreversibility can also help us probe and shed some light on some of the tensions embedded in arms control and disarmament practice, particularly the tension between process and outcomes as well as means and ends.

The multiple meanings of irreversibility

This section examines how irreversibility has been used in the diplomatic practice of disarmament and arms control. Through a survey of the use of irreversibility in various official documents, announcements and treaties, this section provides a snapshot of the varied uses of

⁴ Although the final document was not adopted due to differences over language related to Ukraine, the sections on irreversibility quoted here enjoyed broad support. NPT/CONF.2020/CRP.1/Rev.2, page 27/36

the term and some of the common themes that characterise such use. In doing so, this survey highlights a number of points. First, it demonstrates that while the term is frequently used and referenced, there is no common understanding of its meaning. No widely accepted definition of the term currently exists and even attempts to develop such a definition are few and far between. Instead, the term is frequently used in a self-evident and sometimes rhetorical manner that sometimes masks inconsistencies in its use. Second, while the term has been used most frequently in the context of nuclear disarmament, it has also been used with reference to arms control and its more limited aim of achieving reductions or controls over nuclear weapons. Third, a survey of diplomatic documents reflects widespread support for the term and the concept (although interpretations of its meaning might vary). For example, the term has been supported and used by nuclear weapons states, non-nuclear weapons states and various groupings within the NPT review process as well as in the context of the Treaty of the Prohibition of Nuclear Weapons (TPNW) and arms control treaties. This survey has not seen any state or group of states that has openly objected to the concept. The same cannot be said of the research community, however. Some have openly rejected the concept as unconstructive, arguing that it is detrimental to disarmament as it ‘restricts progress to what can be agreed by the P5’ (Gower and Parthemore 2021). It was also critiqued as part of broader policy objectives in engaging with DPRK denuclearisation (Welna 2018).

Irreversibility as a disarmament principle

Irreversibility features regularly within the context of the NPT as a principle linked to disarmament. The 2000 conference was remarkable for its inclusion of 13 practical steps that boosted the NPT disarmament agenda by inclusion of practical measures. These operationalised the broad requirement for disarmament under NPT article VI. The inaugural use of the term in that particular conference allowed the concept to acquire an added significance as irreversibility became associated with a re-invigorated, forward looking and practical disarmament agenda. Importantly, in its engagement with the concept, the 2000 NPT outcome document referred to irreversibility as a ‘principle’ suggesting an elevated status for the concept and stating that it should apply to “nuclear disarmament, nuclear and other related arms control and reduction measures.”⁵

This rendering of irreversibility as a principle became common language in subsequent NPT review conferences. The 2005 conference didn’t reach consensus on a final outcome document but, in 2010, when such an outcome document was reached, irreversibility was once more acknowledged as a principle. Linked specifically to disarmament, the document notes “the reaffirmation by the nuclear-weapon States of their unequivocal undertaking to accomplish, in accordance with the principle of irreversibility, the total elimination of their nuclear arsenals leading to nuclear disarmament”⁶ Also, the principle is mentioned alongside two other principles. The 2010 outcome document mentions that “all States parties commit to apply the principles of irreversibility, verifiability and transparency in relation to the implementation of

⁵ NPT/CONF.2000/28 (Parts I and II), part I

⁶ NPT/CONF.2010/50 (Vol. I) p. 12

their treaty obligations.”⁷ This formulation of the three principles, mentioned side by side, have become a frequent recurring occurrence.

While the 10th NPT Review Conference didn’t adopt a final document, language about irreversibility as a principle was prominent in proposed drafts, including a reaffirmation of state parties’ ‘commitment to the mutually reinforcing principles of irreversibility, verifiability and transparency’ as well as underscoring ‘the importance of the nuclear-weapon States’ application of these principles in the implementation of their Article VI obligations and related nuclear disarmament commitments under the Treaty.’⁸ That review conference also introduced language aimed at encouraging NPT members states to ‘build an understanding of the application of irreversibility measures’ as well as to ‘exchange of information on the application of the principle of irreversibility.’⁹ Yet, as currently used, the term lacks a clear definition informing what efforts to uphold irreversibility as a principle in disarmament and arms control.

Irreversibility as practical measures

Beyond being elevated to the status of an abstract principle for disarmament and arms control, several references to irreversibility tie it to specific applied tangible measures. These more practical references to irreversibility have focused on both the handling of fissile material of military origin as well as measures applied to weapons-related infrastructure; including fissile material production or testing sites. The use of irreversibility in this register can be common and frequent but is seldom explored in-depth or defined, raising questions about why some measures, and not others, are commonly associated with irreversibility.

One frequently cited use of irreversibility ties it to measures aimed at constraining the re-use of fissile materials for military purposes. The basic idea here is that material extracted from dismantled warheads should not find its way back to nuclear arsenals to build new weapons and in the process reversing dismantlement efforts through the back door. The 2000 NPT outcome document provides an example of such use where it states that the conference ‘welcomes the efforts of several States to cooperate in making nuclear disarmament measures irreversible, in particular, through initiatives on the verification, management and disposition of fissile material declared excess to military purposes.’¹⁰ In a different section, the document also emphasised ‘the importance of international verification, as soon as practicable, of nuclear weapons material designated by each nuclear-weapon State as no longer required for military programmes and that has been irreversibly transferred to peaceful purposes.’¹¹

Similar references exist in the 2010 document as well as other NPT documents, reflecting a recurring understanding that such measures fall under the remit of irreversibility or are taken

⁷ NPT/CONF.2010/50 (Vol. I) p. 20

⁸ NPT/CONF.2020/CRP.1/Rev.2 p.16

⁹ NPT/CONF.2020/CRP.1/Rev.2 p.27

¹⁰ NPT/CONF.2000/28 (Parts I and II), part I p.14

¹¹ NPT/CONF.2000/28 (Parts I and II), part I p.12

with irreversibility in mind.¹² While this rightly highlights the importance of fissile material management post-dismantlement, it can only be conceived as a limited application of irreversibility. Such measures do not address production infrastructure, which, if left unconstrained, could still produce new stocks that can be used for building new weapons. It is also worth noting that these practical applications, aimed at material designated in excess of military use, don't currently feature explicitly in reports by the nuclear weapon states on NPT implementation. In fact, none of the reports produced within the 2015 review cycle refer to irreversibility in the context of fissile material management.

As the concept started to gain wider multilateral currency post 2000, some states started to refer to some of their disarmament measures as 'irreversible' particularly to highlight that they take their disarmament obligations seriously. For example, France used the term twice in 2015 to refer to certain measures it had taken with regard to its nuclear infrastructure and which it linked to irreversibility. These measures were applied, not to nuclear weapons themselves but, to the production and supporting infrastructure historically used in weapons production but undergoing a process of phasing out.

In France's report to the 2015 NPT Review Conference, it stated that it had dismantled its fissile material infrastructure in an irreversible manner.¹³ This entailed the dismantlement of plutonium producing reactors and reprocessing facilities in Marcoule and its highly enriched uranium production facility at Pierrelatte. France had announced that it stopped production in those facilities in 1992 and 1996 respectively, followed by a public moratorium on the production of fissile material in 1996. The moratorium was later followed by the dismantling of the production capacity. This was used as a demonstration of irreversibility and information about it including the costs publicly shared to show that France would no longer produce new material for weapon purposes.¹⁴ While implicit in the French report, stopping production, a public moratorium and destroying the facilities can be considered as a scale carrying different irreversibility potential with the destruction of the facilities the most difficult to reverse.

Also, France took a similar approach when it comes to its nuclear testing sites. A 2015 report stated that France had decided 'to completely and irreversibly dismantle the sites of the Pacific Testing Centre, on the atolls of Mururoa and Fangataufa'.¹⁵ The dismantlement was started in 1996 after the last of the French nuclear tests. According to a French report to the NPT, relevant infrastructure was demolished and destroyed followed by a clean-up operation to ensure radiological remnants were addressed.¹⁶ The dismantlement of the testing infrastructure was complete by 1998 and was followed by a visit of international experts with the involvement of the IAEA. In showcasing its efforts, the French government drew frequently

¹² Sometimes also introducing a role for the IAEA in verification in the context of fissile material in excess of military needs. NPT/CONF.2010/50 (Vol. I) p. 24

¹³ NPT/CONF.2015/10

¹⁴ NPT/CONF.2010/WP.37

¹⁵ NPT/CONF.2015/10

¹⁶ NPT/CONF.2010/WP.36

on irreversibility to demonstrate that it had no intention of reverting to nuclear testing, further substantiating that commitment by signing up to the Comprehensive Test Ban Treaty (CTBT).

Both actions reported by the French government were explicitly linked to irreversibility and tied to facilities linked to weapons production and testing. Given the prominence of these facilities in enabling France to develop nuclear weapons, it indicates a constrained future capacity to develop new weapons particularly if current stockpiles are dismantled and any available fissile material stocks are eliminated or verifiably converted to peaceful uses.¹⁷

The use of irreversibility to reflect specific measures or activities linked to weapons infrastructure has also been incorporated in the TPNW including in the text of the treaty. For example, articles 2, 4 and 8 use irreversibility in the context of either irreversible elimination of nuclear weapons programmes or to reflect the requirement, under the treaty, for the irreversible conversion of all nuclear weapons related facilities for states joining the treaty.¹⁸ This expands the focus of disarmament and irreversibility beyond just the weapons themselves, to also incorporate the necessary infrastructure that would ensure that any re-constitution capability is materially constrained and limited. Yet as these examples show, it is applied in a sporadic manner to specific measures and this leaves room to think more systematically about the range of measures in support of irreversibility and their impact.

Irreversibility as a yardstick to assess progress towards disarmament

One frequent use of the concept, particularly advocated by several non-nuclear weapon states, employs it to distinguish between disarmament measures that are considered more substantial and consequential compared to others on the basis of the ease of their reversibility. In this rendition, irreversibility becomes a yardstick or a rough metric to evaluate disarmament measures and whether they went far enough. This position is frequently reflected in statements as well as working papers within the context of the NPT and other multilateral machinery and championed by key groupings and states pushing multilateral disarmament on the international stage. For example, a recent paper by Non-Aligned Movement paper submitted to the last NPT Review Conference stressed that ‘reductions in deployments and in operational status cannot substitute for irreversible cuts in, and the total elimination of, nuclear weapons’. This use favours one group of measures as more irreversible and therefore worthy of support compared to others.¹⁹

Historically, some of the disarmament critiques of the Strategic Offensive Reductions Treaty (SORT) agreed in 2002 between the United States and the Russian federation drew on irreversibility as a lens to evaluate the instrument. The treaty provided for reductions in deployed strategic forces for both states but didn’t stipulate any destruction of warheads or

¹⁷ For an overview of French capacity to produce fissile material for weapons purposes, see International Panel on Fissile Materials (2023).

¹⁸ A/CONF.229/2017/8

¹⁹ NAM Working Paper NPT/CONF.2020/WP.26

delivery vehicles and gave flexibility to both parties in terms of its implementation. In a New Agenda Coalition paper commenting on the treaty, the group welcomed the quantitative reductions under the treaty but also added: ‘we however question the Treaty’s contribution to nuclear disarmament. The Treaty does not contain verification provisions, is not irreversible, and ignores non-operational warheads. Reductions in deployments and operational status of strategic nuclear warheads cannot substitute for irreversible cuts in, and the total elimination of, nuclear weapons.’²⁰ Variations on that position towards SORT were held by other groups active in multilateral nuclear diplomacy including the NAM and the European Union.²¹

Irreversibility has also been used, by some groups and states, to highlight how some of the soft risk reduction measures are insufficient to achieve meaningful progress towards disarmament. This point was made clearly in a NAM working paper presented to the 2022 NPT Review Conference where the group mentioned that

‘nuclear risk reduction measures, including reductions in deployments and in operational status, cannot substitute for irreversible cuts in, and the total elimination of, nuclear weapons and, accordingly, calls on the nuclear-weapon States to apply the principles of transparency, irreversibility and verifiability to all such cuts, to further reduce their nuclear arsenals, both warheads and delivery systems.’²²

In all such uses, measures, proposals and treaties were judged and assessed through an irreversibility lens and that formed part of the critiques deployed against such actions when they were perceived to fall short of level of irreversibility sought. Acceptable levels remain however implied and not directly elaborated.

Irreversibility as an objective in de-nuclearisation talks with DPRK

One of the most prominent uses of the term materialized within the context of policies aimed at disarming the DPRK. Here, the term was used in official UN instruments including for example Security Council Resolutions on the topic. This started with resolution 1718 in 2006 following DPRK’s nuclear test which stipulates that ‘the DPRK shall abandon all nuclear weapons and existing nuclear programmes in a complete, verifiable and irreversible manner.’²³ In some way, that use – which also combines irreversibility with transparency and verification – mirrors the use of irreversibility as a general disarmament principle applied more broadly to nuclear disarmament as discussed earlier. In this instance, such global disarmament principles are applied to the specific case of DPRK.

²⁰ NPT/CONF.2005/PC.II/16

²¹ NPT/CONF.2005/PC.II/SR.1

²² NAM Working Paper NPT/CONF.2020/WP.20

²³ S/RES/1718 (2006)

Irreversibility has also been used as a reference point for negotiations with the DPRK and its use specifically in the United States reflects internal differences about how to approach the issue. The Clinton administration started negotiations with the DPRK that resulted in the Agreed Framework in 1994. That agreement froze the operation and construction of North Korean nuclear facilities in exchange for aid and the supply of more proliferation-resistant reactors. Irreversibility was not mentioned and a 2004 volume co-authored by one of Clinton administration's chief negotiators is absent of any mention of the concept (Wit, Poneman and Gallucci 2005). The concept started to come into play through its repeated use by the Bush administration. This saw the emergence of 'Complete Verifiable Irreversible Dismantlement' (CVID) as the key mantra for negotiations with the DPRK including in the context of the six party talks with the DPRK (Kim 2004). Yet arguably the key difference between both administration had less to do with irreversibility and more to do with their approach to sequencing aid and inducements with the achievement of DPRK disarmament. Currently, the DPRK currently refuses the idea that its nuclear arsenal should be dismantled at all and uses 'irreversibility' to refer to its nuclear status in contrast with earlier use linking it to dismantlement of its arsenal (Nikkei Asia 2022).

Irreversibility as an ambition for US-Russia arms control

The idea of locking-in progress in relations between United States and Soviet Union/Russia, including in arms control, incorporated thinking about irreversibility and sometimes explicitly. In 1972, Soviet leader Brezhnev and US President Ford discussed 'the transformation of détente into an irreversible process' including through reciprocal arms limitation agreements as a common goal.²⁴ This was re-incarnated in the 1990s after the end of the cold war and became an explicit US and Russian ambition projected explicitly onto the arms control process and what that entailed in terms of reductions in nuclear holdings.

On 14 January 1994, President Clinton and President Yeltsin issued a joint summit statement in which they agreed to 'establish a joint working group to consider steps to ensure the transparency and irreversibility of the process of reduction of nuclear weapons, including the possibility of putting a portion of fissionable material under IAEA safeguards' (Goodby, Lajoie and Diakov 1998). This marked a distinct approach compared to earlier focus in arms control on addressing delivery vehicles (missiles, bombers and launchers) rather than fissile material or warheads. Two working groups were established. One is a working group on safeguards, transparency, and irreversibility (STI) to examine specific measures to improve confidence in and increase the transparency and irreversibility of the process of reducing nuclear weapons. The joint summit was followed by signed an agreement that same year between the United States and Russia cutting off production of plutonium for weapons.²⁵

²⁴ '134. Memorandum of Conversation', Foreign Relations of the United States, 1969–1976, Volume XIV, Soviet Union, October 1971–May 1972. <https://history.state.gov/historicaldocuments/frus1969-76v14/d134>.

²⁵ The role of S&T. Clinton White House Archive.

<https://clintonwhitehouse4.archives.gov/WH/EOP/OSTP/nssts/html/chapt3-1.html>.

At their September 1994 summit meeting, Presidents Clinton and Yeltsin agreed that their two governments should also work together to direct their joint working group on STI to pursue by March 1995 further measures to improve confidence in and increase the transparency and irreversibility of the process of reducing nuclear weapons. By May 1995, both countries agreed on an agenda for confidence-building data exchanges. They also made a commitment not to use any excess fissile material to build new weapons whether such material comes from dismantled weapons, from civilian fuel cycle or from new production.²⁶ These steps and measures reflected in part a focus in arms control on addressing fissile material but also an explicit understanding that such measures constitute a new standard of irreversibility one that was supported at the highest political level in the United States and Russia. Irreversibility featured in the negotiations of SORT and in particular whether warhead removed from deployment should be held in storage or destroyed and agreement was only possible on the first of the two options (CRS 2003-2011). It was also raised in the context of New START implementation in relation to being able to verify launchers converted to conventional use won't return back to nuclear missions (Kristensen 2019). Currently irreversibility, in the context of arms control, does not feature as prominently as it used to in the mid 1990s which perhaps reflect the challenges facing maintaining a proactive arms control agenda now compared to the heydays of the 1990s.

Understanding irreversibility

As the above survey of the term shows, irreversibility has been used in many ways. This raises the question of whether there is sufficient agreement about how the term can be defined.²⁷ Reaching a definition should not be an end in itself. It is a way to develop a common understanding, allowing the term to be used in a consistent manner and to clear confusion about what might fall under the ambit of irreversibility and what belongs outside. Doing so can enable a more structured policy conversation as well as the development of a research agenda with a clear scope and parameters. Given the current polarized nature of multilateral nuclear relations, reaching an agreement between states about the term will be subject to the ebb and flow of diplomacy. However, for the purpose of research, pinning down the concept and its key parameters is crucial to achieving analytical clarity.

At the start of the irreversibility research consortium, a working definition was produced to guide the various research themes (Elbahtimy 2022). It was not imposed as the only definition but presented as the starting point for a conversation that seeks to capture the essence of the concept. In a consortium working paper, irreversibility was defined as 'a feature or quality of a

²⁶ Joint Statement on the Transparency and Irreversibility of the Process of Reducing Nuclear Weapons, May 10, 1995 <https://www.govinfo.gov/content/pkg/PPP-1995-book1/pdf/PPP-1995-book1-doc-pg671.pdf>; The role of S&T. Clinton White House Archive. <https://clintonwhitehouse4.archives.gov/WH/EOP/OSTP/nssts/html/chapt3-1.html>.

²⁷ One view expressed in the KCL 7th March workshop on the topic supported abandoning the term irreversibility due to its ambiguous nature and coming up with an alternative and more affirmative term. However others pointed out that the term has already become entrenched in multilateral nuclear diplomacy and any attempts to pick another term will raise unnecessary suspicions amongst state supportive of irreversible disarmament.

disarmament or an arms control process that involves limiting the capacity for re-armament, including the possible re-constitution of aspects of weapons programmes' (Elbahtimy 2022). That definition was welcomed by many but also debated and constructively challenged by some.²⁸ For the purpose of developing a focused conversation on irreversibility, as well as convergence over its meaning, some key parameters for the concept are further elaborated here.

The centrality of re-armament and influencing weapons re-constitution capacity

As defined here, irreversibility becomes a function of the capacity to re-build nuclear weapons. Whereas irreversibility is frequently associated with and sometimes confused with disarmament, in effect it is all about re-armament. From a policy standpoint and to develop tangible practical actions, 'doing' irreversibility would entail devising policies and procedures to influence the potential and capacity for re-armament. To understand the re-constitution capacity of nuclear weapons, an appreciation of the material as well as the ideational components of that capacity is crucial. These material and ideational components interact to jointly shape the potential for weapons' re-constitution.

In understanding the material component, two distinct but inter-related areas are particularly relevant. Firstly, re-constitution can rely on outputs from the dismantlement of nuclear weapons including component materials and various waste streams. Secondly, re-constitution capacity can rely on available nuclear weapons production capabilities. For nuclear dismantlement outputs, enhancing irreversibility would mean devising measures to ensure that dismantlement of nuclear weapons happens in a way that makes building the weapons from the waste streams more challenging. Here, the more a weapon is reduced to its most basic components which are then either destroyed, modified or put to a different use, the more irreversibility is enhanced. This highlights the importance of thinking about disposition pathways for key dismantlement waste streams and evaluating how difficult it is for them to be used to re-constitute nuclear weapons.

As for the production capacity for new weapons, such measures would address what can be called the 'nuclear weapons production complex.'²⁹ This includes the infrastructure and processes directly involved in producing nuclear weapons. It also involves thinking about the 'civilian nuclear infrastructure' and other infrastructure and processes that are not normally part of weapons production but remain relevant particularly in producing and handling fissile material production. Addressing these elements entails thinking about how that infrastructure, whether purely of military nature, civilian or possible dual-use value, can be handled to enhance irreversibility. This infrastructure can, to various degrees, be dismantled, disabled, converted or allowed to exist with some limitations on their functioning. This can provide a

²⁸ One of the points made was that disarmament and arms control can provide different starting points for thinking about re-armament.

²⁹ For more details on the kind of interventions needed to constrain nuclear weapons production complexes see articles by Nick Ritchie, and Elbahtimy and Peel in this Special Issue.

menu of options about handling this infrastructure and each would lead to a different degree of irreversibility.

The re-constitution capacity is not just a function of material capabilities, such as mastery of fissile material production or weapons' design, alone; without a political agency deciding to put these capabilities to use, weapons will not produce themselves. Therefore, understanding and influencing the capacity for re-constitution includes engaging with motivational and political drivers that shape the desirability, acceptability and appropriateness of reversal. These link with ideas held about the value and validity of keeping and building weapons, sticking to international agreements and are influenced by social identities that shape the range of options available for any social actor, including how they are evaluated and exercised.

In thinking about political or motivational drivers for re-constitution, some of the literature about the drivers of nuclear weapons spread becomes relevant. Literature on nuclear drivers provides well established frameworks for understanding why nuclear weapons are sought (Sagan 1997; Quester 1973; Epstein 1977; Betts 1977; Pelopidas 2011; Biswas 2014; Abraham 2006). This literature emphasizes not just how such weapons become associated with national security related drivers, but also how they can be political objects instrumentalized in domestic debates and bureaucratic politics as well as becoming objects which carry normative and symbolic significance (Hymans 2006; Solingen 2009; Rublee 2009).

Therefore, to effectively ensure that re-constitution or re-armament does not occur entails influencing the perceived value of nuclear weapons. Entrenching disarmament will need to ensure that drivers for weapons production do not emerge and, if they do, then they are not compelling enough to cause backsliding away from disarmament. Key to opening up this process for policy influence is the appreciation that nuclear weapons are social objects that derive their meaning and significance from their social and political contexts rather than thinking of them as immutable objects whose values are pre-determined and fixed. As Nick Ritchie argued nuclear weapons are 'embedded within a web of social relationships, interests and identities' that shape their value (Ritchie 2013; Ritchie 2014). With this framing, disarmament becomes a project that would entail de-valuing of nuclear weapons as nationally prized objects. By extension, enhancing the prospect of irreversibility would entail supporting a process of continuous de-valuation of nuclear weapons such that the option of re-constituting weapons becomes stigmatized and a social taboo with high political and societal costs.³⁰ This also entails re-considering the value attached to nuclear deterrence as the foundation for keeping nuclear weapons. Thinking about irreversibility entails enabling a climate in which re-constituting nuclear weapons becomes viscerally inappropriate or unacceptable.

Irreversibility as a dynamic and a spectrum

³⁰ The concept of taboo has been explored in depth in nuclear studies including in Tannenwald (2005) and Smetana and Wunderlich (2021).

Understanding practical irreversibility to mean concrete measures to limit the capacity for reversal or re-constitution makes it more realistic and useful to think of such measures as inhabiting a spectrum or a scale. In other words, rather than existing in a binary or an absolute form where any specific measure is considered either readily reversible, on the one hand, or irrevocably irreversible, on the other hand, it is more useful to think of *degrees of irreversibility*. This insight was first developed by Cliff, Elbahtimy and Persbo in their 2011 study on irreversibility and is further developed here and reflected upon in multiple contributions to this special issue (Cliff, Elbahtimy and Persbo 2011). Irreversibility is conceived of as a quality or feature that can exist in various grades and shades, each worthy of consideration. It becomes more useful, therefore, to think about *enhancing* irreversibility, rather than about necessarily *achieving* total irreversibility. Doing so also recognizes the multiple factors, including normative, political, and technical, that shape potential for re-armament.

One consequence of thinking about irreversibility as a matter of degree rather than as a binary, is to inquire how much irreversibility is enough. The question is not unfamiliar in the arms control and disarmament literature, which considered the same question with verification (Krass 2020; Gallagher 1997). A key theme for further work on irreversibility can be to chart key milestones on the irreversibility spectrum and evaluate the desirability of each. In more practical terms, this entails weighing the cost of any measures aimed at enhancing irreversibility against their benefits and suitability in terms of constraining re-constitution. In other words, evaluating various degrees of irreversibility would entail appraising the value and impact of irreversibility measures weighed against the cost of such measures. Ultimately, it is important to highlight that any approach to evaluate various degrees of irreversibility will be embedded in views about the appropriateness of re-armament and consequently draw on political as well as technical considerations.

Two disarmament irreversibilities

There are two different ways the logic of irreversibility can be applied to nuclear disarmament. The first applies irreversibility to steps taken towards disarmament or what can be called ‘Irreversibility of the interim’. This starts from the assumption that complete nuclear disarmament can only be a long process which can be achieved through a series of gradual and cumulative steps. Irreversibility applied to this context would entail designing policies aimed at influencing the reversibility potential of those interim steps and neutralizing any backsliding. This would increase the chances that any partial progress achieved is locked-in to allow cumulative follow-on steps towards achieving disarmament. For example, this would ask the question of how to devise measures to increase the chances that deep reductions (short of but en-route toward disarmament) are not reversed or replaced by an arms race that can set the process of disarmament back.

The other can be called ‘irreversibility of a nuclear free world’. This would entail thinking about irreversibility measures in a different context where, at a minimum, nuclear arsenals have been dismantled. Here the outcome of the disarmament process would be intended to last longer (rather than being interim or temporary in ambition) and thus enhancing irreversibility would

entail efforts to make such outcomes more stable. Thinking about irreversibility in this context is important but challenging. It would entail an imaginative leap to envision a future post nuclear world and how it would be constituted and then consider measures that would enhance the prospect that this world remains nuclear free without reverting to nuclear weapons. A nuclear free world here can be seen as an outcome of the disarmament process but as explained earlier any such status would be contingent on the ability to maintain such nuclear free status into the future through measures to enhance irreversibility.

Verification

The relationship between verification and irreversibility calls for more scrutiny. Verification can be defined as ‘a process in which data are collected, collated and analysed in order to make an informed judgement as to whether a party is complying with its obligations.’³¹ Sometimes irreversibility is put on par with verification as an overarching principle to be sought in any disarmament or arms control process. For example, and as highlighted earlier in this article, verification, transparency and Irreversibility are frequently grouped together as three principles guiding nuclear disarmament. In other times, verification is used as a tool to achieve irreversibility; particularly when applied irreversibility measures are sought. This can sometimes be expanded to allow verification, frequently framed as primarily a technical process, to be the main route to ensure higher levels of irreversibility.

This raises the question of how to understand the relationship between verification and irreversibility. As shown earlier, some of the proposed measures for irreversibility in diplomatic practice are linked with the application of verification to fissile material of military origin and therefore in practice fusing together the concepts of verification and irreversibility into one. Ian Anthony reasoned that since verification provides assurance for compliance then it becomes ‘a part of the irreversibility’ (Anthony 2011). But ensuring implementation of commitments have been fulfilled through verification does not dictate what these measures are (some of which can be more reversible than others). Cliff, Elbahtimy and Persbo therefore highlighted that verification and irreversibility can be seen as ‘complementary’ and that verification does not by any means ensure irreversibility (Cliff, Elbahtimy and Persbo 2011, 9, 15). There is room therefore to highlight where both concepts overlap and where they can diverge in scope and outcomes. This can also lead to more clarity and precision about the use of both terms in diplomatic practice.

In addition to exploring how both concepts can be disentangled, it is important as well to explore how introducing irreversibility in arms control and disarmament would result in verification missions that need to be developed anew or current ones adapted and changed to contribute to irreversibility. For example, how can we think of new verification missions tied to monitoring and verifying the capacity for re-armament? How similar or different would verification be if the focus shifts from disarmament to re-armament? In some scenarios,

³¹ This definition was provided by the Report of the Secretary-General: Verification in All Its Aspects, Including the Role of the United Nations in the Field of Verification, UN document A/50/377, 2 September 1995, paragraph 15.

disarmament would entail restrictions on military production complexes that have not been traditionally covered by verification regimes. Higher degrees of irreversibility can entail measures applied to such facilities. What verification measures can be tied to that as well as other new missions that are likely to emerge with the application of irreversibility emerges as a key consideration.

Irreversibility, international law and regime design

It can be argued that every arms control and disarmament regime has a certain degree of irreversibility built into it. Enhancing the endurance and reliability of treaty regimes has long been a consideration for negotiators and politicians. At the end of the day, it is hard to enter, in good faith, into extended processes to design, negotiate and agree treaties or instruments that can be readily reversible the next day. One can therefore try to trace the spectrum of irreversibility as a consideration in designing arms control and disarmament even if the term is not explicitly used. However, it is also not the only consideration. Sometimes providing a room to manoeuvre and adapt flexibility becomes also an attractive prudent option particularly if trust in other parties' compliance is not high. The tension between flexible (more reversible) versus meaningful (less reversible) arms control and disarmament measures can be substantial.

Furthermore, most legally binding arms control and disarmament measures are codified in treaties or agreements that are forged within the broader structure of international law.³² The sustainability and endurance of any agreement in turn is influenced by that overarching legal structure. Here consideration of irreversibility maps over tensions between the desire to achieve a level of legal certainty, on one level, and maintaining a degree of flexibility on another level. The forces of certainty reflect the need for predictability, clarity and reciprocity that are inherent in any agreement. Whereas the degree of flexibility reflects how maintaining a level of autonomy, sovereignty on national security issues. The balance between these two factors has so far shaped the practice of arms control law and allowed for the existence of withdrawal clauses in various WMD related treaties (den Dekker and Coppen 2012). In a legal sense, irreversibility raises questions about the exercise of '*sovereignty*' in disarmament and arms control law, and about how to explore the tensions between sovereignty and the common interest in enhancing reciprocal irreversibility. An aspect of this can be further explored in considering '*withdrawal*' from treaties as one mechanism that can impact on dynamics of irreversibility.

Contributions to this special issue

This special issue is the first of two designed to tackle the issue of irreversibility in global nuclear politics with the aim of unpacking the term and fleshing out the conceptual, practical and research implications of taking irreversibility seriously. In this special issue, Nick Ritchie applies concepts from Science and Technology Studies (STS) to help us understand what

³² For consideration of the legal dimension see Dieter Fleck's article produced within this consortium (Fleck 2023) as well as Thomas Hajnoczi (2023) in this special issue

maximising irreversible nuclear disarmament means (Ritchie 2023). Ritchie advocates approaching nuclear weapons complexes as large socio-political systems embedded in actor-networks. This understanding of nuclear complexes, conceptually drawing on social constructivism as a prism to examine the links between technology and the social world, renders such complexes more malleable and therefore open to stagnation, decline or unravelling if not actively nurtured. This view of nuclear complexes can have radical implications. It opens the possibility for change by presenting such complexes as institutions whose permanence, as frequently normalized by advocates of a nuclear status quo, cannot be taken for granted. Examination of change in other Large Technical Systems, a concept familiar in STS but largely absent in Security Studies, can add new case studies of technologies in decline that can benefit and enrich nuclear studies. The unmaking of such complexes also raises the importance of ‘discursive destabilization’ where the rationale of complexes is challenged and necessarily involves a productive process where an alternative framing and a shared understanding of what becomes acceptable emerges.

Hassan Elbahtimy and Ross Peel also emphasize the importance of focusing on nuclear weapons production complexes (Elbahtimy and Peel 2023). They argue that any effective disarmament regime will need to consider what to do with the infrastructure that supported weapons development and maintenance and could likely enable future re-armament if left in place or unaltered. They start with the premise that irreversibility should be seen as a spectrum and build a framework for potential actions to constrain the operations, outputs, or existence of key elements of the nuclear weapons production complex. In doing so, they identify key processes and facilities for weapons production drawing a distinction between critical and sustaining capabilities. The range of constraints that can be applied to these capabilities will each have a distinct impact on the capacity for re-armament leading to different degrees of irreversibility. Whereas research into disarmament verification led to a better understanding of dismantlement processes, research into irreversibility can enable a focus on infrastructure in nuclear weapons production complexes necessary for building nuclear weapons.

Joseph Rodgers and Heather Williams examine the problem of ‘endurance’ in arms control and disarmament as another manifestation of the pervasive dynamics of irreversibility/reversibility in the field.³³ They coin the term ‘the irreversibility paradox’ to capture these interesting and consequential dynamics. They focus on the process of negotiations of arms control and disarmament where negotiators and policy makers are caught between the desire to agree mutual constraints on military capabilities while maintaining flexibility to pull out as shown in commitment to inserting and using withdrawal clauses to abandon such instruments. They examine six interesting historical case studies where these dynamics are at play. In doing so, they like all contributions to this special issue, highlight the importance of political alongside technical dimensions. They also draw attention to factors informing approaches to irreversibility prior to entering agreements and bring in the role of domestic audiences in contemplating irreversibility.

³³ Hassan Elbahtimy and Ross Peel (2023) Nuclear Weapons Production Complexes in a Disarmed World. Journal of Peace and Nuclear Disarmament

Grant Christopher, Alberto Muti and Noel Scott examine the link between irreversibility and verification emphasizing how they are deeply linked and mutually supportive (Muti, Christopher and Scott 2023). Their article maps out stages of the disarmament process highlighting how verification and irreversibility can be integrated in such a process. They argue that verification contributes to irreversibility through building confidence and reducing incentives for hedging, providing opportunities for voluntary transparency and norm-building, deterring non-compliance. Finally, Thomas Hajnoczi looks at irreversibility from a legal angle (Hajnoczi 2023). He observes that irreversibility has not been consistently used in disarmament and arms control treaties and calls for a broad shared vision for the term. He provides a review of key legal treaty texts that can be linked to irreversibility while calling for the importance of domestic national legislation that would allow the domestic application of international legal norms. He reflects on the importance of having an open debate about withdrawal clauses in treaties drawing on his involvement in the negotiations of the TPNW.

Notes on contributor

Hassan Elbahtimy is Senior Lecturer in the Department of War studies at King's College London and previously served as Director of the Centre for Science and Security Studies (CSSS) and as Trustee and Executive Committee member of the British International Studies Association (BISA). He has written widely on international security and arms control and disarmament issues including in *Foreign Affairs*, *Journal of Strategic Studies*, *Security Studies*, and the *Nonproliferation Review*, among others. His research was awarded the McElveny Grand Prize by the *Nonproliferation Review*.

Disclosure statement

No potential conflict of interest was reported by the author(s).

References

- Abraham, I. 2006. 'The ambivalence of nuclear histories'. *Osiris* 21(1): 49-65.
- Anthony, Ian. 2011. *Irreversibility in Nuclear Disarmament: Political, Societal, Legal and Military-Technical Aspects*. Stockholm: Stockholm International Peace Research Institute.
- Betts, Richard K. 1977. 'Paranooids, Pygmies, Pariahs & Nonproliferation'. *Foreign Policy* 26: 157-183.
- Biswas, S. 2014. *Nuclear desire: Power and the postcolonial nuclear order*. U of Minnesota Press.
- Cliff, D., H. Elbahtimy, & A. Persbo. 2011. *Irreversibility in Nuclear Disarmament: Practical steps against nuclear rearmament*. VERTIC.

https://www.vertic.org/media/assets/Presentations/Irreversibility_Launch_Presentation.pdf.

- CRS. 2003-2011. *Nuclear Arms Control: The Strategic Offensive Reductions Treaty*. March 3, 2003 – February 7, 2011. <https://www.everycrsreport.com/reports/RL31448.html>.
- den Dekker, Guido & Tom Coppen. 2012. 'Termination and Suspension of, and Withdrawal from, WMD Arms Control Agreements in Light of the General Law of Treaties', *Journal of Conflict & Security Law* 17(1): 25-47.
- Elbahtimy, Hassan. 2022. 'Approaching Irreversibility in Global Nuclear Politics', Consortium Working Paper 1.
- Elbahtimy, Hassan and Ross Peel. 2023 'Nuclear Weapons Production Complexes in a Disarmed World'. *Journal of Peace and Nuclear Disarmament*
- Epstein, William. 1977. 'Why states go—and don't go—nuclear'. *The Annals of the American Academy of Political and Social Science* 430 (1): 16-28.
- Fleck, Dieter. 2023. 'Irreversibility in nuclear arms control and disarmament law?' *Journal of Conflict and Security Law* 28(3): 423-466.
- Gallagher, Nancy W. 1997. 'The politics of verification: Why "how much?" Is not enough'. *Contemporary Security Policy* 18 (2): 138-170.
- Goodby, Jim, Roland Lajoie, and Anatoli Diakov. 1998. 'Dismantlement and Irreversibility'. In *Meeting Summary: The Future of Russian-US Strategic Arms Reductions: START III and Beyond*. <https://www.armscontrol.ru/transforming/day2.htm>.
- Gower, J. and C. Parthemore. 2021. *A Practical Strategy for Nuclear Risk Reduction and Disarmament: Fulfilling the Code of Nuclear Responsibility*. Briefer No.17. The Nolan Centre and Council on Strategic Risks. https://councilonstrategicrisks.org/wp-content/uploads/2021/04/A-Practical-Strategy-for-Nuclear-Risk-Reduction-and-Disarmament_Fulfilling-the-Code-of-Nuclear-Responsibility_Briefer-17_2021_4_19.pdf.
- Hajnoczi, Thomas. 2023. 'Legal Reflections on the Irreversibility of Nuclear Disarmament'. *Journal of Peace and Nuclear Disarmament*.
- Hymans, Jacques EC. 2006. *The psychology of nuclear proliferation: Identity, emotions and foreign policy*. Cambridge University Press.
- International Panel on Fissile Materials. 2023. 'Countries: France'. International Panel on Fissile Materials. <https://fissilematerials.org/countries/france.html>.
- IPNDV Working Group 1. 2018. *Food-for-Thought Paper: Achieving Irreversibility in Nuclear Disarmament*. IPNDV. <https://www.ipndv.org/wp-content/uploads/2018/01/IPNDV-WG1-FFT-Irreversibility-Final.pdf>.
- Kim, Ilsu. 2004. 'A Comparative analysis of president Clinton and Bush's handling of the North Korean nuclear weapons program: Power and strategy'. *Pacific Focus* 19 (1): 69-106.
- Krass, Allan S. 2020. *Verification: how much is enough?*. Routledge.
- Kristensen, Hans. 2019. 'New START Treaty Data Shows Treaty Keeping Lid On Strategic Nukes By Hans Kristensen', Federation of American Scientists, 4 October 2019. <https://fas.org/blogs/security/2019/10/new-start-2019-2/>.
- Muti, Alberto, Grant Christopher, and Noel Stott. 2023. 'The Role of Verification in Supporting Irreversible Nuclear Disarmament'. *Journal of Peace and Nuclear Disarmament*

- Nikkei Asia. 2022. 'North Korea makes nuclear weapons policy 'irreversible''. *Nikkei Asia*, 9 September 2022.
- Pelopidas, B. 2011. 'The oracles of proliferation: How experts maintain a biased historical reading that limits policy innovation'. *Nonproliferation Review* 18(1): 297-314.
- Ritchie, Nick. 2013. 'Valuing and devaluing nuclear weapons'. *Contemporary Security Policy* 34 (1): 146-173.
- Ritchie, Nick. 2014. 'Waiting for Kant: devaluing and delegitimizing nuclear weapons'. *International Affairs* 90 (3): 601-623.
- Ritchie, N. 2023. 'Irreversibility and Nuclear Disarmament: Unmaking Nuclear Weapon Complexes'. *Journal for Peace and Nuclear Disarmament* 1-26.
- Ruble, Maria Rost. 2009. *Nonproliferation norms: Why states choose nuclear restraint*. University of Georgia Press.
- Sagan, Scott D. 1997. 'Why do states build nuclear weapons? Three models in search of a bomb', *International security* 21 (3): 54-86.
- Seo, Yoonjung, Larry Register and Heather Chen. 2022. 'North Korea declares itself a nuclear weapons state, in 'irreversible' move', *CNN*, 9 September 2022. <https://edition.cnn.com/2022/09/09/asia/north-korea-kim-nuclear-weapons-state-law-intl-hnk/index.html>.
- Smetana, Michal, and Carmen Wunderlich. 2021. 'Nonuse of nuclear weapons in world politics: Toward the third generation of "nuclear taboo" research'. *International studies review* 23 (3): 1072-1099.
- Solingen, Etel. 2009. *Nuclear Logics*. Princeton University Press.
- Tannenwald, Nina. 2005. 'Stigmatizing the bomb: Origins of the nuclear taboo'. *International Security* 29 (4): 5-49.
- Welna, D. 2018 'Complete, Verifiable, Irreversible' A Tough Goal For North Korea Summit'. *NPR*, 6 June 2018. <https://www.npr.org/2018/06/06/617619192/complete-verifiable-irreversible-a-tough-goal-for-north-korea-summit>.
- Williams, Heather, Jessica Link and Joseph Rodgers. 2023. *Irreversibility in Nuclear Disarmament*. CSIS. <https://www.jstor.org/stable/pdf/resrep47438.1.pdf>.
- Wit, Joel S., Daniel B. Poneman, and Robert L. Gallucci. 2005. *Going Critical: The First North Korean Nuclear Crisis*. Washington DC: Brookings Institution