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A Global Picture of Industrial Interdependencies Between Civil and Military Nuclear Infrastructures

Hinkley Point C in the UK[3] for instance, despite: a delay standing presently at more than a decade; costs multiplying fivefold over original estimates; a series of still unresolved serious technical difficulties; and demands for escalating government financial concessions and guarantees. Globally,[4] a range of different commentaries show how the relatively small number of continuing nuclear programs[5] typically display a similar mix of severely deteriorating conditions and oddly dogged enthusiasm.

It is surprising to see such persistent nuclear attachments, because nuclear energy has clearly become much less attractive, when compared with competing low-carbon options. Worldwide, nuclear is already significantly more expensive than major alternatives like solar photovoltaics and onshore and offshore wind power,[6] with the disadvantage growing fast.[7] Available cost-effective energy resources from these renewables are huge, and their modularity, small unit size and shorter lead times typically make them a more rapid means to carbon emissions abatement.[8][9] t Z Œ } v v µ o Œ À } š • o] u š Z š Z ( ] Œ u [~] v (o Æ] ™ b à

Other stated energy policy aims also favour renewables. Across different countries, these are typically domestic resources whose geographically distributed nature helps avoid the particular vulnerabilities associated with concentrated sites and sources as well as insecure global fuel supply chains.[12] Amidst many complexities, renewables offer employment benefits generally greater than those of nuclear.[13] And capital intensity, large unit size and long lead times are also major financial downsides of established nuclear designs in current investment markets.[14]

power.[23] Nuclear reactors, whether small or commercial-scale, are the only effective means to produce crucial fissile materials for nuclear weapons, like plutonium-239. The fuel supply chain for nuclear power, and uranium enrichment in particular, is the main source for other weapons ingredients like high-enriched uranium. Further specialist materials for various types of thermonuclear weapons, like tritium, are by-products of nuclear power. oo šZ • Zu š Œ] o o]vl•[Z À v lv}Áo P (}Œ u v Ç[24] But less well v • Œ] ‰‰ Œ] š]v ‰µ o] š U Œ • š }(v Z]v involving the wider nuclear skills, v v] •[education, research, design, engineering and industrial capabilities associated with civil nuclear industries, that are also essential in many ways to the sustaining or introduction of nuclear weapons programs or their associated platforms and infrastructures.[25]

Together, these material links and industrial interdependencies have left many important imprints on the world civil nuclear industry. For instance, most reactor design traditions derive from past prioritization of military aims. Heavy water reactors and graphite-moderated designs like the Chernobyl-style RBMK or the French and UK natural uranium gas-graphite reactors were based on principles originally chosen to facilitate on-load refueling for production of plutonium required in nuclear weapons manufacture. Likewise, even the most modern variants of light water reactors are still built around basic engineering principles originally optimized for the confined spaces of nuclear-propelled submarines.[26] Yet, even after many decades of opportunities to establish entirely new designs dedicated to civilian power production, these military-derived variants still account for almost all

whose basic configuration was optimized from first principles solely for safe or economic civilian power. A high proportion of leading designs for a currently much µ v š Z v Á P v Œ š] } v [} (^ u o o D } µ o Œ Z relate even more closely to contemporary nuclear submarine propulsion reactors.[28]

Nor is there any sign that these longstanding connections are diminishing. An additional dimension to civil military nuclear interdependencies has only come to light in recent years. This is the importance to government support of nuclear power in some countries of continuing commitments to build and maintain military, nuclear-propelled submarines.[29] These machines are often identified as being among the most complex and demanding manufactured artefacts ever conceived. Security concerns are seen to require the sustaining of the entire range of necessary industrial capacities w693.3f(d)-4( )33(s)5(u)-16(b).

nuclear-specific engineering and other industrial sectors. So, if civilian nuclear power and its associated specialist practices are to be allowed (like many earlier technologies) to go obsolete, then with more net employment typically available in proportion to investment by other means[34] it seems that the only significant losers would be the nuclear establishments of a small number of countries that maintain military nuclear ambitions. Conversely, for those hoping for long-stalled reversal in either horizontal or vertical nuclear weapons proliferation[35], it is possible that obsolescence of civil nuclear power as an energy source forms a potentially major but under-considered global opportunity.

3: Broad Patterns in National Civil and Military Nuclear Ambitions

In all states with current and past nuclear weapons capabilities, parallel availability of the skills and industrial and research capacities now associated with civil nuclear power have been essential.[36] Thus revenues arising from nuclear electricity sales have also been important, as part of these flow indirectly into supply chains and into research, training and industrial systems that have joint civil and military applications.[37] Some states (notably Israel and North Korea) have built modest military nuclear capabilities without directly pursuing civil nuclear power. But even here, existence of wider international nuclear industries (especially in sponsoring powers) has

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range of alternative options are also typically available for isotope production (like linear accelerators) or substitution of key materials or equipment (as in photoelectric smoke detectors) that either entirely avoid or fall far

Figure 1: Circumstantial Relationships Between Reported Civil Nuclear Ambitions and Different Categories of International Military and Geopolitical Status[42] (civil nuclear plans are based on WNA data)

According to the positions asserted in national data published by the global industry trade body the World Nuclear Association (WNA), the five largest-scale prospective nuclear new build programmes in the world are in (} µ Œ } (š Z ( ] À Z } v µ o Œ weapons states (excepting France).[43] India and Iran are also pursuing ambitious nuclear new-build programmes. And France is an illuminating exception, in that the scale of its existing reliance on nuclear power in itself militates against further large-scale national expansion. So large is the existing French civil nuclear fleet, that the associated national engineering base also required for military purposes, is much less under threat from nuclear decline than in other countries. But the Le Monde newspaper nonetheless does still highlight ^ š Z µ o š] u š ‹ µ • š] } v v Æ ‰ Œ š Œ • • l] v ‰ Œ] À š W Á Z š Œ]] o] š Ç } (} µ Œ v µ o Œ } u weapons programme and our position at the UN [Security Council], if France were to renounce its [nuclear power] plants?'[44]

42 ‹ • … ‡ – Š ‡ ' „ Œ ‡ … – ' ˆ ‹ • – ‡ " ‡ • – Š ‡ " ‡ ƒ " ‡ î † ‡ … Ž ƒ " ‡ † • — … Ž ‡ ƒ " ƒ • „ ‹ – ‹ ' • • ï á " ' Ž ƒ • • ï á is the appropriate source. Data for formally stated nuclear ambitions are ˆ " ' • á ò — … Ž ‡ ƒ " Power in the World Today t r s z ò June 2018, see http://www.world-nuclear.org/information-library/facts-and-figures/world-nuclear-power-reactors-and-uranium-requireme.aspx, accessed 28 June 2018. The allocations of countries to categories in this picture are based entirely on this WNA data with no modifications to reflect alternative views. Where a detailed WNA country report conflicts with the summary table, it is the more detailed data that is used here. Data for regional military power status are ˆ " ' • ‡ – Ž ‡ ˆ ' Ž – ‡ á ò ' ™ – ' … ' • ' ƒ ‡ " ‡ ‰ ‹ ' • ƒ Ž ' ' ™ ‡ " • ã ƒ • ƒ Ž › – ‹ … ƒ Ž … ' • Review of International Studies, October 2010, see

Such military anxieties over declining capabilities seem even more pronounced in other nuclear-armed countries with proportionally less well-established nuclear industries. The major state-held Russian nuclear construction and services company Rosatom is clear that "[t]he reliable provision of Russia's defense capability is the main

the past, only Germany and Taiwan are presented by the WNA to be without any nuclear build or new programmes.[52]

Given the complexities of global affairs, it must be expected that any general pattern like this will include exceptions. That the UAE is the only example in the world of a country displaying high stated civil nuclear ambitions that is not at least a regional military power, is actually an indication of the striking nature of the broader patterns shown in Figure 1. And it is notable in this regard, that the UAE is also at the geographical center of what is currently one of the most intense areas of regional military unrest and whose stated ambitious nuclear plans are in any case somewhat performative. Like North Korea is already a nuclear armed state, which is not formally categorized as a regional military power. But this involves other well known extraordinary circumstances, implicating arguably the single most acute military nuclear standoff in the contemporary world. On the other hand, Germany is the only regional military power, which WNA acknowledges to be actively scaling back its civil nuclear programs. Yett Z] •] • o • } • ‰] o E • l] v • Z š š Z Z policy in Germany has been forced by globally distinctive social mobilization[53] Japan, the current reigning back of plans for nuclear power is conditioned by the even more unique political consequences of the Fukushima catastrophe,[54] but is not reflected in WNA projections. And here, civil-military links are also still alive, for] v • š v U] v • v] } Œ >] Œ o u } Œ š ‰ } o] š]] v ^ Z] P Œ µ / • Z] [• • š š u v š nuclear power plants. Because having nuclear power means that we can manufacture nuclear weapons within a certain period of time and it can be a deterrent".[55]

Albeit circumstantial, it is quite obvious that it tends to be the leading global military powers who are also the leaders in civil nuclear power around the world t and the most committed to large scale new nuclear build. There is no global or regional military power that has not displayed at least some active history of strong strategic pressures to pursue civil nuclear power capabilities. Conversely, no country with a current nuclear

"punches above its weight"[58] v] v] Œ š o Ç o] v l š }]š‰ š^ • o š_]š(š‰ Z Œš u v v š u u Œ • Z]
the UN Security Council.[59]

So, it is no surprise that the

of this last fully considered UK [67] Openly unwelcome to the then Prime Minister Tony Blair [68] (but for reasons that were undeclared), it was this finding that was overridden by the cursory white paper of 2008 in a process acknowledged by Parliamentarians [69]

Grimes et al, are providing specific recommendations for managing the capabilities crisis in the nuclear •µ u Œ]v]v µ•šŒÇ šZŒ}µPZ (µŒšZ Œ vP P u vš Á]šZ šZ]À]o • š}ŒX imaginative methods to better engage with the emergent civil-led build programme on nuclear matters to the benefit of defence_ that ^šZ Z • Œ Z WŒ}PŒ uu 'Œ}µ‰ •š o]•Z Á}Œl•šŒ v š u Æ]uµu ((š]À]o vµ o Œ]vÀ •šu vš_U v šZ š ^DK Œ À]•]š šZ ‰}••] fac]o]š] •]v oµ]vP šZ}•]v šZ]À]o • š}Œ_X [87]

Stephen Lovegrove, current Permanent Secretary at the Ministry of Defense and former Permanent Secretary at the Department for Energy and Climate Change responsible for negotiating the Hinkley Point C contrac stated under questioning by the U.K. Parliament Public Accounts Committee^ t Œ }u‰o š]vP šZ µ]o the nuclear submarines, which carry conventional weaponry. We have at some point to renew the warheads, so there is very definitely an opportunity here for the nation to grasp in terms of building up its nuclear skills. I do not think that that is going to happen by accident; it is going to require concerted Government action to make]š Z ‰[88]‰ vX_ [89]

It is these remarkable conjunctions that have helped lead to reports in the UK[90] and international[91] press, that what is underway in the UK is, in effect, an unacknowledged cross-subsidy (amounting at least to several tens of billions of pounds[92]) away from electricity consumers and to the benefit of military nuclear interests. Whatever the actual figures may prove to be amidst many complexities and uncertainties, prima facie evidence seems clear that future UK electricity prices are being raised significantly higher than would otherwise be the case, at

than a year from the first coverage in major newspapers in other countries, the topic even to be raised in a UK broadsheet (in two major pieces in the Guardian). Yet, despite the strong qualitative evidence reviewed in this paper, analysis of interdependencies, cross-subsidization and strategic complementarities between civil nuclear power and the military sector (especially the nuclear submarine industries) remains undiscussed beyond th

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