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By accident or by design? Pushing global governance of nuclear safety

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1. Introduction

Few other products of human ingenuity generate stronger demand for global governance than civilian nuclear technology. It is therefore reassuring to see that the present nuclear safety regime is relatively closely regulated. An elaborate set of institutions, regulations, and practices aim at safeguarding millions of tons of radioactive material and a vast number of nuclear facilities. Historically, after major nuclear disasters, safety improvements were always made concerning both reactor design and safety governance. The Chernobyl accident, for instance, led to many of the nuclear safety regulations and practices currently in place (Bunn and Heinonen 2011). The Fukushima-Daiichi accidents gave rise to a number of preventive measures, in Japan and beyond, to improve the response to nuclear disasters and to further reinforce nuclear safety in nuclear reactors.[1]

While the evolution of nuclear safety mechanisms occurred incrementally (in response to accidents) it was always shaped by concerns of national sovereignty. Even though governments realize the urgency of strengthening international measures, for nuclear safety, they tend to rely predominantly on voluntary engagement. In this paper, we argue that the governance of nuclear safety should be turned into a more robust regime, including elements of international supervision, monitoring and verification. In other words, instead of working on a *by accident* approach (i.e. in response to accidents), we need to improve nuclear safety *by design*.

We shall argue that a cutting back of "sovereignty" is required so that nation states no longer have full autonomy and unlimited legal and technical control over technological systems. Following the model of "disaggregated sovereignty" (Krasner 2001; Slaughter 2004) with national agencies and technical bodies working across boundaries, the situation of being intimately linked to international conventions and coordinating organizations would be preferable. In a comprehensive global governance regime, states would thereby partly renounce their techno-sovereignty for the sake of common nuclear

[1] See http://ajw.asahi.com/article/0311disaster/fukushima/AJ201505290052. Consulted on July 12th 2015.

safety. It is important to observe that *national security* might be objected to when it comes to agreeing on international governance. Particularly in the case of nuclear security and when states have military nuclear activities it seems unlikely that access will be given to international bodies regarding such activities. Our focus is, however, on the safety of civilian nuclear activities, particularly nuclear energy reactors, where national security concerns are largely irrelevant.[2]

To understand the argument presented in this paper, the difference between nuclear safety, security and safeguarding first needs to be highlighted. The International Atomic Energy Agency (IAEA) describes nuclear safety as "the protection of people and the environment against radiation risks, and the safety of facilities and activities that give rise to radiation risks." (IAEA et al. 2006, p. 5), while nuclear security relates to *intentional* malicious activities and to "[t]he prevention and detection of, and response to, theft, sabotage, unauthorized access, illegal transfer or other malicious acts involving nuclear material, other radioactive substances or their associated facilities" (IAEA 2007, p. 133). Finally, nuclear safeguard helps deter nuclear weapon proliferation by detecting any possible redirecting of nuclear material that could conceivably be used to manufacture nuclear weapons from highly enriched uranium and plutonium. Though the argument in this paper is primarily concerned with nuclear safety, we shall draw comparisons with the governance structure of nuclear security and with safeguarding mechanisms.

The paper is organized as follows. Section 2 discusses changes in the nuclear landscape that urge us to reconsider the global governance of nuclear safety. The existing governance regime for nuclear safety will be reviewed in Section 3 while in Section 4 we shall compare the governance structure of nuclear safety with nuclear security and safeguarding to see what lessons can be learned from such

[2] It should be noted that ensuring the safety of several civilian installations, such as research reactors that use Highly Enriched Uranium, might be sensitive from a national security point of view. The same goes for dual use nuclear technologies such as reprocessing facilities that are used both for military and civilian purposes. In countries that have these kinds of nuclear installations, national security might constitute an objection to globalizing nuclear safety, but there are very few countries that have access to such dual use technologies.

regimes. Section 5 will assess the impact of enforcement while focusing on the regional (supranational) governance structuring of nuclear safety. While the global application of the *by design* approach with international verification and enforcement mechanisms presents the ideal solution, the best feasible approximation we can hope for in the short term is implementation at regional level. Section 6 reviews potential objections to a change in the *by design* approach, arguing that such a comprehensive approach is not only desirable but also feasible.

2. The new global nuclear landscape

Major emerging trends in nuclear energy production and waste management make it pressing to rethink the global governance of nuclear safety. While a state like Germany is cutting back, many new nuclear energy reactors are being built or proposed in many other countries. At present, 59 reactors are under construction while 168 are in the planning phase.[3] These numbers are perhaps surprising given the initial responses to Fukushima. Some experts remain skeptical arguing that many aspiring states lack crucial factors such as proper governance, suitable grids and the available finance (Findlay 2011). According to the WNA and the 2014 *Word Energy Outlook*, nuclear power's share in the world's energy mix will not rapidly increase (IEA 2014). In absolute terms though global nuclear energy production is continuing and perhaps even slightly growing.[4]

It is not, however, the number of additional reactors but rather the shifting global dispersal that is relevant. Alongside the thirty existing nuclear energy countries, at least another eighteen may join in the next decades; an even larger number of countries (45 including the earlier-mentioned eighteen) are, in principle, interested in developing nuclear energy.[5] Table 1 shows that most new reactors will be built

[3] http://www.world-nuclear.org/information-library/facts-and-figures/world-nuclear-power-reactors-and-uranium-requireme.aspx Consulted on September 1st 2016.

[4] Some of the new reactors will simply replace the older ones built in the 1960s.

[5] See http://www.world-nuclear.org/info/Country-Profiles/Others/Emerging-Nuclear-Energy-Countries/

outside OECD countries where, today, roughly 74 percent of all power plants are operable. The landscape will tilt towards non-OECD countries, and especially towards Asia where 69 percent of all new reactors are under construction and where as many as 62 percent of those in the planning phase are located. As China is likely to have the largest percentage of new reactors, the newcomer's share may rise to 18 percent. Among the newcomers are countries with very different levels of capacity. Up to 53 percent of the reactors under construction and 57 percent of those being planned will be located in low GDP countries, including Bangladesh, Jordan, Vietnam, and Algeria. While some have experienced delays in their programs, one may question whether and, if so, when other countries wanting nuclear energy can join, bearing in mind their limited experience and expertise, governance capacities and financial resources (Schneider et al. 2014, p. 7).

Certain developments lead us to think that at least some of these newcomers will eventually have nuclear energy reactors in their grid, because a new mechanism offered by Russia will purportedly ameliorate important potential hurdles for such newcomers. Under the acronym BOO – Build, Own, Operate – the Russian company Rosatom offers to finance, construct and operate a nuclear power plant that will last for sixty years.[6] In the words of Jong Kyun Park, the IAEA Director of the Nuclear Power Division, this unique approach "solves two of the biggest challenges that newcomers face: [a lack of] financing and experienced operators"[7] For Rosatom, the package is intended "to win business from developing countries"[8]. The first country that will receive the BOO comprehensive package is Turkey which has contracted four reactors (Pekar 2014). Rosatom is also negotiating with Algeria, Argentina, Bangladesh, Jordan and many more countries.

[6] See http://uk.reuters.com/article/2013/05/13/uk-rosatom-nuclear-russia-idUKBRE94C09G20130513
[7] Quoted from the website of The Communications Network for Nuclear Energy and Ionizing Radiation: http://www.nucnet.org/all-the-news/2013/11/18/turkey-has-made-important-progress-in-nuclear-power-programme-says-iaea Consulted on May 11th 2015.
[8] Quoted from Reuters http://uk.reuters.com/article/2013/05/13/uk-rosatom-nuclear-russia-idUKBRE94C09G20130513 Consulted on May 11th 2015.

Similarly, the merger of two Chinese state nuclear companies has created global corporation that is geared to supplying reactors inside and outside China.[9] As potential obstacles disappear it seems likely that more newcomers from the Global South will join in the next couple of years. This, then, creates a wealth of national versus transnational safety governance challenges, particularly since according to the Russian proposal Rosatom will continue to operate its newly built plants. Among these challenges are also concerns related to *stranded facilities* those where, sometime in the future, an agreement breaks down for political reasons or a supplier withdraws or goes bankrupt. These scenarios emphasize the need to consider such bilateral collaborations within the broader international context.

Finally, the supply and demand sides are not only changing with regard to the newcomers, but also in the existing nuclear energy producing countries. There are a number of initiatives to facilitate multinational and multilateral collaborations both for the "front-end" and the "back-end" of the nuclear fuel cycle. The former relate to the mining and milling of uranium ore, enrichment, fuel fabrication and the use of fuel in nuclear reactors. Temporary storage, possible treatment such as reprocessing and the final disposal of radioactive waste are referred to as back-end matters. Multinational initiatives at the front-end relate mostly to nuclear fuel services. This is also offered by Rosatom in addition to its BOO concept. The idea of leasing nuclear fuel also involves a take-back option, which means that the client does not need to worry about nuclear waste disposal, a back-end activity in the nuclear fuel cycle.

There are also far-reaching back-end developments. While, according to international agreements, the producing countries are responsible for the disposal of their waste, the interest in multinational solutions to waste disposal is growing. Multinational repositories offer considerable economic, safety, security and non-proliferation advantages, particularly for smaller members with just one or two nuclear energy reactors (Bunn et al. 2001; McCombie and Chapman 2002). A large portion of the nuclear energy producing countries will undoubtedly consist of small members. Still, multilateral

[9] See: http://www.reuters.com/article/2015/02/04/china-nuclear-ma-idUSL4N0VE05Q20150204

proposals automatically generate a number of unprecedented governance challenges (Taebi 2012; Rosner, Kollar, and Malone 2015). The idea of establishing such a multinational repository is seriously being considered for EU countries that possess radiotoxic waste. Moreover, in a recently published report by the Government of South Australia, the option of establishing international disposal in that region to host used fuel from other countries has been discussed and is considered to be viable (Scarce 2016). Indeed these collaborations, especially back-end agreements, raise concerns related to nuclear waste transportation by water, rail, and road and sometimes also over great distances; e.g. Japanese spent fuel was reprocessed in the UK for many years and the extracted uranium and plutonium together with the remaining High Level Waste were afterwards shipped back to Japan. Such collaborations essentially heighten international risks, risks that are not confined to the participating countries thereby, again, strongly indicating the need for a global governance regime for nuclear safety.

3. The inadequacy of the existing nuclear safety governance regime

The previous section outlined a nuclear landscape that is tilting toward new countries with little expertise in nuclear technology. This is why we argue that a global governance regime for nuclear safety needs to be considered or reconsidered. Our interest is not only in new and inexperienced countries. Also countries with decades of experience would similarly benefit from a more robust global regime for nuclear safety. In this section, we shall first review the existing conventions, standards, guidelines and mechanisms for guaranteeing nuclear safety on a global scale. The most important ones all adhere to the notion of national sovereignty or to a vendor's independent self-regulation rather than to securing international control, monitoring and verifying. We conclude that the current regime is inadequate and insufficient.

Let us first review that current regime. The IAEA has a comprehensive and detailed set of safety standards. Different levels of safety hold safety fundamentals – "which set out basic objectives,

concepts and principles" – Safety Requirements – "which establish basic requirements […] in the case of particular activities or applications" and Safety Guides – or detailed recommendations (Findlay 2011, p. 107). None of these standards are, however, legally binding and there is no international monitoring and verification as stressed by NGOs and other critical observers. The IAEA's Convention on Nuclear Safety (CNS) is probably the most important instrument for nuclear safety governance, the key objective there being "to achieve and maintain a high level of nuclear safety worldwide through the enhancement of *national measures and international co-operation*" (IAEA 1994, Article 1; own italics). In its preamble, the CNS explicitly states that responsibility for nuclear safety rests with the states that operate such facilities. Rather than providing a monitoring and compliance system, the CNS parties convene at review meetings where "contracting parties report at regular intervals on how they implement each of the obligations under the Convention" (Tonhauser 2013, p. 172). While this was an important innovation in nuclear governance in the post-Chernobyl era, at the time when the Convention was drafted, national reports did not assess nuclear safety in each state but merely reported on compliance with the broad provisions of the CNS (Findlay 2011). Peer review is rather limited as national reports are only open to national governments; NGO's, academics or other interested parties do not have access to the review reports (Findlay 2011, p. 105). Judgment on compliance thus depends on the information voluntarily provided by each state.[10]

In response to Chernobyl, the nuclear industry established the World Association of Nuclear Operators (WANO) to enhance nuclear safety. The WANO "exists purely to help its members accomplish the highest levels of operational safety and reliability."[11] Their responsibility model combines the individual responsibility of each nuclear power plant operator with collective responsibility "to assess,

[10] The IAEA also organizes peer reviews involving regulators and operators as well as providing advisory services to help state agencies implement their CNS obligations.
[11] See http://www.wano.info/en-gb/aboutus/ Consulted on January 29th 2015.

inform, help and emulate other nuclear operators"[12]. Among other things, the WANO does peer reviews for its members and records the lessons learned. WANO's procedures respect each individual vendor's independence. The peer reviews remain confidential. Though they are shared with members (government-owned and private operators) they are not disseminated within the IAEA or other external bodies (Findlay 2011, p. 113). So, while these mechanisms have undoubtedly improved the global safety levels of nuclear reactors, WANO's peer review system lacks transparency.

The final nuclear safety legal instrument noted here pertains to the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management. This convention regulates the back-end of the fuel cycle and, like the CNS, compliance with this convention is based on a review system requiring parties to report at regular intervals on the implementation of each obligation (Tonhauser 2013). Again, there are no monitoring or verification mechanisms.

If one looks at the history of nuclear safety governance, it was clearly the meltdown in Chernobyl that first prompted national governments, the industry but also the international community to acknowledge the relevance of global rather than national governance regimes (Savchenko 1995). The disaster had an enduring impact on nuclear safety, it "provided the impetus for two conventions designed to help prevent nuclear accidents", namely the CNS and the Joint Convention on the Safety of Spent Fuel Management and the Safety of Radioactive Waste Management (Findlay 2012, p. 32). The Fukushima accidents similarly led to a range of improvements in the governance of nuclear safety, specifically concerning swift response to nuclear accidents and the safety of operational and new nuclear power plants by improving "the effectiveness and transparency of the Convention [on Nuclear Safety] peer review process" (IAEA 2014, p. 9). Calling for more transparency clearly constitutes a step towards safety governance. Yet the lessons learnt from Japan are predominantly relevant on a national

[12] Cited from the 'Membership Obligation' page of the WANO-website. See http://www.wano.info/en-gb/members/membershipobligations Consulted on January 29th 2015.

level: lobby for better regulation, retain a good overview and improve transparency (e.g. Wang and Chen 2012). In that way the principle of national sovereignty is reinforced and the incremental way in which crucial mechanisms ensure that nuclear safety has evolved are taken for granted.

An overreliance on national regulations and regulators for the ensuring of global nuclear safety is clearly insufficient. Apart from anything else, different nations assess the adequacy of their national regulations differently. In a study performed by the American Nuclear Regulatory Commission, the US and Japanese regulatory requirements at the time of the Fukushima-Daiichi accidents in 2011 were compared. While there were similarities in the design bases requirements and guidelines, the Japanese regulatory requirement neither considered problems or events beyond design (such as station blackouts) nor natural phenomena such as tsunamis and floods (NRC 2013, 3). Still, in other areas US regulations also leave room for improvement. Hecht (1998) emphasizes that in nuclear safety and security are always deeply ingrained in national techno-cultures, which can differ widely. Establishing global safety requirements and having an international body that would oversee them would at least reduce the likelihood of such divergences going unnoticed.

One potential risk of international approaches lies in the danger of triggering a *race to the bottom* following the merging of different national regulations. In other words, there is a tendency to lower standards after international collaboration has taken place. The hope is that stronger regulators such as the US NRC might want to avoid a race to the bottom; after all, they are in the position of having to negotiate the outcome with other regulators. But we should also acknowledge that when renegotiating, some actors (for instance some NRC licensees) might see an opening for lowering standards. The setting of international standards therefore needs to be accompanied by a warrant. To this end, the involvement of international organizations such as the IAEA might be a good way of avoiding such a race to the bottom when negotiating multinational safety standards.

The second problem and one that exposes the inadequacy of overreliance on national regulations and regulators is what is termed the *revolving door* dilemma. This refers to the shuttling of the same personnel between the regulatory bodies and the industry that they regulate. "Those who held prior industry employment may prove to be more sympathetic to industry [while], those who are eyeing industry employment after their work for a regulatory authority may seek to ingratiate themselves to their prospective future employers by being lenient in enforcing rules" (Ferguson and Jansson 2013, 17). We do not wish to imply that supranational or multinational governance would altogether resolve the revolving door dilemmas, but since more countries will participate in a strengthened international safety regime and since internationally speaking there is "something at stake", this dilemma seems less pronounced in the international context than in a domestic context.

Both issues – the different assessments of national regulation and the revolving door dilemma – are problems that have emerged within existing nuclear power countries and also pose potential safety risks to the newly entering countries.

4. Comparing the governance of nuclear safety, security and safeguard

Let us now compare the governance regimes of nuclear safety with nuclear security and safeguard (non-proliferation) to see what lessons can be learned. As revealed in the previous section, there are no strong international verification and enforcement mechanisms for nuclear safety governance; the nuclear security regime is even weaker than the safety regime and the IAEA's programs were, until recently, fairly small (Ferguson and Reed 2009). On the one hand this is surprising because nuclear security relates to the threat of nuclear or other radioactive material being used for criminal purposes (such as nuclear terrorism). On the other hand, as *national security* is often at stake in nuclear security governance, any country's reluctance to renounce its sovereignty becomes more understandable. Nuclear security is "almost exclusively governed by national law" (Tonhauser 2013, 174). Bunn (2013)

argues that in governing nuclear security we can learn from existing nuclear safety practices and mechanisms. This notion underlies President Obama's new *Nuclear Security Summit* initiative to help reduce "the amount of dangerous nuclear material in the world, improving the security of all nuclear material and radioactive sources [and] improving international cooperation."[13] The IAEA (2013) has undertaken several important measures to improve global nuclear security, including assisting states to establish a national nuclear security regime, offering international guidance, providing instruments, developing international agreements as well as promoting self-assessment and international peer-reviews. These efforts are, however, initiated at a state's request and they lack international monitoring or verification systems.

In nuclear safeguard or non-proliferation, the IAEA has the most far-reaching governance regime and functions as an effective *watchdog*. Non-compliance with nuclear safeguard agreements could "subject the State to curtailment or suspension of assistance provided by the Agency, the recall of material and equipment, and/or the suspension of the privileges and rights of Agency membership" (Tonhauser 2013, 183). Perhaps, more importantly, non-compliance could be reported to the General Assembly of the United Nations to trigger Security Council resolutions. In practice, however, non-compliance is a much more complicated process, because there are no clear definitions of what constitutes non-compliance. In the past every single case of non-compliance has posed its own unique challenges to the IAEA (Findlay 2015). The Iranian nuclear dossier and the Security Council's resolutions against Iran illustrate the complexity of the process of observing and reporting non-compliance to the IAEA bodies.

The governance landscape becomes even more complex if we observe that nations have agreed to compromise their national sovereignty when it comes to nuclear non-proliferation, despite the strong link with national security. Early theorists recognized the revolutionary impact of nuclear weapons and

[13] See: http://www.nss2014.com/en.

assumed that classical sovereignty principles were technologically outdated (Herz 1957; Deudney 1995). The very practice of nuclear deterrence during the Cold War undermined the notion of sovereignty; i.e. treaties on test bans, non-proliferation and the reduction of nuclear arsenals came to depend on transnational technical systems and institutional mechanisms of mutual surveillance and verification practices (Adler 1992; Sagan 1993; Podvig 2006). Deudney (1995, pp. 224-225) acknowledged a partial "republicanization of nuclear governance", because "these treaties establish an elaborate system of on-site inspections and monitoring that have no historical precedents in their degree of intrusiveness." The non-proliferation treaty (NPT) is also one of the most asymmetric international treaties.[14]

In short, the fact remains that the imperative of retaining national sovereignty is still guiding the civilian use of nuclear technology while its safety regulation is outdated and out of sync with the other areas of nuclear governance. As Pfotenhauser et al. (2012) emphasize with reference to Fukushima "current national models of nuclear governance are not adequate. In the light of the extensive supranational links, it seems anachronistic at best that key regulatory aspects of power plant licensing and security and safety standards should remain the exclusive preserve of national governments." Indeed, despite the sometimes strong rhetoric of 'technological sovereignty', nuclear technology is by nature highly non-indigenous; it is founded on numerous transnational links, business connections, and on the transfer of people, expertise, and staff (Krige 2006; Hecht 2012; Sarkar 2014). The overemphasis on national sovereignty places dangerous obstacles in the way of regulatory response to the shifting global nuclear landscape.

5. Think globally, enforce regionally

[14] It requires that its signatories renounce their right to gather knowledge and develop actual nuclear weapon programs, and remains – despite heavy criticism by the non-aligned movement – respected and fully functional.

So far we have argued that given the future redistribution and transnationalization of nuclear energy production, a more robust regime of global governance is needed. There are two questions that need to be answered, namely i) what key elements does such *governance* entail and ii) what exactly is meant by *global*?

We think that such a regime should, ideally speaking, include more international monitoring and verification (to ensure that safely regulations are properly acted upon) and should have a clear enforcement mechanism with possible sanction regimes for violations. At the bare minimum, it needs to entail some kind of *transparent* international oversight mechanism. In nuclear safety governance we can also learn from environmental governance in relation to the role of public scrutiny and "civic science" (Carrozza 2015). Transparency also ought to become a key element of existing peer review systems. For instance, even if only the two elements of monitoring and verification are in place – without a working enforcement mechanism – that could contribute to better safety because *transparent* monitoring systems could lead to naming and shaming among corporations and nation states. While there are diverging opinions about the extent of the influence of shaming as an incentivizing mechanism for compliance (Friman 2015) and particularly to corporations' receptiveness to naming and shaming (Taebi and Safari Forthcoming), it is safe to assume that a strong power of public scrutiny is effected by the media, NGOs and independent scientists. While we have argued that more international transparency would increase safety, we should also acknowledge that the risk of shaming could push corporations into rejecting any additional restrictions imposed by a new governance regime. We will further discuss this objection to transparency in the following section (Section 6).

The second aspect of such an approach has to do in the definition of the term global. The thrust of our argument is not so much that nuclear safety needs to be completely globalized but rather that it should not simply be left to nation states. For instance, monitoring and verification could well be first accomplished at regional level, whereas regulations and standards need to be agreed upon globally. At

regional level, countries tend to be less afraid of losing their voice (and thereby their sovereignty), thus meaning that governments would more readily acknowledge the need for nuclear safety. Proven regional approaches already exist, such as in the form of the EU safety regulations that are applicable to all EU member states, or the Association of Southeast Asian Nations (ASEAN). In addition, the Sendai Framework for disaster risk reduction (UN 2015) is promoting a regional approach to disaster risk management. In fact, the existing frameworks could serve as a powerful platform to reduce any transnational risks linked to nuclear power. In the following section we will discuss examples of regional approaches, along with potential objections.

6. Improving global nuclear safety by design: the challenges and opportunities

There are at least three hurdles to putting such a comprehensive global safety regime in place; these pertain to i) the tensions in international politics, ii) the stickiness of national sovereignty and iii) industry's resistance to additional restrictions and to issues of proprietary commercial information. In the following paragraphs we will briefly review these potential objections. We strongly believe that a robust global nuclear safety regime is not only necessary but also feasible provided it manages to address the following issues.

The first obstacle in international collaboration on nuclear safety is a political one since it relates to the positions of countries in the global political landscape, particularly where newcomers are concerned. Iran, for instance, is the youngest nuclear energy producing country and the only one with an operational nuclear power plant which is not a member of the Convention on Nuclear Safety. Iran's reluctance to become a member has been linked to its political isolation. As part of the agreed to Joint Comprehensive Plan of Action (JCPOA) between Iran and the six world powers, international collaboration on nuclear safety will start and will presumably also include membership of the

Convention of Nuclear Safety.[15] Since Iran is operating the only nuclear power plants in the Persian Gulf region, neighboring countries are keen for Iran to comply with international standards on nuclear safety. It is worth noting that Iran expressed its willingness to exchange data with its neighbors on radio-ecological issues and "to create a regional safety convention for the supervision of power plant operations to ensure the monitoring and control of their activities."[16] Iran's proposal does show that countries seem to be inclined – even during tense national security situations – to organize nuclear safety at regional level. Yet, political rivalries and tension in a region could endanger the endurance of such a regime.[17]

On a related note, there have been numerous bilateral nuclear collaborations that were not regionally dominated, such as the Franco-Indian collaboration designed to provide India with nuclear energy technologies (Sarkar 2015). Other examples include collaborations between Germany and China or, in the past, between the US and Japan. Sometimes, political rivalry renders regional collaboration virtually impossible. For instance, it seems highly unlikely that India and Pakistan would be open to such collaboration. Indeed, regional collaboration merely represents one type of supranational collaboration, but considering the political sensitivities in certain regions, it seems more likely that bilateral and other international collaboration (outside the region in question) would be more likely to succeed in those regions. Moreover, regional and other international collaborations should be orchestrated by international organizations such as the IAEA or the NEA (the OCED's specialized nuclear agency) as well as by non-governmental initiatives set up by organizations that are specialized in issues of nuclear

[15] Provision 8 in the Joint Comprehensive Plan of Action as agreed between Iran and the six world powers. See: http://eeas.europa.eu/statements-eeas/docs/iran_agreement/iran_joint-comprehensive-plan-of-action_en.pdf

[16] Cited from The National UAE. http://www.thenational.ae/uae/gcc-countries-repeat-call-for-iran-to-join-international-nuclear-convention Consulted on January 19th 2016.

[17] Also in the Iran example, the proposal to make a regional convention was not well-received by the UAE, the other pending nuclear energy producer in the Persian Gulf region; the UAE insisted that Iran needs to first become a member of the IAEA Convention on Nuclear Safety.

safety. The involvement of such an international organization is needed to – for example – ensure that a race to the bottom does not take place as a result of international collaborations.

The second hurdle in improving the *by design* approach is that it will require countries to partly renounce their national sovereignty. Although there can hardly be any other technology more intimately linked to national prestige and pride, in agreeing to treaties related to civilian and military nuclear systems that are in place, countries already implicitly accept certain constraints; we have discussed this issue at some length in Section 3. In various areas, from nuclear safeguarding to aviation, where the obligatory regulations of the International Civil Aviation Organization demand strong enforcement (Weber 2007), countries have accepted limitations to national sovereignty. In addition to benefits at national level, there seems to be an implicit acknowledgement that greater nuclear safety also provides global 'public goods'. A regional approach would presumably engender fewer difficulties with regard to national sovereignty, and the public good achieved (nuclear safety in their region) would be more graspable.[18]

This is perhaps most visible in regional platforms for economic collaborations such as the recently agreed upon Trans-Pacific Partnership, that also needs to regulate issues of risk and public safety. Populist attacks upon global trade agreements fail torecognize that the global, transnational and international dimensions of risk regulations in a trade setting is a rather complex and crucial issue (van Asselt, Versluis, and Vos 2013; van Asselt, Everson, and Vos 2014), but it seems reasonable to expect regional trade collaborations to serve as placeholders for regional nuclear safety collaborations. In other words, the regional economic connectivity incentivizes collaboration between countries to improve nuclear safety across the board. Clearly, such collaboration to improve nuclear safety is not about creating neocolonialist "nuclear stewardship". Instead, collaboration on an equal footing aims to

[18] Also in bilateral or multinational collaborations smaller countries could still have a say in the final outcome; this might reduce their reluctance to accept internationally or supranationally imposed restrictions.

underpin legitimate transnational/regional monitoring and verification mechanisms in collaborating countries.

The third – and perhaps most powerful – objection to such a regime is that it would subject the nuclear industry to additional restrictions. This might lead to opposition, particularly in nuclear technology exporting countries such as Russia and South Korea, the US, France, and Japan. As state and industrial interests are often intertwined, and as some companies are state-owned, imposing regulations on an important export product could affect state revenue. Companies might wield claims to sovereign jurisdiction as powerful tools for avoiding intrusive global governance. Moreover, proprietary issues and intellectual property could constitute very strong objections for individual corporations as well as for the entire nuclear industry to such governance regimes. While this is a legitimate concern we believe that increasing global nuclear safety has undeniable benefits for exporting countries and for companies too. Any major nuclear accident is horrific because of the human lives lost and the environmental consequences, but it also has a major impact on the nuclear industry. This impact is, in the first place, in the country where the accident has taken place – only a few nuclear reactors in Japan have returned to production since the Fukushima Daiichi disaster and Japan's nuclear future now seems to be uncertain – and it affects the company that has produced that type of reactor. For instance, in the hypothetical case that there might be a major accident with one of ROSATOM's exported reactors, it seems likely that some future clients could well reconsider their contracts. But there are perhaps greater ramifications for the nuclear industry in general.

What supports the claim that such collaborations might be feasible is the success of the Institute of Nuclear Power Operation (INPO) in the United States. Established by the American nuclear industry, INPO performs nuclear plant evaluations and identifies weaknesses and points for improvement. In a sense, INPO could be considered a "private regulatory bureaucracy" in that it only shares the results of such reviews with other nuclear operators (Rees 1994, 2). INPO was essentially built on the notion that

every nuclear vendor is *a hostage* of every other nuclear vendor, because if something goes wrong with any nuclear reactor in the US, it will have "ruinous consequences for the entire industry" (Rees 1994, 2). While the institutional settings are not exactly the same, it does show that close collaboration is possible and that the industry is capable of overcoming proprietary issues; i.e. the sharing of individual power plant information with competitors. INPO's success testifies to the fact that the nuclear industry could be open to additional restrictions and regulatory rulings. However, part of INPO's success lies in the fact that it is an industry *internal* correction mechanism that does not involve reporting to public regulators. This highlights an important dilemma because, on the one hand, more transparency leads to the possibility of naming and shaming thus increasing the sensitivity of corporations to matters of nuclear safety. On the other hand, the more transparent it is to the outside world, the less willing the industry will be to agree on additional (international) restrictions. This is what Potoski and Prakash (2004) term the 'regulation dilemma'. In other words, the stricter the regulatory regime and enforcement mechanism is, the less likely industry will be to voluntarily accept such restrictions. This means that a fine balance must be struck between the degree of transparency and industry's willingness to accept additional regulations as well as verification and enforcement mechanisms.

Ultimately, there seems to be a window of opportunity for overcoming collective action barriers now and introducing a *change by design* approach since major exporters such as Russia and China do not yet have constructions in different countries and are likely, out of pure self-interest, to be more amenable to an agreement on more stringent standards, liability and monitoring. Clearly, nuclear safety needs to be strengthened globally before the great shift can take place.

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