Working Group Paper #8

Rosatom and Civilian Nuclear Power: Recommendations for Sanctions against the Russian Federation

The International Working Group on Russian Sanctions

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The International Working Group on Russian Sanctions aims to provide expertise and experience to governments and companies around the world by assisting with the formulation of sanctions proposals that will increase the cost to Russia of invading Ukraine and support democratic Ukraine in the defense of its territorial integrity and national sovereignty. Our working group is comprised of independent experts from many countries, but coordinates and consults with the Government of Ukraine and those governments imposing sanctions. This consultation process helps to inform our views, but our members express independently held opinions and do not take direction from or act at the behest of the Government of Ukraine or any other person or entity. The views expressed in this paper represent our own independent, nonpartisan collective assessments for how best to use economic leverage to end Putin's war, supplemented by discussions with nuclear experts at the Atlantic Council (US), at the Nuclear Energy Institute (US) and energy experts from the DiXi Group (Ukraine). This working paper expands on an idea first presented in our original Action Plan, a proposal to extend sanctions to Russian nuclear power exports. The ideas in this paper have been informed by additional memos and papers posted on our website. [1]

I. Executive Summary

We see three reasons for Ukraine's partners to apply sanctions to Russia's trade in nuclear power and related products, services, and investments:

Safety. Russia has shown a flagrant disregard for nuclear safety in its actions in Ukraine, both at the Chornobyl power plant in the spring and more recently and acutely at the Zaporizhzhia nuclear power plant (NPP). It has previously located military equipment on the site, threatened workers at the plant, as well as allegedly undertaking deliberate sabotage, including by shelling at the plant and cutting it off from backup power, thus creating a clear and present danger of a major nuclear safety incident. As the Russian government's agent in nuclear power, Rosatom bears particular responsibility for the development of this dangerous situation. Furthermore, the International Atomic Energy Agency (IAEA) has issued a set of recommendations for improving nuclear safety at Zaporizhzhia, which Rosatom has failed to implement.

Influence. Russia has actively used its nuclear offer as part of an influence strategy, with Rosatom representatives based at Russian embassies, and Rosatom, as an agent of the Russian government, seeking to lock countries into Russian nuclear technology, codes and standards, and generally promoting Russian government actions and objectives. We also

[1] Similar to other papers produced by this working group, our aim in this paper was not to produce a consensus document, but instead to provide a menu of possible additional measures to be considered by governments, multilateral institutions, and private actors. The implications of every sanction have not been thoroughly analysed, and not everyone necessarily agrees with every specific sanction or action proposed.

highlight the risk for Ukraine's partners, many of whom buy enriched uranium and other nuclear products and services from Rosatom. Russia may seek to exploit this dependency on Russian nuclear services, as Gazprom has done in the case of gas. Such concerns have contributed to Finland's decision to cancel its contract for a Russian nuclear power plant (Hanhikivi) earlier this year.

Trade. Finally, Russia has a sizeable trade in nuclear products – including the sale of raw uranium, conversion services, enrichment services, and nuclear plant construction and allied services, with revenues reported by Rosatom in 2021 as $8.9 billion, and an order backlog for nuclear plant construction worth $140 billion, according to Rosatom. Sanctions on this trade will reduce Russia's foreign earnings and leverage over other countries, increase Russia's isolation and pressure on the Russian economy. and reduce Russia's ability to wage war on Ukraine.

Correspondingly, we see three key objectives to sanctioning Rosatom and the Russian nuclear industry, in order of priority:

1) Deterrence: To respond to Russia's flagrant breaches of good nuclear safety practice at Zaporizhzhia NPP, and incentivize Rosatom and the Russian armed forces to behave responsibly and cooperate fully with the IAEA, so as to minimize the risk of a nuclear incident;

2) Dependency: To reduce dependency on a hostile power in the nuclear fuel cycle in the advanced economies;

3) Damage: To reduce Russia's export earnings and influence.

First, with immediate effect, we propose a three-step strategy in an effort to protect nuclear safety in Ukraine: a first "warning shot" round of sanctions to impose pain on Rosatom for breaches of nuclear safety already committed and to clarify that they are not exempt from sanctions, combined with clear communication that further sanctions will follow if they fail to bring their behavior into line with IAEA recommendations. Furthermore, a punitive set of sanctions should be worked up, communicated, and applied in the event of a major nuclear incident in Ukraine as a result of irresponsible Russian actions.

In the initial round of sanctions, we would propose a ban on supply of raw uranium from Russia; personal sanctions on key Rosatom officials, including members of the Rosatom Board, the Rosatom CEO (Likhachev) and the CEOs of key Rosatom subsidiaries; personal sanctions on Rosatom employees who have interfered at nuclear power plants in occupied Ukraine and taken actions endangering nuclear safety; a freeze on any new contracts with Rosatom for enrichment or processing services, and a freeze on any new contracts for construction of nuclear power plants; expulsion of Rosatom from the Global Compact for breach of its human rights principles; and a ban on Russian or Belarusian citizens at the IAEA from having access to data on Ukrainian nuclear power or being involved in decision-

making on Ukrainian nuclear power. We would also explore withholding critical nuclear supplies from Russia – such as export of specialized carbon fiber to Russia from South Korea and other partners – until there is full cooperation with the IAEA on management of Zaporizhzhia NPP and the IAEA reports that all safety issues have been resolved.

We propose that further rounds of sanctions for non-compliance with IAEA safety recommendations should include additional personal sanctions and announcement of further steps to reduce the role of Rosatom in nuclear fuel supply in Western countries. The punitive package of sanctions which would be imposed for a major nuclear incident at a Ukrainian nuclear plant under Russian occupation should include such measures as: taking control of Rosatom investments in Western countries on grounds of national security; closure of Rosatom offices and expulsion of Rosatom-affiliated diplomats; exclusion of Rosatom from all intergovernmental and research project agreements, except in so far as they are judged to help prevent nuclear proliferation and secure nuclear safety or directly contribute to a humanitarian objective, such as medical research; personal sanctions on all senior Rosatom officials in the Rosatom holding company and at Rosatom subsidiaries; company sanctions on Rosatom and all its 262 subsidiaries and 50 affiliated companies – preventing them from being able to trade in Western currencies or do business with Western companies – with a tightly drawn exemption for a single company on the Russian side to service any nuclear contracts which are deemed to be essential.

Second, we propose that Western governments set the objective of reducing dependency on Rosatom at nuclear operators in the advanced economies to a low-risk level. This requires setting targets to reduce dependence upon Rosatom to a low-risk level – which could take up to four years, given the lead times required to expand conversion and enrichment capacity, although on paper potential exists for faster action – and providing enough certainty on future demand for nuclear conversion and enrichment services to facilitate the investment to create the capacity to replace Rosatom. As part of this effort, we urge all Western governments and Western companies with a high level of dependence on Rosatom to find alternative suppliers as rapidly as practical for conversion, enrichment and other nuclear services. Here, we highlight the opportunity for operators of Soviet/Russian heritage plants to replace Rosatom as their fuel supplier with Westinghouse, as Ukraine (for its whole fleet) and the Czech Republic (for two of its reactors) have done this year.

Third, we urge all countries cooperating with Russia in nuclear power, e.g., to construct a nuclear power plant, to freeze such cooperation until Russia has ended its invasion of Ukraine. More generally, in the nuclear industry, people often talk about a “100-year relationship”, given the long duration of construction, operation, and decommissioning of a nuclear power plant. A reliable and predictable partner who meets commitments is necessary for such a long-run relationship. In our view, no country can be considered a reliable partner if it behaves in the reckless, aggressive manner as demonstrated by Russia during its invasion of Ukraine. We therefore further would urge countries to terminate existing contracts with Rosatom. We particularly advise the Hungarian government to replace Rosatom as the lead contractor at the Paks-2 NPP expansion project in Hungary.

II. Sanctions on Nuclear Power: Why and How?

Why The Time Has Come to Act

On other aspects of Russia's trade in energy, Ukraine's partners have now implemented sanctions, or sanctions are in the process of being implemented. Coal sanctions are currently in force. Sanctions on oil are already in place (in the United States and United Kingdom) or are being implemented, with the near-complete European embargo on crude oil from December 2022 and on oil products from February 2023, alongside a price reduction mechanism to cap the price of Russian oil sold to third countries. Gas purchases have been massively reduced, with a ban in the UK, and an EU commitment to end purchases of Russian gas over time.

However, in contrast to this action on Russia's fossil fuel energy exports, there has only been a limited impact on Russia's nuclear energy exports so far, with actions by individual countries rather than any agreement on sanctions. In particular, Finland has decided to terminate a contract with Rosatom to construct a nuclear power plant, and Ukraine and the Czech Republic decided this year to completely end and substantially reduce their dependence on Rosatom for nuclear fuel supply, respectively.

This relative inaction on nuclear power likely reflects three factors:

First, an assessment that imposing sanctions on nuclear fuel services could be disruptive to Ukraine's partners, given Russia's central role in some nuclear services, including conversion, or post-mining treatment of uranium, and enrichment, which is a process to increase the proportion of fissile uranium. For instance, a recent Columbia University study (Bowen and Dabbar 2022) suggested that Russia accounted for 40% of global conversion services in 2020, while Rosatom reported that it supplied 38% of the market for enriched uranium in 2021. This dominant position makes it potentially difficult to find a substitute for Rosatom in conversion and enrichment services, particularly for some countries such as the United States and South Korea, who are heavily dependent on Russia for enriched uranium.

Second, an assessment that Russia's exports earnings from nuclear products are relatively small – $9 billion in 2021, or 1.8% of Russian 2021 export earnings of $494 billion, largely consisting of nearly $5 billion from power plant construction, and $3.4 billion from nuclear fuel services. Although significant, this is still 1/27 less than the $245 billion provided by oil and gas exports in 2021. This suggests that constraining Russian nuclear power exports are less of a priority.

Third, broader policy reasons for caution on imposing sanctions on nuclear power including the desire to maintain cooperation with Russia in nuclear matters as part of the wider effort to prevent nuclear proliferation, ensure nuclear safety and maintain dialogue between nuclear powers on nuclear matters.

Nevertheless, we believe that these factors are now less compelling. In terms of dependency, the Rosatom position may not be as dominant as some of the headline figures suggest. With regards to conversion services, the World Nuclear Association data shows that the dependency on Russia may be short-lived, with a major French plant run by Orano ramping up, and a large-scale US plant owned by ConverDyn scheduled to be on line in 2023. The associated increase in conversion capacity from these projects significantly exceeds Rosatom's total conversion capacity (Table 1).

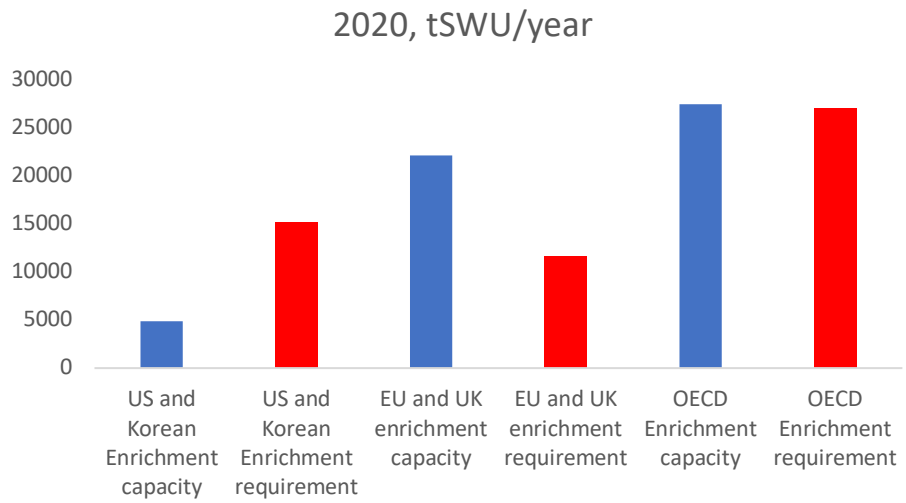
Table 1. Estimated UF6 conversion capacity and utilization for 2020, tU

Converter	*Country*	*Nameplate capacity (tU)*	*Capacity utilization %*	*Capacity utilization (tU)*
Cameco	Canada	12,500	72%	9,000
CNNC	China	15,000	53%	8,000
ConverDyn	USA	7,000	0%	0
Orano	France	15,000	17%	2,600
Rosatom	Russia	12,500	96%	12,000
Total		62,000	51%	31,600

Source: World Nuclear Association

Second, some data sources imply that the dependency on Russian supply in enrichment services may be manageable, although clearly more acute than the dependency in conversion services. In particular, the OECD's data shows a significant US and Korean lack of domestic enrichment capacity. Yet at the same time, the OECD's data reveals that there is significant spare enrichment capacity in Europe, particularly in Germany, the United Kingdom, and the Netherlands, which is potentially available to offset any shortfall in Rosatom supply to the US and Korea. For instance, if one considers the set of countries which are Ukraine's partners – reasonably proxied by membership of the OECD – enrichment capacity and enrichment requirements are broadly balanced (Figure 1). This analysis suggests that there are already viable options for mitigating Western dependency on the supply of enriched uranium from Russia. However, we recognize that this may not be a full dataset, e.g., it apparently does not include Ukraine's own need for enriched uranium, and that many policymakers remain more cautious on the scope for rapidly replacing Rosatom as a supplier of enriched uranium.

Figure 1. U.S. and South Korean enrichment deficit balanced by European enrichment surplus?



Source: OECD, Nuclear Energy Data 2021

In terms of the impact of sanctions, we would make several points. First, Russian export earnings from nuclear services ($9 billion per annum) are substantial. It is possible to reduce them and constrain Russia's ability to finance the war in a way which does not impose major costs on Ukraine's partners – moving more rapidly on parts of the nuclear fuel cycle where Rosatom has a modest presence, e.g., supply of mined uranium, and more deliberately on parts of the nuclear fuel cycle, such as conversion and enrichment services, where Rosatom has a more substantial presence. Second, the larger part of Russian export earnings (around $5 billion per annum) come from construction of nuclear power plants abroad. Financing constraints on the Russian side can have a material impact.

Table 2. Data from Rosatom's 2021 annual report on overseas orders and revenues

Portfolio of overseas orders, USD billion

	2019	**2020**	**2021**
10-year portfolio of overseas orders, including:	135.7	138.3	139.9
NPP construction abroad	93.0	89.1	84.1
Nuclear fuel assemblies	29.0	30.9	34.0
Other activities	13.7	18.3	21.8
Overseas revenue, USD million			
	2019	**2020**	**2021**
Overseas revenue, including:	7,228	7,475	8,979
NPP construction abroad	3,595	4,098	4,896
Nuclear fuel services	3,082	2,899	3,336
Other activities	551	479	747

Source: Rosatom Annual Report 2021

Finally, we see four broader reasons for taking a robust line with Russia on nuclear power:

First, and most important, Russia has been acting recklessly and dangerously in its actions at Ukrainian NPPs, specifically at Zaporizhzhia NPP, therefore raising the risk of a nuclear accident, or even nuclear sabotage. Rosatom bears particular responsibility for this situation, as the agent of the Russian government responsible for nuclear power.

Second, the nuclear industry has been through a period of decline since the 2011 Fukushima accident, but the adjustment has largely happened in the privately-owned Western nuclear industry, which has closed mines and reduced capacity. Meanwhile, Rosatom has continued expanding, leaving it with a high market share and subsequent leverage. Now that the nuclear industry is entering a period of growth, Rosatom's high market share is providing an unacceptable level of influence for a hostile power in a key part of the energy system.

Third, Rosatom and Russia's overseas nuclear sales and promotion are a key part of Russia's diplomatic effort, particularly to the many developing countries to which it offers nuclear technology. Thwarting that effort will restrain Russian influence.

Fourth, as a consequence of Russia's illegal and unrecognized annexation of four Ukrainian provinces, including Zaporizhzhia, President Vladimir Putin has signed a decree requiring Zaporizhzhia NPP to be treated as "federal property" of the Russian Federation in a unilateral attempt to appropriate Ukrainian property.

In short, we think that this combination of considerations – options to manage dependency on Rosatom, opportunities to reduce Russian export earnings, and wider reasons for taking a robust line with Rosatom – imply that Ukraine's partners should now move to sanction Russian nuclear power and Rosatom.

Proposed Actions

The overriding imperative in this situation is to deter a nuclear incident, at Zaporizhzhia or elsewhere in Ukraine, whether as a result of intentional Russian action or as a result of consistently reckless behavior.

Our proposed strategy is to impose an initial package of warning sanctions, serving two purposes:

1) It counters the idea – which has so far been true – that Russia can act with impunity in nuclear matters, which may encourage further reckless behavior; and

2) It increases the credibility of a threat of further sanctions for non-compliance with IAEA recommendations, up to a punitive package of sanctions if there is a nuclear incident while Russia is in charge.

We recognize that this strategy to deter a nuclear incident as a result of sabotage or neglect by Russia may not be sufficient, given Russia's reckless recent behavior, and that its actions are largely decided by one man (perhaps in a small inner circle) rather than by a more predictable institutional process. However, we believe that it provides the right incentives, and therefore contributes to reducing risk.

In the initial package of warning measures, we propose the following measures:

1) A ban on supply of raw uranium from Russia. This ban will hit Russian mining and force Central Asian supplies currently shipped through Russia to find an alternative route to advanced economy markets. However, with a large volume of recently mothballed and prospective mines in other countries, including Ukraine's partners Canada and Australia, and a relatively modest Russian share of mined uranium supply, we see this as having only a modest impact on price and supply. This assessment reflects that Russia is a relatively small producer – accounting for 2,635 tons out of global production of 48,332 tons in 2021, i.e., 5.5% of the total, according to the World Nuclear Association (WNA);

2) Personal sanctions on key Rosatom officials, including members of the Rosatom Board, the Rosatom CEO (Likhachev) and the CEOs of key Rosatom subsidiaries (Uranium One, Tenex, TVEL). As we have argued in our paper on personal sanctions, these measures – asset freezes and travel bans – can be effective measures against the many members of the Russian elite who have assets and part of their family and life in the West. They are also disruptive to the enterprises without undermining their capacity to act, since they can appoint replacement officials to handle contracts with companies subject to sanctions legislation;

3) Kurchatov Institute. We propose to impose sanctions on the Kurchatov Institute, which is Russia's leading nuclear research institute. The Kurchatov Institute issued a statement supporting and justifying Russia's invasion of Ukraine in the immediate aftermath of the invasion, repeating false allegations from Russian propaganda. In particular, we propose to impose sanctions on the President of the Kurchatov Institute, Mr. Mikhail Kovalchuk, who is also the brother of Yuri Kovalchuk, one of the closest members of Putin's inner circle.

4) Personal sanctions on Rosatom employees who have interfered at nuclear power plants in occupied Ukraine and taken actions endangering nuclear safety, to ensure appropriate responsibility for the systematic intimidation of Ukraine's nuclear power plant employees and the sabotage and theft of Ukrainian nuclear property;

5) A freeze on any new contracts with Rosatom for nuclear fuel services, and a freeze on any new contracts for construction of nuclear power plants;

6) Expulsion of Rosatom from the Global Compact. Rosatom signed up to The Global Compact in October 2020, which includes commitments to support and respect the protection of internationally proclaimed human rights; and make sure that they are not complicit in human rights abuses. We believe Rosatom should be expelled from the Global Compact for gross violation of these principles. As a state-owned enterprise, Rosatom supports and implements the policy of the Russian government, which has launched a war of aggression and conquest against Ukraine, committing numerous war crimes and human rights violations, including indiscriminate shelling and destruction of civilians and civilian property, and the intentional targeting of civilian infrastructure, particularly energy infrastructure. Furthermore, as the agency of the Russian government responsible for nuclear matters, Rosatom is responsible for the actions of the Russian government at the occupied Chornobyl and Zaporizhzhia NPPs, including the campaign of intimidation against Energoatom staff at those facilities, and the neglect of basic standards of nuclear safety by the occupying authorities, recklessly running the risk of a major nuclear incident.

7) Restrained Russian influence in the IAEA. To ensure impartiality on the part of the IAEA, and that it acts in the best interests of the international community and in line with its mandate, not as an agent of the Russian government, Russian and Belarus citizens in IAEA management should be excluded from access to data on Ukraine and excluded from the decision-making process on Ukrainian matters.

In addition, we think that Ukraine's partners should target any critical dependencies Rosatom may have, to reinforce the message that Rosatom and the Russian government and armed forces will face costs if they fail to behave responsibly with respect to Ukrainian nuclear power. For instance, the Ukrainian Ministry of Energy has noted that that the creation and operation of gas centrifuges for the isotopic enrichment of Russian uranium requires the use of carbon fiber of a certain brand and quality – a dual-use product – which Russia does not produce. This especially applies to gas centrifuges of the 9th and 9+ generations, which are used at the PJSC "Kovrovsky Mechanical Plant" (JSC "TVEL", Russian Federation). The South Korean company "Hyosung advanced materials Co" is the main supplier of this fiber. We would propose to ban supply to Russia of this carbon fiber, with supply of carbon fiber resuming, conditional on IAEA confirmation of full cooperation from Russia in the management of the Zaporizhzhia NPP, and that all outstanding safety issues at the plant have been resolved.

Alongside this warning package of measures, we propose that Ukraine and its partners communicate that further sanctions will be imposed on Rosatom at regular intervals if it fails to ensure compliance with IAEA recommendations on nuclear safety at Zaporizhzhia. These recommendations – the so-called "seven pillars" of nuclear safety – include maintaining the physical integrity of the facilities, ensuring safety and security systems are fully functional, ensuring operating staff can fulfil their safety and security duties and make decisions free of

undue pressure, ensuring secure off-site power supply from the grid to all nuclear sites, ensuring uninterrupted logistical supply chains and transportation to and from the sites, ensuring effective radiation monitoring systems and emergency preparedness and response, and ensuring reliable communication with the regulator. More generally, according to the IAEA, a nuclear safety and security protection zone should be established around Zaporizhzhia NPP. We propose that this progressive tightening of sanctions on Rosatom should target in the first instance personal sanctions on senior Rosatom officials and Rosatom officials active in Ukraine, and further steps by Ukraine's partners to replace Rosatom as a nuclear fuel supplier.

We further propose that a punitive package of sanctions be prepared, communicated to Rosatom, and imposed if there is a major nuclear incident at a Ukrainian nuclear plant under Russian occupation.

We propose that this punitive package should include:

1) Taking control of Rosatom assets in Western countries on grounds of national security;

2) Closure of Rosatom representative offices, particular those in countries that have partnered with Ukraine, such as the offices in Prague, Budapest, Paris, Washington, Tokyo, and Singapore, and expulsion of Rosatom-affiliated Russian diplomats;

3) Review of all international research projects involving Rosatom, with a view to exclusion of Rosatom from the International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO), the Generation IV International Forum (GIF), and the Stable Nuclear Energy Technological Platform (SNETP). Similarly, the International Thermonuclear Experimental Reactor (ITER) and Euroatom cooperation with Russia should be reviewed, with a view to terminating cooperation. Continued cooperation should be strictly limited to what is justified as helping prevent nuclear proliferation and secure nuclear safety, or contributes directly to a humanitarian objective, such as medical research;

4) Personal sanctions on all senior Rosatom officials in the Rosatom holding company and at Rosatom subsidiaries;

5) Company sanctions on Rosatom and all its 262 subsidiaries and 50 affiliated companies – preventing their ability to trade in Western currencies or do business with Western companies.

In the event of a nuclear incident, we would propose full sanctions on Rosatom and all its subsidiaries and officials, with a tightly drawn exemption, requiring a special license, for the Russian side to provide a limited range of nuclear fuel services for a limited time

period. At the same time, to make this threat credible, the risk of a Rosatom countersanction through withholding critical inputs into the nuclear fuel cycle in Western countries – e.g., converted and enriched uranium – should be mitigated by active efforts to expand Western conversion and enrichment capacity, and to redeploy the excess enrichment capacity in Europe to cover any shortfall in supply of enriched uranium to the United States or Korea.

Looking ahead, even if a nuclear incident on Ukraine is avoided, we believe that the current level of Western dependency on Russian supply of nuclear fuel services – particularly in conversion and enrichment – is no longer acceptable, especially after the use Russia has made of its leverage in gas supply to try and squeeze Europe to stop supporting Ukraine. Russia's actions have included squeezing supply clandestinely to induce shortages and higher prices, unilaterally abrogating contracts, and deliberately sabotaging infrastructure. Such dependency on a hostile power needs to be reduced to a low level of risk for nuclear to be a truly secure source of power for the advanced economies. We suggest that a low-risk level of trade with Russia in nuclear services would be a level where a complete interruption of Russian supply could be fully covered by other sources, without significant disruption.

However, reducing dependency on Russian nuclear fuel services to a low-risk level will require a determined and sustained effort. The pace at which this objective can be achieved depends on several factors, including:

1) The available inventories of uranium, which in some cases, e.g., in Europe, may amount to several years of stocks, but in others, e.g., the United States, may be more modest;

2) The capacity to expand the supply of raw uranium, which involves reopening mines;

3) The capacity to expand conversion capacity, and where the pace at which planned non-Russian conversion capacity will come online is uncertain;

4) The pace and conditions under which European holders of excess enrichment capacity can support the "deficit" enrichment countries, i.e., US and Korea, and the pace at which alternative capacity for enrichment can be brought online. For instance, if imports of enriched uranium are allowed from Russia again post conflict without restriction, this could undermine the economics of Western companies' investment in capacity expansion – so facilitating investment from alternative providers is likely to require a long-term commitment from Western governments e.g., a ban on Russian imports over some threshold level or a purchase contract;

5) The pace at which any other critical dependencies on Rosatom, e.g., for the supply of lithium-7 to prevent corrosion in US pressurized nuclear reactors, can be mitigated.

In short, with a clear strategy to achieve security of supply in the nuclear fuel cycle, and sustained government policy to support private sector investment in expanding uranium mining, conversion, and enrichment capacity, we see the potential to reduce dependency on Rosatom in the nuclear supply chain in the advanced economies to a low-risk level relatively rapidly. Experts suggest that Rosatom could be displaced from nuclear conversion and enrichment services in the advanced economies in about four years. On paper, it looks possible to act even faster, given surplus European enrichment capacity. We would recommend that Ukraine's partners publicly announce an objective to reduce dependency on Rosatom to a low level, to focus and drive the effort. Clearly, this effort should seek to create a competitive supply position with more than one supplier in each part of the nuclear fuel cycle to avoid giving any particular company a monopoly position, to the extent possible.

We also note that there is often an understandable preference to maintain a relationship with the original equipment manufacturer (OEM), since they may have a better understanding of the technology. However, in the case of Soviet/Russia-heritage reactors – typically abbreviated as VVER and known in English as water-water energetic reactors – there is now an actionable solution to reliance on Rosatom. Westinghouse has provided a certified alternative to Rosatom as fuel supplier since 2011, and Westinghouse has now replaced Rosatom as the fuel supplier at the majority of Ukraine's VVER-1000 fleet and is scheduled to complete this transition across Ukraine's nuclear fleet – a mix of VVER-440s and VVER-1000s – in early 2025. This provides an implementable option of an alternative fuel supply for other countries with Soviet or Russian-heritage reactors who currently rely on Rosatom for their fuel supply. We would in particular recommend that Ukraine's European partners with such reactors – Bulgaria, Czech Republic Finland, Hungary, and Slovakia - explore this option carefully. Moreover, we would urge all countries with Soviet and Russian-heritage nuclear reactors to engage with Energoatom and Westinghouse to understand the scope for replacing Rosatom fuel in their nuclear fuel cycle with Western nuclear fuel.

Making Rosatom Pay

We propose that, if as part of its attempt to change borders by force and annex part of Ukraine, Russia continues to act in breach of the normal standards of nuclear safety, then Rosatom should pay a cost. It should first be alerted to that cost by an immediate warning package of sanctions in response to the breaches which have already occurred. These sanctions should be regularly tightened until Rosatom is acting in accordance with IAEA safety recommendations. In the event of a nuclear incident in Ukraine, Rosatom should face a complete shutout from the advanced economies – losing its assets, markets, and offices – with immediate effect, and a direct challenge to its position in developing countries.

On the other hand, should Rosatom demonstrate a more responsible attitude towards its obligations to secure nuclear safety at temporarily occupied plants in Ukraine, the impact on Rosatom would be debilitating rather than catastrophic, with a substantial loss of market

share in its advanced economy markets over the coming years, and a downgrading in the level of cooperation with the advanced economies.

By contrast, if Russia ends its invasion of Ukraine and settles all outstanding obligations for the payment of appropriate reparations and compensations, and if Rosatom fulfils its nuclear safety obligations in Ukraine conscientiously, then the road would be open for Rosatom over time to resume playing a role in nuclear power markets and research in the advanced economies.

III. Conclusion: Sanctions on the Russian Nuclear Industry

We propose to strengthen sanctions on nuclear power first by focusing on nuclear safety, by imposing a cost for current breaches of nuclear safety norms that have already occurred in a warning package of sanctions, by committing to tighten those sanctions further until IAEA safety recommendations are met, and finally by preparing a punitive package of sanctions if Russia and Rosatom cause a nuclear incident in temporarily occupied Ukraine.

We further propose a strategy for reducing dependency on Rosatom in the nuclear industry in the advanced economies to a low risk level. And ultimately, we urge all countries at least to freeze any current nuclear cooperation they have with Rosatom while the war continues, and to consider terminating contracts with Rosatom, on the grounds that Russia's unreliable behavior makes it an unsuitable partner for a long-term nuclear relationship.

1) **First, we propose a "warning shot" package of sanctions**, to impose a cost on Rosatom for Russia's breaches of nuclear safety. In particular, we propose sanctions on raw uranium, where Russia can be relatively easily substituted as a supplier; a ban on new contracts with Rosatom to construct nuclear plants and new contracts for nuclear fuel cycle services, including for conversion and enrichment; personal sanctions on the senior leadership of Rosatom (Rosatom Board and CEO, CEOs of key subsidiaries) and Rosatom officials active in Ukraine; expulsion of Rosatom from the Global Compact; and a ban on Russian and Belarusian citizens at IAEA from having access to data related to Ukraine and input into decision-making on Ukrainian nuclear plants. Separately, we also propose a ban on the supply to Russia of any critical inputs, such as carbon fiber used for uranium enrichment, pending full cooperation with the IAEA on securing the safety of the Zaporizhzhia NPP. To reinforce this message, we propose that additional sanctions – further personal sanctions on Rosatom officials and further loss of Rosatom business in the advanced economies – be imposed on Rosatom at regular intervals, if it fails to bring the Zaporizhzhia NPP back into compliance with IAEA safety recommendations.

   In addition, we propose that Ukraine's partners agree upon a punitive package of sanctions which should be "on the shelf" and ready to go if Russia's actions at

Zaporizhzhia or elsewhere lead to a nuclear incident. In this package, we would propose taking control of Rosatom investments in Western countries, on grounds of national security; closure of Rosatom offices and expulsion of Rosatom-affiliated diplomats in Western countries; exclusion of Rosatom from all intergovernmental and research projects, except in so far they are judged to be required to prevent nuclear proliferation and secure nuclear safety or directly contribute to a humanitarian objective, such as medical research; personal sanctions on all senior Rosatom officials in the Rosatom holding company and Rosatom subsidiaries; and company sanctions on Rosatom and all its subsidiaries – including the 261 subsidiaries consolidated within the reporting boundary of the State corporation Rosatom as well as the 50 subsidiaries which are outside that boundary. This will prevent these subsidiaries – many of whom have their own accounts, contracts, and legal personality – from being able to trade in Western currencies or do business with Western companies. We would propose a tightly drawn exemption for a single company on the Russian side to service any existing nuclear contracts and research projects which are deemed to be essential.

2) **Second, we advocate action to reduce dependency on Rosatom in the nuclear fuel cycle in the advanced economies** to a low-risk level that can be fully substituted at short notice if required, without significant disruption. After a decline in interest following the 2011 Fukushima accident, nuclear power is now experiencing a strong renewal of interest, partly since it can provide dispatchable or baseload low-carbon power, and partly in response to the unreliability of gas and oil supplies. But this interest is hampered by the concern that nuclear power is not fully secure, since a hostile power, i.e., Russia, has considerable leverage and influence over the industry, due to Rosatom's central role in nuclear conversion and enrichment. We propose Western governments should set an objective of reducing any dependency on Rosatom to a low-risk level and provide sufficient clarity about forward demand for nuclear power to incentivize the investment to create substitute mining, conversion and enrichment capacity. Experts suggest that new investments can largely replace Rosatom in the nuclear fuel cycle in the advanced economies in around four years, with scope on paper to move substantially more rapidly, given substantial surplus conversion and enrichment capacity in the advanced economies. Ukraine's partners should explore options to allow spare enrichment capacity in Europe to be available for plants in the USA and Korea in particular, in case of any shortfall in Russian supply. In addition, we highlight the opportunity for owners of Soviet/Russian-heritage nuclear reactors ("VVER"-style reactors) to switch from using Rosatom as their fuel supplier to using Westinghouse as their fuel supplier, as Ukraine has done.

3) **Finally, we propose action to reduce Rosatom's export earnings**, reflected in particular in its large backlog of overseas construction contracts. In practice, little progress on these contracts is likely at the moment, since Russia will struggle to finance international nuclear projects while the war and sanctions persist. Nonetheless, Rosatom clearly is seeking to maintain its position: over the summer,

Hungary issued construction licenses for two Rosatom nuclear power plant units, in a move widely seen as a signal that Rosatom would continue to implement the project despite the war. Rosatom has signed several MoUs on nuclear cooperation this year, including with Brazil, Myanmar, and Uzbekistan.

In response, we suggest Ukraine and its partners should pursue a two-pronged strategy. First, they should actively promote Western nuclear technology, as an alternative to Russian technology, and to avoid Russian technology, codes and standards dominating an industry which now looks set to be entering a period of growth. Second, they should actively push countries with Rosatom contracts to construct a nuclear plant – e.g., Bangladesh, India, Turkey, Egypt, Saudi Arabia, and the United Arab Emirates – to follow Finland's example and terminate the contract, and countries with Rosatom fuel supply to follow Ukraine's example and find an alternative supplier.

In the nuclear industry, people often talk about a "100-year relationship", given the long duration of construction, operation and decommissioning of a nuclear plant. For such a long run relationship to work, people need a reliable and predictable partner who meets its commitments. In our view, no country can be considered a reliable partner if it behaves in the reckless and aggressive manner demonstrated by Russia during its invasion of Ukraine, where Russia has breached international law, broken treaty obligations and committed multiple human rights abuses in an attempt to change international borders by force. Moreover, Russia has behaved particularly irresponsibly with respect to energy: using access to energy supplies and control of energy infrastructure as a tool of political leverage, failing in its obligation to behave responsibly with respect to nuclear power, and intentionally targeting civilian energy infrastructure in war with the objective of causing civilian suffering to weaken Ukrainian morale. We propose that Ukraine and its partners should approach the governments of all countries that propose to continue developing their nuclear capabilities with the aid of Rosatom to highlight the risks of such a relationship, given Russia's aggressive foreign policy and willingness to use leverage over energy as an instrument of coercion, and to propose that they switch from Rosatom to a Western partner in nuclear plant construction and nuclear fuel supply.

Note: The inclusion of affiliations is for identification purposes only and does not represent an endorsement of shared views with the co-signer.

Dr. Anders Åslund, Senior Fellow, Stockholm Free World Forum.

Alex Bashinsky, LLM, Certified Global Sanctions Specialist (ACAMS).

Torbjörn Becker, Director of Stockholm Institute of Transition Economics, Stockholm School of Economics.

Anne L. Clunan, Associate Professor of National Security Affairs, Naval Postgraduate School, and Faculty Affiliate, Center for International Security and Cooperation (CISAC), Stanford University. *The views here are my own, and not those of the U.S. Navy, Department of Defense, or Government.*

Anastassia Fedyk, Assistant Professor of Finance, the Haas School of Business, University of California - Berkeley; Co-organizer of the Economists for Ukraine group.

Yuriy Gorodnichenko, Quantedge Presidential Professor of Economics, Department of Economics, University of California - Berkeley; Co-organizer of the Economists for Ukraine group.

Denis Gutenko, Ukrainian Emerging Leaders Program Fellow, Stanford University, and Former Head of the State Fiscal Service of Ukraine.

James Hodson, Director and Chief Executive Officer, AI for Good Foundation; Co-organizer of the Economists for Ukraine group.

Eric Johnson, Former Managing Director, Cambridge Associates; Former National Security Council Staff, White House Situation Room.

Bronte Kass, Program Manager, Freeman Spogli Institute for International Studies (FSI), Stanford University; Assistant Coordinator, International Working Group on Russian Sanctions.

Craig Kennedy, Center Associate, Davis Center for Russian and Eurasian Studies, Harvard University.

Dr. Tyler Kustra, Assistant Professor of Politics and International Relations, University of Nottingham, Nottingham, UK.

Michael McFaul, Director, Freeman Spogli Institute for International Studies (FSI), Professor of Political Science, and Hoover Institution Senior Fellow, Stanford University; Coordinator, International Working Group on Russian Sanctions.

Benjamin Moll, Professor, London School of Economics and Political Science.

Tymofiy Mylovanov, President of the Kyiv School of Economics; Associate Professor, University of Pittsburgh.

Jacob Nell, Senior Research Fellow, Kyiv School of Economics; Former Chief Russia Economist, Morgan Stanley.

Olesksandr Novikov, Head of the National Agency on Corruption Prevention, Ukraine.

Steven Pifer, Affiliate, Center for International Security and Cooperation (CISAC), Stanford University; Former U.S. Ambassador to Ukraine.

Lukasz Rachel, Assistant Professor of Economics, University College London.

Dr. Benjamin L. Schmitt, Project Development Scientist, Harvard University; Senior Fellow for Democratic Resilience, Center for European Policy Analysis; Rethinking Diplomacy Fellow, Duke University Center for International and Global Studies.

Natalia Shapoval, Vice President for Policy Research, Kyiv School of Economics.

Daria Sofina, National Agency on Corruption Prevention, Ukraine.

Jeffrey Sonnenfeld, Senior Associate Dean and Professor, Yale School of Management.

Dr. Kathryn Stoner, Mosbacher Director and Senior Fellow, Center for Democracy, Development and Rule of Law (CDDRL), and Professor, Freeman Spogli Institute for International Studies (FSI), Stanford University.

William B. Taylor, Former U.S. Ambassador to Ukraine; Vice President, Russia and Europe, United States Institute of Peace.

Nariman Ustaiev, Ukrainian Emerging Leaders Program Fellow, Stanford University; Co-Founder and Director of Gasprinski Institute for Geostrategy.

Pavlo Verkhniatskyi, Managing Partner, Director, COSA.

Denys Yatsyshyn, Director, Corporate Relations, U.S.-Ukraine Business Council (USUBC).