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#### Advantage One: Proliferation

#### And, cascading prolif ensures extinction

Kroenig, 12 [May 26th, Matthew Kroenig: Assistant Professor of Government, Georgetown University and Stanton Nuclear Security Fellow, Council on Foreign Relations, The History of Proliferation Optimism: Does It Have A Future? Prepared for the Nonproliferation Policy Education Center, <http://www.npolicy.org/article.php?aid=1182&tid=30>]

Proliferation Optimism: Proliferation optimism was revived in the academy in Kenneth Waltz’s 1979 book, Theory of International Politics.[[1]](#footnote-1)[29] In this, and subsequent works, Waltz argued that the spread of nuclear weapons has beneficial effects on international politics. He maintained that states, fearing a catastrophic nuclear war, will be deterred from going to war with other nuclear-armed states. As more and more states acquire nuclear weapons, therefore, there are fewer states against which other states will be willing to wage war. The spread of nuclear weapons, according to Waltz, leads to greater levels of international stability. Looking to the empirical record, he argued that the introduction of nuclear weapons in 1945 coincided with an unprecedented period of peace among the great powers. While the United States and the Soviet Union engaged in many proxy wars in peripheral geographic regions during the Cold War, they never engaged in direct combat. And, despite regional scuffles involving nuclear-armed states in the Middle East, South Asia, and East Asia, none of these conflicts resulted in a major theater war. This lid on the intensity of conflict, according to Waltz, was the direct result of the stabilizing effect of nuclear weapons. Following in the path blazed by the strategic thinkers reviewed above, Waltz argued that the requirements for deterrence are not high. He argued that, contrary to the behavior of the Cold War superpowers, a state need not build a large arsenal with multiple survivable delivery vehicles in order to deter its adversaries. Rather, he claimed that a few nuclear weapons are sufficient for deterrence. Indeed, he even went further, asserting that any state will be deterred even if it merely suspects its opponent might have a few nuclear weapons because the costs of getting it wrong are simply too high. Not even nuclear accident is a concern according to Waltz because leaders in nuclear-armed states understand that if they ever lost control of nuclear weapons, resulting in an accidental nuclear exchange, the nuclear retaliation they would suffer in response would be catastrophic. Nuclear-armed states, therefore, have strong incentives to maintain control of their nuclear weapons. Not even new nuclear states, without experience in managing nuclear arsenals, would ever allow nuclear weapons to be used or let them fall in the wrong hands. Following Waltz, many other scholars have advanced arguments in the proliferation optimist school. For example, Bruce Bueno de Mesquite and William Riker explore the “merits of selective nuclear proliferation.”[[2]](#footnote-2)[30] John Mearsheimer made the case for a “Ukrainian nuclear deterrent,” following the collapse of the Soviet Union.[[3]](#footnote-3)[31] In the run up to the 2003 Gulf War, John Mearsheimer and Steven Walt argued that we should not worry about a nuclear-armed Iraq because a nuclear-armed Iraq can be deterred.[[4]](#footnote-4)[32] And, in recent years, Barry Posen and many other realists have argued that nuclear proliferation in Iran does not pose a threat, again arguing that a nuclear-armed Iran can be deterred.[[5]](#footnote-5)[33] What’s Wrong with Proliferation Optimism? The proliferation optimist position, while having a distinguished pedigree, has several major problems. Many of these weaknesses have been chronicled in brilliant detail by Scott Sagan and other contemporary proliferation pessimists.[[6]](#footnote-6)[34] Rather than repeat these substantial efforts, I will use this section to offer some original critiques of the recent incarnations of proliferation optimism. First and foremost, proliferation optimists do not appear to understand contemporary deterrence theory. I do not say this lightly in an effort to marginalize or discredit my intellectual opponents. Rather, I make this claim with all due caution and with complete sincerity. A careful review of the contemporary proliferation optimism literature does not reflect an understanding of, or engagement with, the developments in academic deterrence theory in top scholarly journals such as the American Political Science Review and International Organization over the past few decades.[[7]](#footnote-7)[35] While early optimists like Viner and Brodie can be excused for not knowing better, the writings of contemporary proliferation optimists ignore the past fifty years of academic research on nuclear deterrence theory. In the 1940s, Viner, Brodie, and others argued that the advent of Mutually Assured Destruction (MAD) rendered war among major powers obsolete, but nuclear deterrence theory soon advanced beyond that simple understanding.[[8]](#footnote-8)[36] After all, great power political competition does not end with nuclear weapons. And nuclear-armed states still seek to threaten nuclear-armed adversaries. States cannot credibly threaten to launch a suicidal nuclear war, but they still want to coerce their adversaries. This leads to a credibility problem: how can states credibly threaten a nuclear-armed opponent? Since the 1960s academic nuclear deterrence theory has been devoted almost exclusively to answering this question.[[9]](#footnote-9)[37] And, unfortunately for proliferation optimists, the answers do not give us reasons to be optimistic. Thomas Schelling was the first to devise a rational means by which states can threaten nuclear-armed opponents.[[10]](#footnote-10)[38] He argued that leaders cannot credibly threaten to intentionally launch a suicidal nuclear war, but they can make a “threat that leaves something to chance.”[[11]](#footnote-11)[39] They can engage in a process, the nuclear crisis, which increases the risk of nuclear war in an attempt to force a less resolved adversary to back down. As states escalate a nuclear crisis there is an increasingprobability that the conflict will spiral out of control and result in an inadvertent or accidental nuclear exchange. As long as the benefit of winning the crisis is greater than the incremental increase in the risk of nuclear war, threats to escalate nuclear crises are inherently credible. In these games of nuclear brinkmanship, the state that is willing to run the greatest risk of nuclear war before back down will win the crisis as long as it does not end in catastrophe. It is for this reason that Thomas Schelling called great power politics in the nuclear era a “competition in risk taking.”[[12]](#footnote-12)[40] This does not mean that states eagerly bid up the risk of nuclear war. Rather, they face gut-wrenching decisions at each stage of the crisis. They can quit the crisis to avoid nuclear war, but only by ceding an important geopolitical issue to an opponent. Or they can the escalate the crisis in an attempt to prevail, but only at the risk of suffering a possible nuclear exchange. Since 1945 there were have been many high stakes nuclear crises (by my count, there have been twenty) in which “rational” states like the United States run a risk of nuclear war and inch very close to the brink of nuclear war.[[13]](#footnote-13)[41] By asking whether states can be deterred or not, therefore, proliferation optimists are asking the wrong question. The right question to ask is: what risk of nuclear war is a specific state willing to run against a particular opponent in a given crisis? Optimists are likely correct when they assert that Iran will not intentionally commit national suicide by launching a bolt-from-the-blue nuclear attack on the United States or Israel. This does not mean that Iran will never use nuclear weapons, however. Indeed, it is almost inconceivable to think that a nuclear-armed Iran would not, at some point, find itself in a crisis with another nuclear-armed power and that it would not be willing to run any risk of nuclear war in order to achieve its objectives. If a nuclear-armed Iran and the United States or Israel have a geopolitical conflict in the future, over say the internal politics of Syria, an Israeli conflict with Iran’s client Hezbollah, the U.S. presence in the Persian Gulf, passage through the Strait of Hormuz, or some other issue, do we believe that Iran would immediately capitulate? Or is it possible that Iran would push back, possibly even brandishing nuclear weapons in an attempt to deter its adversaries? If the latter, there is a real risk that proliferation to Iran could result in nuclear war. An optimist might counter that nuclear weapons will never be used, even in a crisis situation, because states have such a strong incentive, namely national survival, to ensure that nuclear weapons are not used. But, this objection ignores the fact that leaders operate under competing pressures. Leaders in nuclear-armed states also have very strong incentives to convince their adversaries that nuclear weapons could very well be used. Historically we have seen that in crises, leaders purposely do things like put nuclear weapons on high alert and delegate nuclear launch authority to low level commanders, purposely increasing the risk of accidental nuclear war in an attempt to force less-resolved opponents to back down. Moreover, not even the optimists’ first principles about the irrelevance of nuclear posture stand up to scrutiny. Not all nuclear wars would be equally devastating.[[14]](#footnote-14)[42] Any nuclear exchange would have devastating consequences no doubt, but, if a crisis were to spiral out of control and result in nuclear war, any sane leader would rather be facing a country with five nuclear weapons than one with thirty-five thousand. Similarly, any sane leader would be willing to run a greater risk of nuclear war against the former state than against the latter. Indeed, systematic research has demonstrated that states are willing to run greater risks and, therefore, more likely to win nuclear crises when they enjoy nuclear superiority over their opponent.[[15]](#footnote-15)[43] Proliferation optimists miss this point, however, because they are still mired in 1940s deterrence theory. It is true that no rational leader would choose to launch a nuclear war, but, depending on the context, she would almost certainly be willing to risk one. Nuclear deterrence theorists have proposed a second scenario under which rational leaders could instigate a nuclear exchange: a limited nuclear war.[[16]](#footnote-16)[44] By launching a single nuclear weapon against a small city, for example, it was thought that a nuclear-armed state could signal its willingness to escalate the crisis, while leaving its adversary with enough left to lose to deter the adversary from launching a full-scale nuclear response. In a future crisis between a nuclear-armed China and the United States over Taiwan, for example, China could choose to launch a nuclear attack on Honolulu to demonstrate its seriousness. In that situation, with the continental United States intact, would Washington choose to launch a full-scale nuclear war on China that could result in the destruction of many more American cities? Or would it back down? China might decide to strike hoping that Washington will choose a humiliating retreat over a full-scale nuclear war. If launching a limited nuclear war could be rational, it follows that the spread of nuclear weapons increases the risk of nuclear use. Again, by ignoring contemporary developments in scholarly discourse and relying exclusively on understandings of nuclear deterrence theory that became obsolete decades ago, optimists reveal the shortcomings of their analysis and fail to make a compelling case. The optimists also error by confusing stability for the national interest. Even if the spread of nuclear weapons contributes to greater levels of international stability (which discussions above and below suggest it might not) it does not necessarily follow that the spread of nuclear weapons is in the U.S. interest. There might be other national goals that trump stability, such as reducing to zero the risk of nuclear war in an important geopolitical region. Optimists might argue that South Asia is more stable when India and Pakistan have nuclear weapons, but certainly the risk of nuclear war is higher than if there were no nuclear weapons on the subcontinent. In addition, it is wrong to assume that stability is always in the national interest. Sometimes it is, but sometimes it is not. If stability is obtained because Washington is deterred from using force against a nuclear-armed adversary in a situation where using force could have advanced national goals, stability harms, rather than advances, U.S. national interests. The final gaping weakness in the proliferation optimist argument, however, is that it rests on a logical contradiction. This is particularly ironic, given that many optimists like to portray themselves as hard-headed thinkers, following their premises to their logical conclusions. But, the contradiction at the heart of the optimist argument is glaring and simple to understand: either the probability of nuclear war is zero, or it is nonzero, but it cannot be both. If the probability of nuclear war is zero, then nuclear weapons should have no deterrent effect. States will not be deterred by a nuclear war that could never occur and states should be willing to intentionally launch large-scale wars against nuclear-armed states. In this case, proliferation optimists cannot conclude that the spread of nuclear weapons is stabilizing. If, on the other hand, the probability of nuclear war is nonzero, then there is a real danger that the spread of nuclear weapons increases the probability of a catastrophic nuclear war. If this is true, then proliferation optimists cannot be certain that nuclear weapons will never be used. In sum, the spread of nuclear weapons can either raise the risk of nuclear war and in so doing, deter large-scale conventional conflict. Or there is no danger that nuclear weapons will be used and the spread of nuclear weapons does not increase international instability. But, despite the claims of the proliferation optimists, it is nonsensical to argue that nuclear weapons will never be used and to simultaneously claim that their spread contributes to international stability. Proliferation Anti-obsessionists: Other scholars, who I label “anti-obsessionists” argue that the spread of nuclear weapons has neither been good nor bad for international politics, but rather irrelevant. They argue that academics and policymakers concerned about nuclear proliferation spend too much time and energy obsessing over something, nuclear weapons, that, at the end of the day, are not all that important. In Atomic Obsession, John Mueller argues that widespread fears about the threat of nuclear weapons are overblown.[[17]](#footnote-17)[45] He acknowledges that policymakers and experts have often worried that the spread of nuclear weapons could lead to nuclear war, nuclear terrorism and cascades of nuclear proliferation, but he then sets about systematically dismantling each of these fears. Rather, he contends that nuclear weapons have had little effect on the conduct of international diplomacy and that world history would have been roughly the same had nuclear weapons never been invented. Finally, Mueller concludes by arguing that the real problem is not nuclear proliferation, but nuclear nonproliferation policy because states do harmful things in the name of nonproliferation, like take military action and deny countries access to nuclear technology for peaceful purposes. Similarly, Ward Wilson argues that, despite the belief held by optimists and pessimists alike, nuclear weapons are not useful tools of deterrence.[[18]](#footnote-18)[46] In his study of the end of World War II, for example, Wilson argues that it was not the U.S. use of nuclear weapons on Hiroshima and Nagasaki that forced Japanese surrender, but a variety of other factors, including the Soviet Union’s decision to enter the war. If the actual use of nuclear weapons was not enough to convince a country to capitulate to its opponent he argues, then there is little reason to think that the mere threat of nuclear use has been important to keeping the peace over the past half century. Leaders of nuclear-armed states justify nuclear possession by touting their deterrent benefits, but if nuclear weapons have no deterrent value, there is no reason, Ward claims, not to simply get rid of them. Finally, Anne Harrington de Santana argues that nuclear experts “fetishize” nuclear weapons.[[19]](#footnote-19)[47] Just like capitalists, according to Karl Marx, bestow magical qualities on money, thus fetishizing it, she argues that leaders and national security experts do the same thing to nuclear weapons. Nuclear deterrence as a critical component of national security strategy, according to Harrington de Santana, is not inherent in the technology of nuclear weapons themselves, but is rather the result of how leaders in countries around the world think about them. In short, she argues, “Nuclear weapons are powerful because we treat them as powerful.”[[20]](#footnote-20)[48] But, she maintains, we could just as easily “defetish” them, treating them as unimportant and, therefore, rendering them obsolete. She concludes that “Perhaps some day, the deactivated nuclear weapons on display in museums across the United States will be nothing more than a reminder of how powerful nuclear weapons used to be.”[[21]](#footnote-21)[49] The anti-obsessionists make some thought-provoking points and may help to reign in some of the most hyperbolic accounts of the effect of nuclear proliferation. They remind us, for example, that our worst fears have not been realized, at least not yet. Yet, by taking the next step and arguing that nuclear weapons have been, and will continue to be, irrelevant, they go too far. Their arguments call to mind the story about the man who jumps to his death from the top of a New York City skyscraper and, when asked how things are going as he passes the 15th story window, replies, “so far so good.” The idea that world history would have been largely unchanged had nuclear weapons not been invented is a provocative one, but it is also unfalsifiable. There is good reason to believe that world history would have been different, and in many ways better, had certain countries not acquired nuclear weapons. Let’s take Pakistan as an example. Pakistan officially joined the ranks of the nuclear powers in May 1998 when it followed India in conducting a series of nuclear tests. Since then, Pakistan has been a poster child for the possible negative consequences of nuclear proliferation. Pakistan’s nuclear weapons have led to further nuclear proliferation as Pakistan, with the help of rogue scientist A.Q. Khan, transferred uranium enrichment technology to Iran, Libya, and North Korea.[[22]](#footnote-22)[50] Indeed, part of the reason that North Korea and Iran are so far along with their uranium enrichment programs is because they got help from Pakistan. Pakistan has also become more aggressive since acquiring nuclear weapons, displaying an increased willingness to sponsor cross-border incursions into India with terrorists and irregular forces.[[23]](#footnote-23)[51] In a number of high-stakes nuclear crises between India and Pakistan, U.S. officials worried that the conflicts could escalate to a nuclear exchange and intervened diplomatically to prevent Armageddon on the subcontinent. The U.S. government also worries about the safety and security of Pakistan’s nuclear arsenal, fearing that Pakistan’s nukes could fall into the hands of terrorists in the event of a state collapse or a break down in nuclear security. And we still have not witnessed the full range of consequences arising from Pakistani nuclear proliferation. Islamabad has only possessed the bomb for a little over a decade, but they are likely to keep it for decades to come, meaning that we could still have a nuclear war involving Pakistan. In short, Pakistan’s nuclear capability has already had deleterious effects on U.S. national security and these threats are only likely to grow over time. In addition, the anti-obsessionists are incorrect to argue that the cure of U.S. nuclear nonproliferation policy is worse than the disease of proliferation. Many observers would agree with Mueller that the U.S. invasion of Iraq in 2003 was a disaster, costing much in the way of blood and treasure and offering little strategic benefit. But the Iraq War is hardly representative of U.S. nonproliferation policy. For the most part, nonproliferation policy operates in the mundane realm of legal frameworks, negotiations, inspections, sanctions, and a variety of other tools. Even occasional preventive military strikes on nuclear facilities have been far less calamitous than the Iraq War. Indeed, the Israeli strikes on nuclear reactors in Iraq and Syria in 1981 and 2007, respectively, produced no meaningful military retaliation and a muted international response. Moreover, the idea that the Iraq War was primarily about nuclear nonproliferation is a contestable one, with Saddam Hussein’s history of aggression, the unsustainability of maintaining the pre-war containment regime indefinitely, Saddam’s ties to terrorist groups, his past possession and use of chemical and biological weapons, and the window of opportunity created by September 11th, all serving as possible prompts for U.S. military action in the Spring of 2003. The claim that nonproliferation policy is dangerous because it denies developing countries access to nuclear energy also rests on shaky ground. If anything, the global nonproliferation regime has, on balance, increased access to nuclear technology. Does anyone really believe that countries like Algeria, Congo, and Vietnam would have nuclear reactors today were it not for Atoms for Peace, Article IV of the NPT, and other appendages of the nonproliferation regime that have provided developing states with nuclear technology in exchange for promises to forgo nuclear weapons development? Moreover, the sensitive fuel-cycle technology denied by the Nuclear Suppliers Group (NSG) and other supply control regimes is not even necessary to the development of a vibrant nuclear energy program as the many countries that have fuel-cycle services provided by foreign nuclear suppliers clearly demonstrate. Finally, the notion that nuclear energy is somehow the key to lifting developing countries from third to first world status does not pass the laugh test. Given the large upfront investments, the cost of back-end fuel management and storage, and the ever-present danger of environmental catastrophe exemplified most recently by the Fukushima disaster in Japan, many argue that nuclear energy is not a cost-effective source of energy (if all the externalities are taken into account) for any country, not to mention those developing states least able to manage these myriad challenges. Taken together, therefore, the argument that nuclear nonproliferation policy is more dangerous than the consequences of nuclear proliferation, including possible nuclear war, is untenable. Indeed, it would certainly come as a surprise to the mild mannered diplomats and scientists who staff the International Atomic Energy Agency, the global focal point of the nuclear nonproliferation regime, located in Vienna, Austria. The anti-obsessionsists, like the optimists, also walk themselves into logical contradictions. In this case, their policy recommendations do not necessarily follow from their analyses. Ward argues that nuclear weapons are irrelevant and, therefore, we should eliminate them.[[24]](#footnote-24)[52] But, if nuclear weapons are really so irrelevant, why not just keep them lying around? They will not cause any problems if they are as meaningless as anti-obsessionists claim and it is certainly more cost effective to do nothing than to negotiate complicated international treaties and dismantle thousands of warheads, delivery vehicles, and their associated facilities. Finally, the idea that nuclear weapons are only important because we think they are powerful is arresting, but false. There are properties inherent in nuclear weapons that can be used to create military effects that simply cannot, at least not yet, be replicated with conventional munitions. If a military planner wants to quickly destroy a city on the other side of the planet, his only option today is a nuclear weapon mounted on an ICBM. Therefore, if the collective “we” suddenly decided to “defetishize” nuclear weapons by treating them as unimportant, it is implausible that some leader somewhere would not independently come to the idea that nuclear weapons could advance his or her country’s national security and thereby re-fetishize them. In short, the optimists and anti-obsessionists have brought an important perspective to the nonproliferation debate. Their arguments are provocative and they raise the bar for those who wish to argue that the spread of nuclear weapons is indeed a problem. Nevertheless, their counterintuitive arguments are not enough to wish away the enormous security challenges posed by the spread of the world’s most dangerous weapons. These myriad threats will be considered in the next section. Why Nuclear Proliferation Is a Problem The spread of nuclear weapons poses a number of severe threats to international peace and U.S. national security including: nuclear war, nuclear terrorism, emboldened nuclear powers, constrained freedom of action, weakened alliances, and further nuclear proliferation. This section explores each of these threats in turn. Nuclear War. The greatest threat posed by the spread of nuclear weapons is nuclear war. The more states in possession of nuclear weapons, the greater the probability that somewhere, someday, there is a catastrophic nuclear war. A nuclear exchange between the two superpowers during the Cold War could have arguably resulted in human extinction and a nuclear exchange between states with smaller nuclear arsenals, such as India and Pakistan, could still result in millions of deaths and casualties, billions of dollars of economic devastation, environmental degradation, and a parade of other horrors. To date, nuclear weapons have only been used in warfare once. In 1945, the United States used one nuclear weapon each on Hiroshima and Nagasaki, bringing World War II to a close. Many analysts point to sixty-five-plus-year tradition of nuclear non-use as evidence that nuclear weapons are unusable, but it would be naïve to think that nuclear weapons will never be used again. After all, analysts in the 1990s argued that worldwide economic downturns like the great depression were a thing of the past, only to be surprised by the dot-com bubble bursting in the later 1990s and the Great Recession of the late Naughts.[[25]](#footnote-25)[53] This author, for one, would be surprised if nuclear weapons are not used in my lifetime. Before reaching a state of MAD, new nuclear states go through a transition period in which they lack a secure-second strike capability. In this context, one or both states might believe that it has an incentive to use nuclear weapons first. For example, if Iran acquires nuclear weapons neither Iran, nor its nuclear-armed rival, Israel, will have a secure, second-strike capability. Even though it is believed to have a large arsenal, given its small size and lack of strategic depth, Israel might not be confident that it could absorb a nuclear strike and respond with a devastating counterstrike. Similarly, Iran might eventually be able to build a large and survivable nuclear arsenal, but, when it first crosses the nuclear threshold, Tehran will have a small and vulnerable nuclear force. In these pre-MAD situations, there are at least three ways that nuclear war could occur. First, the state with the nuclear advantage might believe it has a splendid first strike capability. In a crisis, Israel might, therefore, decide to launch a preemptive nuclear strike to disarm Iran’s nuclear capabilities and eliminate the threat of nuclear war against Israel. Indeed, this incentive might be further increased by Israel’s aggressive strategic culture that emphasizes preemptive action. Second, the state with a small and vulnerable nuclear arsenal, in this case Iran, might feel use ‘em or loose ‘em pressures. That is, if Tehran believes that Israel might launch a preemptive strike, Iran might decide to strike first rather than risk having its entire nuclear arsenal destroyed. Third, as Thomas Schelling has argued, nuclear war could result due to the reciprocal fear of surprise attack.[[26]](#footnote-26)[54] If there are advantages to striking first, one state might start a nuclear war in the belief that war is inevitable and that it would be better to go first than to go second. In a future Israeli-Iranian crisis, for example, Israel and Iran might both prefer to avoid a nuclear war, but decide to strike first rather than suffer a devastating first attack from an opponent. Even in a world of MAD, there is a risk of nuclear war. Rational deterrence theory assumes nuclear-armed states are governed by rational leaders that would not intentionally launch a suicidal nuclear war. This assumption appears to have applied to past and current nuclear powers, but there is no guarantee that it will continue to hold in the future. For example, Iran’s theocratic government, despite its inflammatory rhetoric, has followed a fairly pragmatic foreign policy since 1979, but it contains leaders who genuinely hold millenarian religious worldviews who could one day ascend to power and have their finger on the nuclear trigger. We cannot rule out the possibility that, as nuclear weapons continue to spread, one leader will choose to launch a nuclear war, knowing full well that it could result in self-destruction. One does not need to resort to irrationality, however, to imagine a nuclear war under MAD. Nuclear weapons may deter leaders from intentionally launching full-scale wars, but they do not mean the end of international politics. As was discussed above, nuclear-armed states still have conflicts of interest and leaders still seek to coerce nuclear-armed adversaries. This leads to the credibility problem that is at the heart of modern deterrence theory: how can you threaten to launch a suicidal nuclear war? Deterrence theorists have devised at least two answers to this question. First, as stated above, leaders can choose to launch a limited nuclear war.[[27]](#footnote-27)[55] This strategy might be especially attractive to states in a position of conventional military inferiority that might have an incentive to escalate a crisis quickly. During the Cold War, the United States was willing to use nuclear weapons first to stop a Soviet invasion of Western Europe given NATO’s conventional inferiority in continental Europe. As Russia’s conventional military power has deteriorated since the end of the Cold War, Moscow has come to rely more heavily on nuclear use in its strategic doctrine. Indeed, Russian strategy calls for the use of nuclear weapons early in a conflict (something that most Western strategists would consider to be escalatory) as a way to de-escalate a crisis. Similarly, Pakistan’s military plans for nuclear use in the event of an invasion from conventionally stronger India. And finally, Chinese generals openly talk about the possibility of nuclear use against a U.S. superpower in a possible East Asia contingency. Second, as was also discussed above leaders can make a “threat that leaves something to chance.”[[28]](#footnote-28)[56] They can initiate a nuclear crisis. By playing these risky games of nuclear brinkmanship, states can increases the risk of nuclear war in an attempt to force a less resolved adversary to back down. Historical crises have not resulted in nuclear war, but many of them, including the 1962 Cuban Missile Crisis, have come close. And scholars have documented historical incidents when accidents could have led to war.[[29]](#footnote-29)[57] When we think about future nuclear crisis dyads, such as India and Pakistan and Iran and Israel, there are fewer sources of stability that existed during the Cold War, meaning that there is a very real risk that a future Middle East crisis could result in a devastating nuclear exchange.

#### Global interest makes nuclear industry expansion dangerous now

Banks and Ebinger, 11 [John P, Charles K, John is a fellow with the Energy Security Initiative at the Brookings Institution, Charles is senior fellow and director of the Energy Security Initiative at the Brookings Institution, “Introduction: Planning a Responsible Nuclear Future” in “Business and Nonproliferation”, p. googlebooks]

Nuclear energy is a twentieth-century innovation but until recently has not spread beyond a relatively small number 0F industrialized nations (see maps on pages 4 5). All this is about to change. With global electricity demand increasing dramatically, greenhouse gas emissions, and energy security becoming national priorities, developed and developing countries alike are reexamining nuclear energy as a means of providing a reliable E scalable source of low-carbon power. The International Energy Agency (IEA) projects that global electricity demand will increase 2.2 percent a year to 2035, with about 80 percent of that growth occurring in emerging economies outside the Organization for Economic Cooperation £ Development (OECD).' Even if new policy initiatives are introduced to lower carbon dioxide (CO2) emissions Q combat global climate change, global energy-related CO2 emissions are expected to increase 21 percent between 2008 2035.1 Emerging market economies account For all of this projected increase in emissions. In the face of rising prices and increasing volatility in the oil market, many of these economies have shifted their attention to nuclear energy as a means of reducing dependence on oil (often a major source of their power generation), improving their balance of payments, and bolstering national energy security.’ Currently, 440 reactors with a total capacity of 375 gigawatts (G\Wc) arc in operation worlclwicle.\* As of March 2011, 65 nuclear reactor units, with a total capacity of 63 G\Ve, are under construction.5 As of April 2011, 158 projects are also on order or planned and 326 proposed." These preparations For replacing or expanding reactor ﬂeets Q For new entries to the marketplace follow a decades-long lull in construction suggest a “nuclear renaissance” has begun. \Y/hile “renaissance” implies a revival or return to a better time. the global expansion of nuclear energy in the coming decades will differ in several resects from the way civilian nuclear power developed between the late 1950s mid-19805. First, the scope and pace of this new deployment could be signiﬁcantly larger than in previous periods of expansion: some recent analyses put installed nuclear capacity up at 550—850 G\Ve by 2035. depending on assumptions about the implementation of low-carbon energy policiesf In IEA projections, a 50 per- cent cut in energy-related CO, emissions by 2050 would require global capacity to reach 1,200 G\Ve, a net addition of 30 G\Ve each year over the next forty years.“ To put this ﬁgure into perspective, during the period of nuclear p0wer’s most rapid expansion (1981-90). capacity increased by only 20 G\Ve a year, slowing to an annual average of 4 G\X/e from 1991 to 2006." To achieve large- scale reductions in energy—related CO: emissions, nuclear capacity must there- lore grow not only faster but also For several decades longer than during nuclear energy's previous “golden age." (As the preface indicates, safety concerns arising in the aftermath ofthe Fukushima accident will slow or scale back nuclear power expansion globally in the short term. At the same time, the longer-term impact of Fukushima on global nuclear power expansion will be less adverse, especially in emerging market countries.) Also different today is the number of countries seeking to build their ﬁrst nuclear power reactor. Some sixty-ﬁve countries have expressed interest in or are actively planning for nuclear power."' As the International Atomic Energy Agency (IAEA) points out, however, most of these countries are merely “con- sidering” the range of issues involved in nuclear power development. Many of them cannot realistically afford the large costs associated with civilian nuclear power programs. According to some analyses, countries with a GDP ofless than $50 billion could not spend several billion dollars building a reactor." ln addi- tion, many aspirant countries still lack the electricity grids required For nuclear power: electricity systems with a capacity below l0 G\Ve are unlikely to be able to accommodate a nuclear reactor.“ Some countries could address this issue by expanding electricity interconnections with neighboring states or developing ower export arrangements; however, these alternatives are not widely available in any case would take time to implement. At the same time, a number of countries have credible plans to become new nuclear energy states (NNES). The IAEA has indicated that ten to twenty-ﬁve countries might begin operating their ﬁrst plants by 2030, whereas since Cher- nobyl only thrce—China, Mexico, Romania—havc brought nuclear plants online for the ﬁrst time.” The following list shows the stages of progress of eleven emerging market countries in their ellorts to develop a civilian nuclear energy programz“ —Power reactors under construction: Iran.“ —Contracts signed, legal regulatory infrastructure well developed: United Arab Emirates (UAE), Turkey. —Committed plans, legal Q regulatory infrastructure developing: Vietnam, jordan. —\Well-developed plans but commitment pending: Thailand. Indonesia. Egypt, Kazakhstan. —Developing plans: Saudi Arabia, Malaysia. Emerging market nations entertaining the construction of new nuclear power capacity lace several critical issues. Domestically, each must establish strong institutions and viable regulatory frameworks addressing health, safety, prolif- eration, environmental concerns while ensuring that adequate human ﬁnancial resources are available for these tasks. Even if a state is willing to buy a nuclear reactor on a “turnkey” basis (paying For an outside operator to build Q run the system), it must still train its own nationals in these various respects Q establish a strong academic industrial culture in all aspects of commercial nuclear operations in order to achieve a sound, sustainable program. The NNES will need to build these capabilities in a sufficient timely manner. New States One of the biggest challenges in any expansion of the civilian nuclear sector is that of maintaining and strengthening the global regime for nuclear proliferation. The changing geopolitical J security environment, combined with the political instability of many regions countries that aspire to develop civilian nuclear reactor technology, has already raised proliferation concerns. Nuclear power reactors could become attractive targets for terrorists, who might also seek access to ﬁssile material for radiological dispersal devices (“dirty bombs”) or for nuclear weapons. With such materials more widely available, the proliferation risks could mount. As commercial enrichment and recycling programs multiply, countries may be tempted also to develop latent nuclear weapons capabilities, especially if they aspire to attain regional predominance, international standing, or the capabilities of regional rivals. An expansion of nuclear energy could further tax an already stressed proliferation regime. In light ofArticle IV of the Nuclear Treaty (NPT), wl1icl1 states that the treat shall not aﬁect the “inalienable right . . . to develop research, production duse of nuclear energy For peaceful purposes without discrimination . . . the right to partici ate in, the fullest possible exchange of equipment, materials H scientiﬁc ii technological information For the peaceful uses olinuclear energy, ” some nations are considering acquisition of fuel cycle capabilities as a way to avoid further dependence on foreign suppliers when they develop nuclear power.“ The NPT contains no provisions to restrict acquisition of such capabilities, although members of the Nuclear Suppliers Group (a voluntary group of nations that restricts nuclear exports) have long practiced restraint on technology transfers of sensitive components of the Fuel cycle. A sharp increase in the demand for nuclear fuel could enhance the commercial attractiveness of uranium enrichment reprocessing, enticing new entrants into the market." Nations with large uranium resources might seek to add value to their uranium exports by moving further up the chain of produc- tion or by expanding current capabilities (Australia, Canada, Kazakhstan, South Africa have all discussed this option recently). Even if the high cost of Fuel cycle activities proves to be a disincentive to their development, the NNES— especially in emerging markets—may consider Fuel supply security exercis- ing sovereign rights under Article IV of the NPT more relevant than economic drivers in their decisions about enrichment or reprocessing.“ With governments playing an increasing role in securing and meeting nuclear contracts, political motivations might also enter into assessments of the nuclear capabilities neces- sary for recipient countries. The great danger in the race to build out new capacity is that some new players may not take proliferation concerns as seriously as existing service providers. To address these issues, there has been a reinvigorated discussion of multilat- eral nuclear approaches (MN/\s). M NAs establish a framework to safeguard Arti- cle IV rights, speciﬁcally by limiting the diffusion ofsensitive nuclear materials E technologies while concurrently guaranteeing long-term supply of nuclear fuel to civilian nuclear power programs. Some steps in this direction include two recently approved fuel banks: the Russian-backed lnternational Uranium Enrich- ment Center in Angarsk the ME/\ Nuclear Threat Initiative Fuel Bank.” The institutional challenges to the regime are compounded both by the actions of rogue states such as Iran’s clandestine nuclear program and North Korea’s nuclear weapons testing Q new uranium enrichment pro- gram, Q by non-state activities such as the operations ofblack market nuclear networks arranged by Pakistani scientist A. Khan. Conﬁdence in the regime’s ability to respond to resolve proliferation threats has thus fallen. New technologies may put further stress on the system. Particularly worrying are the expansion of centrifuge technology, commercialization of the laser enrichment process, development and deployment of next-generation reprocessing techniques that require advanced safeguards, and the potential spread of fast reactors. Although the impact of these dynamics is tlifﬁcult to foresee, the proliferation regime needs to keep pace with the rapidly changing, complex nuclear market, especially those developments activities that facilitate the expansion of uranium enrichment and spent fuel reprocessing. This is a major challenge for a regime already under stress.

#### Plan prevents global prolif and solidifies leadership

Wharton, 9/27/12 [Art Wharton is a principal project engineer at Westinghouse Electric Company LLC in Nuclear Power Plants Business & Project Development. He is a member of the ANS Planning Committee, ANS Public Policy Committee, the ANS Operations and Power Division Program Committee, is the Treasurer of the ANS Operations and Power Division, is the Pittsburgh ANS Local Section Past Chair, a Trustee on the Board of Pittsburgh’s Urban Pathways Charter School, and is a guest contributor to the ANS Nuclear Café, “U.S. Global Nuclear Leadership Through Export-Driven Engagement, <http://ansnuclearcafe.org/2012/09/27/u-s-global-nuclear-leadership-through-export-driven-engagement/>]

It’s logical that ANS would want U.S. nuclear technology to dominate the global market; but the position statement does not come from a market-driven angle—it is noted as a non-proliferation measure. This may seem paradoxical at first, but I ask the audience: Would you rather the U.S. nuclear energy industry influence the world’s developing countries as they inevitably build their nuclear infrastructure? Or would you prefer the influence of the nuclear energy industry of another country, which might not enforce and teach the same level of rigor in operational excellence, human performance, and design for non-proliferation?¶ ANS is now taking the stance that nuclear energy is not only a valuable source of domestic stability, but also an international security imperative. As developing countries begin taking advantage of nuclear energy as a clean energy source (this is already well underway and accelerating), the United States will be looked toward for its technology leadership in nuclear energy.¶ 1-2-3 Agreements¶ For bilateral nuclear trade agreements (known as 1-2-3 Agreements), it is imperative that the 1-2-3s be negotiated in a way that assures safety, but does not necessarily demand that a sovereign nation give up its sovereignty (such as automatically requiring that a country never “enrich” uranium to the very low levels required for use as nuclear fuel). The origination of the ANS position statement was a U.S. House of Representatives bill proposed to essentially enact a “gold standard” in 1-2-3 agreements, after the United Arab Emirates had agreed to forego its right to enrich uranium as an anti-proliferation measure. Since we know that these types of requirements are not being placed on agreements among other countries, such a requirement would place the United States in an uncompetitive stance, left to watch from the sidelines as the international nuclear trade landscape develops. Logically, ANS would like to see American technology leading the way to a cleaner and safer energized world.¶ The exportation of peaceful nuclear technology is highly valuable to developing nations. Historically, countries that developed nuclear energy technology actually developed nuclear weapons first, before they realized how much more valuable nuclear technology is for peaceful purposes. Why not help developing countries skip that first step?¶ U.S. nuclear technology is designed with anti-proliferation in mind as part of global security policy, so the exportation of U.S. nuclear energy technology as a market leader serves as a security imperative, to ensure that peaceful and nonproliferative technology isused dominantly throughout the world. I ask again: Would you rather see a developing country install U.S. technology under the guidance and influence of the United States? Or, would you rather see a developing country buy from someone else?¶ Influence and control¶ This is actually an area where Position Statement 83 may bring a little discomfort to the people in the nonproliferation community. It contains an undertone of influence, rather than control, over the expansion of nuclear science and technology in the international community. When I was a very young boy, my parents were able to control me; indeed, it was their responsibility to control me as I was raised. But something weird happened as I grew up into my teen years: I gained a sense of sovereignty. I could think for myself, act for myself, and I was pretty sure I knew more than them anyway, as most teenagers do. I wasn’t completely grown up yet, but the game had changed. My parents could no longer expect the ability to control me, but needed to still influence me to grow into a productive member of society (Craig Piercy, the Washington, D.C. representative for ANS, tells of this paradigm shift with pictures of his children as they grew up—it’s personally compelling and relatable).¶ In a global society where the United States out-spends everyone else on national defense (and shall we say, international defense), there yet comes a time when even the immense capability of the U.S. Armed Forces cannot effectively control the global community—but the positive example of the U.S. nuclear energy industry, its exemplary safety record, and its operational excellence can serve as a beacon of influence as it exports its technology.¶ This is why the United States must be the market leader in the exportation of peaceful nuclear technology. But I’m not done.¶

#### US leadership offsets dangerous tech

Ferguson, 10 [Dr. Charles D. Ferguson, President of the Federation of American Scientists, Adjunct Professor in the Security Studies Program at Georgetown University and Adjunct Lecturer in the National Security Studies Program at the Johns Hopkins University, May 19, 2010, Statement before the House Committee on Science and Technology for the hearing on Charting the Course for American Nuclear Technology: Evaluating the Department of Energy’s Nuclear Energy Research and Development Roadmap, <http://www.fas.org/press/_docs/05192010_Testimony_HouseScienceCommHearing%20.pdf>]

\*PHWR = pressurized heavy water reactor

The United States and several other countries have considerable experience in building and operating small and medium power reactors. The U.S. Navy, for example, has used small power reactors since the 1950s to provide propulsion and electrical power for submarines, aircraft carriers, and some other surface warships. China, France, Russia, and the United Kingdom have also developed nuclear powered naval vessels that use small reactors. Notably, Russia has deployed its KLT-40S and similarly designed small power reactors on icebreakers and has in recent years proposed building and selling barges that would carry these types of reactors for use in sea-side communities throughout the world. China has already exported small and medium power reactors. In 1991, China began building a reactor in Pakistan and started constructing a second reactor there in 2005. In the wake of the U.S.-India nuclear deal, Beijing has recently reached agreement with Islamabad to build two additional reactors rated at 650 MWe.2 One of the unintended consequences of more than 30 years of sanctions on India’s nuclear program is that India had concentrated its domestic nuclear industry on building small and medium power reactors based on Canadian pressurized heavy water technology, or Candu-type reactors. Pressurized heavy water reactors (PHWRs) pose proliferation concerns because they can be readily operated in a mode optimal for producing weapons-grade plutonium and can be refueled during power operations. Online refueling makes it exceedingly difficult to determine when refueling is occurring based solely on outside observations, for example, through satellite monitoring of the plant’s operations. Thus, the chances for potential diversion of fissile material increase. This scenario for misuse underscores the need for more frequent inspections of these facilities. But the limited resources of the International Atomic Energy Agency have resulted in a rate of inspections that are too infrequent to detect a diversion of a weapon’s worth of material.3 The opening of the international nuclear market to India may lead to further spread of PHWR technologies to more states. For example, last year, the Nuclear Power Corporation of India, Ltd. (NPCIL) expressed interest in selling PHWRs to Malaysia.4 NPCIL is the only global manufacturer of 220 MWe PHWRs. New Delhi favors South-to-South cooperation; consequently developing states in Southeast Asia, sub-Saharan Africa, and South America could become recipients of these technologies in the coming years to next few decades. Many of these countries would opt for small and medium power reactors because their electrical grids do not presently have the capacity to support large power reactors and they would likely not have the financial ability to purchase large reactors. What are the implications for the United States of Chinese and Indian efforts to sell small and medium power reactors? Because China and India already have the manufacturing and marketing capability for these reactors, the United States faces an economically competitive disadvantage. Because the United States has yet to license such reactors for domestic use, it has placed itself at an additional market disadvantage. By the time the United States has licensed such reactors, China and India as well as other competitors may have established a strong hold on this emerging market. The U.S. Nuclear Regulatory Commission cautioned on December 15, 2008 that the “licensing of new, small modular reactors is not just around the corner. The NRC’s attention and resources now are focused on the large-scale reactors being proposed to serve millions of Americans, rather than smaller devices with both limited power production and possible industrial process applications.” The NRC’s statement further underscored that “examining proposals for radically different technology will likely require an exhaustive review” ... before “such time as there is a formal proposal, the NRC will, as directed by Congress, continue to devote the majority of its resources to addressing the current technology base.”6 Earlier this year, the NRC devoted consideration to presentations on small modular reactors from the Nuclear Energy Institute, the Department of Energy, and the Rural Electric Cooperative Association among other stakeholders.7 At least seven vendors have proposed that their designs receive attention from the NRC.8 Given the differences in design philosophy among these vendors and the fact that none of these designs have penetrated the commercial market, it is too soon to tell which, if any, will emerge as market champions. Nonetheless, because of the early stage in development, the United States has an opportunity to state clearly the criteria for successful use of SMRs. But because of the head start of China and India, the United States should not procrastinate and should take a leadership role in setting the standards for safe, secure, and proliferation-resistant SMRs that can compete in the market. Several years ago, the United States sponsored assessments to determine these criteria.9 While the Platonic ideal for small modular reactors will likely not be realized, it is worth specifying what such an SMR would be. N. W. Brown and J. A. Hasberger of the Lawrence Livermore National Laboratory assessed that reactors in developing countries must: • “achieve reliably safe operation with a minimum of maintenance and supporting infrastructure; • offer economic competitiveness with alternative energy sources available to the candidate sites; • demonstrate significant improvements in proliferation resistance relative to existing reactor systems.”10 Pointing to the available technologies at that time from Argentina, China, and Russia, they determined that “these countries tend to focus on the development of the reactor without integrated considerations of the overall fuel cycle, proliferation, or waste issues.” They emphasized that what is required for successful development of an SMR is “a comprehensive systems approach that considers all aspects of manufacturing, transportation, operation, and ultimate disposal.” Considering proliferation resistance, their preferred approach is to eliminate the need for on-site refueling of the reactor and to provide for waste disposal away from the client country. By eliminating on-site refueling the recipient country would not need to access the reactor core, where plutonium—a weapons-usable material—resides. By removing the reactor core after the end of service life, the recipient country would not have access to fissile material contained in the used fuel. Both of these proposed criteria present technical and political challenges.

And, the plan shapes international norms – history proves

Lieberman, 11 [November 15, 2011 Nonproliferation, Congress, and Nuclear Trade: Plus ça change, plus c’est la même chose¶ Jodi Lieberman Jodi Lieberman is senior government relations¶ specialist at the American Physical Society in¶ Washington, D.C, http://csis.org/files/publication/111116\_nonproliferation\_congress\_and\_nucleartrade.pdf

U.S. Nonproliferation Influence While 123 agreements are an important U.S. nonproliferation tool, they are not the only ones available. U.S. nonproliferation policy and bilateral and multilateral initiatives are also a key part of U.S. influence on global nonproliferation norms and actions. U.S. nonproliferation influence is also derived from its leadership role over the last 50 years in making nonproliferation a significant foreign policy objective. The United States has been instrumental in helping create the essential elements of the nonproliferation regime, including the Nuclear Non-Proliferation Treaty (NPT), the Nuclear Suppliers Group, the Convention on the Physical Protection of Nuclear Material, and many others. In addition, its own domestic policies have helped shape norms of nonproliferation. According to Scott Sagan, “U.S. policymakers and scholars…too often ignore or underestimate the influence of U.S. domestic nuclear decisions on those of foreign governments… American nuclear policies play an important role in shaping—if not fully determining—the decisions made in other capitals regarding nuclear power, the nuclear fuel cycle, and nuclear security.”23 One example of U.S. influence on nuclear issues is its decision to abandon plutonium reprocessing in the 1970s. Once the Carter administration officially withdrew government support for reprocessing in the United States and cancelled construction of commercial breeder reactors in April 1977, it exerted pressure on other countries to do the same. The administration believed that this decision would end U.S. exports of reprocessing technologies, thus limiting their availability, and would ultimately lead other countries to follow suit. While France and Japan went forward with their plutonium reprocessing efforts, of the 32 countries that at some point in their history pursued reprocessing, 12 abandoned plans altogether due, at least in part, to U.S. diplomatic pressure.24 Writing in the Bulletin of Atomic Scientists in 1976, President Carter reflected on a world in which, “by 1990, developing nations alone will produce enough plutonium in their reactors to build 3000 Hiroshimasized bombs a year… This prospect of a nuclear future is particularly alarming if a large number of nations develop their own national plutonium reprocessing facilities with the capacity to extract plutonium from the spent fuel… [T]he danger is not so much in the spread of nuclear reactors themselves… The far greater danger lies in the spread of facilities for the enrichment of uranium and the reprocessing of spent reactor fuel.”25 He stated that while the United States has not approved the export of enrichment and reprocessing technologies, “some of the other principal suppliers of nuclear equipment have begun to make such sales…[making it] absolutely essential to halt the sale of such plants.” U.S. success in convincing these countries to forgo reprocessing was helped by the United States setting an example domestically by not reprocessing (and low uranium prices). Although countries that had already embarked on commercial reprocessing were not swayed to abandon their large investments for nonproliferation reasons, no countries have initiated commercial reprocessing programs since then. U.S. assistance to other countries in safeguards and nuclear security also helps accomplish its nonproliferation goals. Programs implemented by the Departments of Energy, Defense, and State, as well as the Nuclear Regulatory Commission, generally include technical, financial and/or “in-kind” assistance. Technical assistance is provided in a broad range of areas and has included, inter alia, help in: implementing state systems of accounting and control of nuclear materials (SSACs); training former nuclear weapons scientists in “peaceful” applications of their expertise; implementation of UN Security Council Resolution 1540; development of nuclear security regulations; and strengthening physical protection of nuclear facilities. Financial assistance has included: funding for implementation of IAEA safeguards and UN Security Council Resolution 1540; and contribution to the IAEA nuclear security fund for strengthening protection of nuclear materials. In-kind assistance includes provision of U.S. experts and equipment. At the highest levels, presidential initiatives can help underscore the importance of nonproliferation in U.S. foreign policy. For example, in April 2010, President Barack Obama convened a Nuclear Security Summit in Washington, D.C., the goal of which was to “come to a common understanding of the threat posed by nuclear terrorism, to agree to effective measures to secure nuclear material, and to prevent nuclear smuggling and terrorism.”26 More than 40 heads of state attended and made national commitments relating to nuclear security.27 The countries agreed on a work plan related to support for and implementation of UN Security Council Resolution 1540, the Convention on the Physical Protection of Nuclear Material (CPPNM), IAEA nuclear security efforts, and other activities to account for and protect weaponsusable nuclear material. A second nuclear security summit will be held in South Korea in 2012.

#### And, LFTR reactors are key – in situ reprocessing checks fissile diversion

**Martin, 12** [May 8th, Richard, A contributing editor for Wired since 2002, he has written about energy, for Time, Fortune, The Atlantic, and the Asian Wall Street Journal, editorial director for Pike Research, the leading cleantech research and analysis firm, former Technology Producer for ABCNews.com, Technology Editor for The Industry Standard (2000-2001), and Editor-at- Large for Information Week (2005-2008), recipient of the “Excellence in Feature Writing" Award from the Society for Professional Journalists and the White Award for Investigative Reporting, Educated at Yale and the University of Hong Kong, , “SuperFuel: Thorium, the Green Energy Source for the Future”, ISBN 978—0»230-116474]

\*LFTR = liquid fluoride thorium reactor

IN REPORTING ON THE THORIUM POWER MOVEMENT, I heard plenty of reasons why it would never work. After a year or so I classified them into three categories: market barriers, challenges related to waste and proliferation, and what I came to call the traditionalist argument. The market-based argument is simple: the nuclear power industry has a fuel today that is abundant and inexpensive. Why should it switch to a new, relatively unproven fuel? These assumptions are faulty (uranium may well not be inexpensive and plentiful much longer—see the comments of Srikumar Banerjee, chair of India’s Atomic Energy Commission, from chapter 7). More important, this argument does not take into account the broader costs and risks of uranium-based nuclear power, which have been highlighted by the Fukushima-Daiichi accident. There’s little chance of nuclear power’s fulfilling its promise until those costs are driven down—by shifting to thorium power. The waste and proliferation issues are more complicated, and I will break them down into four elements.“ In distilled form they sum up the objections to thorium from both the nuclear establishment and antinuclear groups. 1. The use of enriched uranium or plutonium in thorium fuel to **ignite the fission** reaction carries proliferation risks, and U-233 is as useful as Pu-239 for making nuclear bombs. This is the central claim of those who dismiss thorium’s prospects for reducing the nuclear waste stream: Solid-fuel thorium reactors produce both U233 (the fissile daughter element of Th232) and plutonium, so what’s the difference? What’s more, thorium reactors require lowenriched uranium or plutonium to initiate the fission reaction, thus creating more material that can be refined into bombs. The kernel of truth here is that the U233 (and thus the plutonium as well) created in the transmutation of thorium is contaminated by U232, one of the nastiest isotopes in the universe. With a half-life of less than 70 years, U-232 decays into the radioisotopes bismuth-212 and thallium-208, which emit intense gamma rays that make it very, very hard to handle and transport (not to mention reprocess) and that would very likely destroy the electronics of any weapon into which they were built. Theoretically, it's possible to make a bomb with U-233, but plutonium is much easier to make and does not come with the problematic U-232. Militaries will always opt for plutonium and U235, because they can't afford to expose their personnel to the deadly risks of U232. As for terrorists, they'd be better off simply buying natural uranium on the open market and finding a way to enrich it. The United States reportedly tested bombs with U-233 cores in the late 1950s, but no country has ever included it as a material as a part of its nuclear weapons program. It's useless even for the most zealous of hypothetical suicide bombers, because they’d probably never reach their target. 2. Most proposed thorium reactors require reprocessing to separate out the U-233 for use in fresh fuel. As with conventional uranium power plants that include reprocessing, bomb-making material is separated out, making it vulnerable to theft or diversion. **This is a tired canard**. Never mind that every nuclear fuel cycle currently in production or contemplated generates “bomb-making material” -- this statement ignores the **realities of weapons building**. Most Gen IV designs described in this chapter involve fuel recycling; indeed, as the Peterson report stated, recycling is critical to the future of nuclear power. To be sure, reprocessing spent fuel rods from a solid fuel thorium reactor is not a simple matter, whether you’re making bombs or new fuel. But it’s important to note that, as with all these arguments, external reprocessing is necessary **only for solid fuel** reactors, not LFTRs. Alone among advanced reactor designs, LFTRs have the capacity to reprocess the fuel **in the reactor** building itself, while the reactor is operating. There’s **no opportunity** for diversion unless you raid the entire plant, shut down the reactor, and figure out a way to separate and abscond with the weaponizable isotopes. Good luck with that. 3. The claim that radioactive waste from thorium reactors creates waste that would have to be isolated from the environment for only 500 years, whereas irradiated uranium-only fuel remains dangerous for hundreds of thousands of years, is false. Thorium-based reactors create long-lived fission products like technetium-99 (its half-life is more than 200,000 years), and thorium- 232 is extremely long lived (its half-life is 14 billion years). This argument ignores the larger context. The volume of fission products from thorium-based solid fuel reactors is about a tenth of that from conventional reactors. What's more, in small amounts, many of these fission products have become common in modern life. Technetium-99, for example, is powerful stuff, worthy of respectful treatment; it’s also commonly used, in a slightly altered form, in medical imaging procedures. Millions of patients ingest it every day without significant risk. The amounts of technetium-99 produced in solid-fuel thorium reactors would be negligible; in LFTRs it would be processed off along with other fission products and largely recycled. Some geological storage will be required, but in general waste from LFTRs decays to safe, stable states within a few hundred years, far less than the millennia required for the by-products of uranium reactors. As for Th-232, it's long lived but safe. The longerlived a radioactive element is, the lower its radioactivity, with its very long half-life, Th-232 is an exceedingly weak producer of radiation. It is so common that it's found in small amounts in virtually all rock, soil, and water. You could sleep with it under your pillow and suffer no ill effects. 4. Reprocessing of thorium fuel cycles has not been successful because uranium-232 is created along with uranium-233. U-232, which has a halflife of about 70 years, is extremely radioactive and is therefore quite dangerous in small quantities. U-232 is indeed extremely radioactive, but its brief half-life means that in less than a century half of it will have decayed to a stable form. Because isotopes decay at a geometric rate (50 percent of half of the original material, or one-quarter of the original, is still radioactive after another 70 years, then one-eighth, one-sixteenth, and so on), the decrease in radioactivity drops off quickly. Many, many hazardous materials are put in storage for centuries. We do not object to them. To summarize, the most common objections to thorium power from the perspective of radioactive waste and the proliferation of nuclear weapons are inflated for solid fuel reactors, and they simply do not apply to LFTRs. That leaves the traditionalist argument, which essentially echoes Milton Shaw and the WASH-1222 report from 1972: It can’t be done because it has never been done before. When I heard this brand of defeatism, it always came from someone with a vested interest in the current nuclear power establishment. I’ll explore the traditionalist argument in more detail in the final pages of this book.

#### Federal action is key to reverse industry decline and influence reactor adoption

Wallace and Williams, 12 [Michael, Senior Adviser, U.S. Nuclear Energy Project, Sarah, CSIS, “Nuclear Energy in America: Preventing It’s Early Demise,” http://csis.org/files/publication/120417\_gf\_wallace\_williams.pdf]

America’s nuclear energy industry is in decline. Low natural gas prices, financing hurdles, new safety and security requirements, failure to resolve the waste issue and other factors are hastening the day when existing reactors become uneconomic, making it virtually impossible to build new ones. Two generations after the United States took this wholly new and highly sophisticated technology from laboratory experiment to successful commercialization, our nation is in danger of losing an industry of unique strategic importance, unique potential for misuse, and unique promise for addressing the environmental and energy security demands of the future. The pace of this decline, moreover, could be more rapid than most policymakers and stakeholders anticipate. With 104 operating reactors and the world’s largest base of installed nuclear capacity, it has been widely assumed that the United States—even without building many new plants—would continue to have a large presence in this industry for some decades to come, especially if existing units receive further license extensions. Instead, current market conditions are such that growing numbers of these units are operating on small or even negative profit margins and could be retired early. Our nation is in danger of losing an industry of **unique** strategic **importance**, unique potential for misuse, and unique promise for addressing the environmental and energy security demands of the future.60 | Center for Strategic and International Studies Meanwhile, China, India, Russia, and other **countries are looking to** significantly expand their nuclear energy commitments. By 2016, China could have 50 nuclear power plants in operation, compared with only 14 in 2011. India could add 8 new plants and Russia 10 in the same time frame. These trends are expected to accelerate out to 2030, by which time China, India, and Russia could account for nearly 40 percent of global nuclear generating capacity. Meanwhile, several smaller nations, mostly in Asia and the Middle East, are planning to get into the nuclear energy business for the first time. In all, as many as 15 new nations could have this technology within the next two decades. Meanwhile, America’s share of global nuclear generation is expected to shrink, from about 25 percent today to about 14 percent in 2030, and—if current trends continue—to less than 10 percent by mid-century. **With the center of gravity** for global nuclear investment **shifting** to a new set of players, the United States and the international community face a difficult set of challenges: stemming the **spread of nuclear weapons-**usable materials and know-how; preventing **further catastrophic nuclear accidents**; providing for safe, long-term nuclear waste management; and protecting U.S. energy security and economic competitiveness. **In this context, federal action** to reverse the American nuclear industry’s impending decline is a national security imperative. The United States cannot afford to become irrelevant in a new nuclear age. Our nation’s commercial nuclear industry, its military nuclear capabilities, and its strong regulatory institutions can be seen as three legs of a stool. All three legs are needed to support America’s future prosperity and security and to shape an international environment that is conducive to our long-term interests. Three specific aspects of U.S. leadership are particularly important. First, managing the national and global security risks associated with the spread of nuclear technology to countries that don’t necessarily share the same perspective on issues of nonproliferation and nuclear security or may lack the resources to implement effective SHARE OF NET GLOBAL NUCLEAR GENERATION 1980-2030 Source: Energy Information Agency (EIA) databaseGlobal Forecast 2012 | 61 safeguards in this area. An approach that relies on influence and involvement through a viable domestic industry is likely to be **more effective** and less expensive than trying to contain these risks militarily. Second, **setting global norms** and standards for safety, security, operations, and emergency response. As the world learned with past nuclear accidents and more recently with Fukushima, a major accident anywhere can have lasting repercussions everywhere. As with nonproliferation and security, **America’s ability to exert leadership** and influence in this area is directly linked to the strength of our domestic industry and our active involvement in the global nuclear enterprise. A strong domestic civilian industry and regulatory structure have immediate national security significance in that they help support the nuclear capabilities of the U.S. Navy, national laboratories, weapons complex, and research institutions. Third, in the past, the U.S. government could exert influence by striking export agreements with countries whose regulatory and legal frameworks reflected and were consistent with our own nonproliferation standards and commitments. At the same time, our nation set the global standard for effective, independent safety regulation (in the form of the Nuclear Regulatory Commission), led international efforts to reduce proliferation risks (through the 1970 NPT Treaty and other initiatives), and provided a model for industry self-regulation. The results were not perfect, but America’s institutional support for global nonproliferation goals and the regulatory behaviors it modeled clearly helped shape the way nuclear technology was adopted and used elsewhere around the world. This influence seems certain to wane if the United States is no longer a major supplier or user of nuclear technology. With existing nonproliferation and safety and security regimes looking increasingly inadequate in this rapidly changing global nuclear landscape, American leadership and leverage is more important and more central to our national security interests than ever. To maintain its leadership role in the development, design, and operation of a growing global nuclear energy infrastructure, the next administration, whether Democrat or Republican, must recognize the invaluable role played by the commercial U.S. nuclear industry and take action to prevent its early demise.

#### They are prolif resistant and spur elimination of global plutonium stockpiles

Donohue, 8/27/12 [Nathan Donohue is a research intern for the Project on Nuclear Issues, CSIS, “Thorium and its Value in Nonproliferation”, <http://csis.org/blog/thorium-and-its-value-nonproliferation>]

The Federation of American Scientists (FAS) recently featured an article on their Science Wonk blog entitled “[What about thorium?](http://www.fas.org/blogs/sciencewonk/2012/08/what-about-thorium/)” As the article discussed, thorium is an element, which like uranium, has the ability to be utilized to produce nuclear power. More importantly, thorium fueled reactors are reported to be more proliferation resistant than uranium fueled reactors. However, despite these assertions, thorium has almost universally been ignored in favor of uranium based nuclear power reactors. The purpose of this piece is to conduct a review of thorium and to develop a better understanding of thorium’s nonproliferation benefits as it relates to nuclear power production. As FAS notes, natural thorium is a fertile material, while not itself fissionable, can be converted into a fissile material suitable to sustain a nuclear fission chain reaction. Accordingly, when natural thorium captures neutrons it becomes a new isotope of thorium which then goes through a process of decay where over a period of weeks, the thorium actually turns into **uranium in the form of U-233**. Unlike natural thorium, this U-233 is a fissile material suitable to sustain a nuclear fission chain reaction. The use of thorium to produce nuclear power is not a new concept. Research into thorium began in the late 1950’s and in 1965, Alvin Weinberg, the head of the Oak Ridge National Laboratory, and his team [built](http://www.wired.com/magazine/2009/12/ff_new_nukes/) a working thorium reactor using a molten salt bath design. Thorium was [used](http://www.neimagazine.com/story.asp?storyCode=2054564) to power one of the first commercial nuclear power plants in the U.S. in Shippingport, Pennsylvania in 1977. Nevertheless, research into thorium never found a foothold in the U.S. nuclear power infrastructure. By 1973, thorium research and development was fading to the uranium based focus of the U.S. nuclear industry, which was in the process of developing 41 new nuclear plants, all of which used uranium. The Shippingport facility was one of the last vestiges of thorium research in the U.S. for decades. Recently there has been a renewed focus on thorium based nuclear power, specifically in regards to the benefits related to spent fuel, [including](http://www.iaea.org/Publications/Magazines/Bulletin/Bull511/51104894344.pdf) research involving the European Commission, India, Canada, Slovakia, the Russian Federation, China, France and the Republic of Korea. The utilization of thorium is purported to have the ability to reduce spent fuel waste by upwards of 50% while at the same time reducing the amount of plutonium within the fuel. To that end, thorium fuel designs are regarded as a better alternative for power production in terms of the plutonium proliferation risk inherent in spent fuel from uranium-fueled reactors. For example, all 104 reactors in the U.S. use uranium fuel. In these reactors, when the uranium in the form of U-238 captures extra neutrons, it goes through a [process](http://nuclearweaponarchive.org/Library/Plutonium/index.html) of decay whereby **plutonium in the form of Pu-239** is produced. The spent fuel can then be reprocessed to isolate and remove this plutonium, which can then be used in the core of a nuclear weapon. Roughly **13 kilograms** (kg) of reactor grade plutonium is necessary to power a nuclear weapon. In total, these 104 U.S. reactors accumulate roughly 2,000 tons of spent fuel per year. The 2,000 tons of waste produced annually by these nuclear utilities, contains roughly [25,520](http://www.fas.org/rlg/980826-pu.htm) kg of plutonium or enough plutonium to build 1,963 nuclear weapons a year. Globally, the total world generation of reactor-grade plutonium in spent fuel is equal to roughly [70](http://www.world-nuclear.org/info/inf15.html) tons annually; more than two times what the U.S. produces. Conversely, there is the thorium seed and blanket design. This reactor [concept](http://www.wired.com/magazine/2009/12/ff_new_nukes/) is based on a design comprised of inner seed rods of uranium which provide neutrons to an outer blanket of thorium-uranium dioxide rods, creating U-233, which in turn powers the nuclear reactor. The important difference with this design is in the nature of the spent fuel. As advocates of thorium such as the U.S. company Lightbridge purport, this process would [realize](http://www.oecd-nea.org/science/meetings/arwif2001/57.pdf) a significant reduction in the “quantity and quality” of plutonium produced within the spent fuel, achieving upwards of an 80% reduction in plutonium. For [example](http://www.americanscientist.org/issues/feature/2003/5/thorium-fuel-for-nuclear-energy/5.), “a thorium-fueled reactor …would produce a total of 92 kilograms of plutonium per gigawatt-year of electricity generated, whereas a conventional water-cooled reactor would result in 232 kilograms.” In addition to a lower percentage of plutonium in the spent fuel, the composition of the plutonium produced is different as well, [featuring](http://www.oecd-nea.org/science/meetings/arwif2001/57.pdf.) a higher content of the plutonium isotopes Pu-238, Pu-240, and Pu-242. Weapons-grade plutonium requires roughly 90% plutonium in the form of Pu-239. Plutonium with higher contents of Pu-238 and Pu-240 is inherently unpredictable, and can spontaneously fission, making it “difficult or impossible to compress a bomb core containing several kilograms of plutonium to supercriticality before the bomb [disassembles] with a greatly reduced yield.” This reduces the reliability of a given nuclear weapon, thus making the thorium process less suitable for the development of plutonium for a nuclear weapon**.** The International Atomic Energy Agency [considers](http://hdl.handle.net/1721.1/29956) plutonium containing more than 81% Pu-238 “not weapons-usable.” Although thorium offers the ability to reduce the plutonium risk inherent in spent fuel, it does not eliminate the need for enriched uranium. Specifically, Lightbridge’s seed and blanket fuel technology would [require](http://www.ltbridge.com/assets/Thorium_Fuel_Fact_Sheet.pdf) uranium enriched to less than 20 % in both the seed and blanket fuel rods. Equally significant, the U-233 that is produced in the seed and blanket design poses its own proliferation concern. A nuclear weapon can be constructed with a significant quantity of U-233, which the IAEA defines as [8](http://moltensalt.org/references/static/downloads/pdf/ORNL-6952.pdf) **kg of U-233**, and both the U.S. and India have [detonated](http://en.wikipedia.org/wiki/Nuclear_weapons_testing) nuclear devices which utilized U-233. At the same time though, U-233 produced through this design also contains a small amount of the uranium isotope U-232, which emits a powerful, highly penetrating gamma ray. As [noted](http://www.iaea.org/Publications/Magazines/Bulletin/Bull511/51104894344.pdf) by Ray Sollychin, the Executive Director of the Neopanora Institute-Network of Energy Technologies, this reportedly makes “U233 weapons significantly more difficult to conceal and much more dangerous to handle.” In addition, reactors which use a thorium based seed and blanket design are engineered so that the U-233 which is produced is simultaneously denatured or blended with U-238, further reducing its suitability for a nuclear weapon. Moreover, the blanket is designed to remain within the reactor for upwards of nine to twelve years. This allows for the U-233 that is produced within the blanket to burn “[in situ](http://hdl.handle.net/1721.1/29956).” Lastly, any attempt to prematurely remove the blanket and separate the U-233 from the U-238, U-234 and U-236 isotopes [will](http://hdl.handle.net/1721.1/29956) also “remove the fissile U-235 from the resulting enriched steam,” once again making it unsuitable for a nuclear weapon. From this brief review of thorium and its properties, it appears clear that from a proliferation standpoint, that thorium fueled reactors provide for a safer nuclear power production process. In fact, it begs the question why thorium was overlooked in the first place. The simple answer is that the U.S. nuclear infrastructure was originally designed to facilitate mass quantities of plutonium for the production of a nuclear weapons arsenal. According to an [article](http://www.wired.com/magazine/2009/12/ff_new_nukes/) by Richard Martin in Wired magazine, “Locked in a struggle with a nuclear- armed Soviet Union, the U.S. government in the 60’s chose to build uranium-fueled reactors — in part because they produce plutonium that can be refined into weapons-grade material.” During the Cold War, maintaining nuclear parity with the Soviets was an overarching goal. Yet, with the end of the Cold War, the focus has shifted from acquiring nuclear weapons to stymying their development by both state and non-state actors. Therefore, the plutonium byproduct of the global nuclear power infrastructure has now become a liability and a proliferation risk. As the IAEA has [noted](http://www-pub.iaea.org/mtcd/publications/pdf/te_1450_web.pdf), “for nuclear power to be accepted as a significant contributor of primary energy in the next century, it should be based on a fuel cycle, which is highly proliferation-resistant.” For this reason, further research and development of thorium needs to be explored, not only in terms of seed and blanket technology but other thorium based designs as well, [including](http://www.iaea.org/Publications/Magazines/Bulletin/Bull511/51104894344.pdf) thorium-based Pebble Bed Reactor, fast reactors (liquid metal cooled and gas cooled); and advanced designs such as Molten Salt Reactor and Accelerator Driven System.

#### And, in-situ reprocessing removes plutonium – solves extinction from terrorism

Rhodes, 12 [February, Professor Chris Rhodes is a writer and researcher. He studied chemistry at Sussex University, earning both a B.Sc and a Doctoral degree (D.Phil.); rising to become the youngest professor of physical chemistry in the U.K. at the age of 34. A prolific author, Chris has published more than 400 research and popular science articles (some in national newspapers: The Independent and The Daily Telegraph) He has recently published his first novel, "University Shambles" was published in April 2009 (Melrose Books), “Hopes Build for Thorium Nuclear Energy”, <http://oilprice.com/Alternative-Energy/Nuclear-Power/Hopes-Build-for-Thorium-Nuclear-Energy.html>]

There is much written to the effect that thorium might prove a more viable nuclear fuel, and an energy industry based upon it, than the current uranium-based process which serves to provide both energy and weapons - including "depleted uranium" for armaments and missiles. There are different ways in which energy might be extracted from thorium, one of which is the accelerator-driven system (ADS). Such accelerators need massive amounts of electricity to run them, as all particle accelerators do, but these are required to produce a beam of protons of such intensity that until 10 years ago the prevailing technology meant that it could not have been done. As noted below, an alternative means to use thorium as a fuel is in a liquid fluoride reactor (LFR), also termed a molten salt reactor, which avoids the use of solid oxide nuclear fuels. Indeed, China has made the decision to develop an LFR-based thorium-power programme, to be active by 2020.¶ Rather like nuclear fusion, the working ADS technology is some way off, and may never happen, although Professor Egil Lillestol of Bergen University in Norway is pushing that the world should use thorium in such ADS reactors. Using thorium as a nuclear fuel is a laudable idea, as is amply demonstrated in the blog "Energy from Thorium" (<http://thoriumenergy.blogspot.com/>). However, the European Union has pulled the plug on funding for the thorium ADS programme, which was directed by Professor Carlo Rubbia, the Nobel Prize winner, who has now abandoned his efforts to press forward the programme, and instead concentrated on solar energy, which was another of his activities. Rubbia had appointed Lillestol as leader of the CERN physics division over two decades ago, in 1989, who believes that the cause is not lost.¶ Thorium has many advantages, not the least being its greater abundance than uranium. It is often quoted that there is three times as much thorium as there is uranium. Uranium is around 2 - 3 parts per million in abundance in most soils, and this proportion rises especially where phosphate rocks are present, to anywhere between 50 and 1000 ppm. This is still only in the range 0.005% - 0.1% and so even the best soils are not obvious places to look for uranium. However, somewhere around 6 ppm as an average for thorium in the Earth's crust is a reasonable estimate. There are thorium mineral deposits that contain up to 12% of the element, located at the following tonnages in Turkey (380,000), Australia (300,000), India (290,000), Canada and the US combined (260,000)... and Norway (170,000), perhaps explaining part of Lillestol's enthusiasm for thorium based nuclear power. Indeed, Norway is very well endowed with natural fuel resources, including gas, oil, coal, and it would appear, thorium.¶ An alternative technology to the ADS is the "Liquid Fluoride Reactor" (LFR), which is described and discussed in considerable detail on the <http://thoriumenergy.blogspot.com/> blog, and reading this has convinced me that the LFR may provide the best means to achieve our future nuclear energy programme. Thorium exists naturally as thorium-232, which is not of itself a viable nuclear fuel. However, by absorption of relatively low energy "slow" neutrons, it is converted to protactinium 233, which must be removed from the reactor (otherwise it absorbs another neutron and becomes protactinium 234) and allowed to decay over about 28 days to uranium 233, which is fissile, and can be returned to the reactor as a fuel, and to breed more uranium 233 from thorium. The "breeding" cycle can be kicked-off using plutonium say, to provide the initial supply of neutrons, and indeed the LFR would be a useful way of disposing of weapons grade plutonium and uranium from the world's stockpiles while converting it into useful energy.¶ The LFR makes in-situ reprocessing possible, much more easily than is the case for solid-fuel based reactors. I believe there have been two working LFR's to date, and if implemented, the technology would avoid using uranium-plutonium fast breeder reactors, which need high energy "fast" neutrons to convert uranium 238 which is not fissile to plutonium 239 which is. The LFR is inherently safer and does not require liquid sodium as a coolant, while it also **avoids the risk of plutonium getting into the hands of terrorists**. It is worth noting that while uranium 235 and plutonium 239 could be shielded to avoid detection as a "bomb in a suitcase", uranium 233 could not, because it is always contaminated with uranium 232, which is a strong gamma-ray emitter, and is far less easily concealed.¶ It has been claimed that thorium produces "250 times more energy per unit of weight" than uranium. Now this isn't simply a "logs versus coal on the fire" kind of argument, but presumably refers to the fact that while essentially all the thorium can be used as a fuel, the uranium must be enriched in uranium 235, the rest being "thrown away" and hence wasted as "depleted" uranium 238 (unless it is bred into plutonium). If both the thorium and uranium were used to breed uranium 233 or plutonium 239, then presumably their relative "heat output" weight for weight should be about the same as final fission fuels? If this is wrong, will someone please explain this to me as I should be interested to know?¶ However, allowing that the LFR in-situ reprocessing is a far easier and less dangerous procedure, the simple sums are that contained in 248 million tonnes of natural uranium, available as a reserve, are 1.79 million tonnes of uranium 235 + 246.2 million tonnes of uranium 238. Hence by enrichment 35 million tonnes (Mt) of uranium containing 3.2% uranium 235 (from the original 0.71%) are obtained. This "enriched fraction" would contain 1.12 Mt of (235) + 33.88 Mt of (238), leaving in the other "depleted" fraction 248 - 35 Mt = 213 Mt of the original 248 Mt, and containing 0.67 Mt (235) + 212.3 Mt (238). Thus we have accessed 1.79 - 0.67 = 1.12 Mt of (235) = 1.12/224 = 4.52 x 10\*-3 or 0.452% of the original total uranium. Thus on a relative basis thorium (assuming 100% of it can be used) is 100/0.452 = 221 times as good weight for weight, which is close to the figure claimed, and a small variation in enrichment to a slightly higher level as is sometimes done probably would get us to an advantage factor of 250!¶ Plutonium is a by-product of normal operation of a uranium-fuelled fission reactor. 95 to 97% of the fuel in the reactor is uranium 238. Some of this uranium is converted to plutonium 239 and plutonium 241 - usually about 1000 kg forms after a year of operation. At the end of the cycle (a year to 2 years, typically), very little uranium 235 is left and about 30% of the power produced by the reactor actually comes from plutonium. Hence a degree of "breeding" happens intrinsically and so the practical advantage of uranium raises its head from 1/250 (accepting that figure) to 1/192, which still weighs enormously in favour of thorium!¶ As a rough estimate, 1.4 million tonnes of thorium (about one third the world uranium claimed, which is enough to last another 50 years as a fission fuel) would keep us going for about 200/3 x 50 = 3,333 years. Even if we were to produce all the world's electricity from nuclear that is currently produced using fossil fuels (which would certainly cut our CO2 emissions), we would be O.K. for 3,333/4 = 833 years. More thorium would doubtless be found if it were looked for, and so the basic raw material is not at issue. Being more abundant in most deposits than uranium, its extraction would place less pressure on other fossil fuel resources used for mining and extracting it. Indeed, thorium-electricity could be piped in for that purpose.¶ It all sounds great: however, the infrastructure would be huge to switch over entirely to thorium, as it would to switch to anything else including hydrogen and biofuels. It is this that is the huge mountain of resistance there will be to all kinds of new technology. My belief is that through cuts in energy use following post peak oil (and peak gas), we may be able to produce liquid fuels from coal, possibly using electricity produced from thorium, Thorium produces less of a nuclear waste problem finally, since fewer actinides result from the thorium fuel cycle than that from uranium. Renewables should be implemented wherever possible too, in the final energy mix that will be the fulcrum on which the survival of human civilization is poised.

#### And, dual use tech makes other reactor types prolif prone – the plan is key to tech transfers

Hargraves, 12 [July, Robert, Robert Hargraves has written articles and made presentations about the liquid fluoride thorium reactor and energy cheaper than from coal – the only realistic way to dissuade nations from burning fossil fuels. His presentation “Aim High” about the technology and social benefits of the liquid fluoride thorium reactor has been presented to audiences at Dartmouth ILEAD, Thayer School of Engineering, Brown University, Columbia Earth Institute, Williams College, Royal Institution, the Thorium Energy Alliance, the International Thorium Energy Association, Google, the American Nuclear Society, and the Presidents Blue Ribbon Commission of America’s Nuclear Future. With coauthor Ralph Moir he has written articles for the American Physical Society Forum on Physics and Society: Liquid Fuel Nuclear Reactors (Jan 2011) and American Scientist: Liquid Fluoride Thorium Reactors (July 2010). Robert Hargraves is a study leader for energy policy at Dartmouth ILEAD. He was chief information officer at Boston Scientific Corporation and previously a senior consultant with Arthur D. Little. He founded a computer software firm, DTSS Incorporated while at Dartmouth College where he was assistant professor of mathematics and associate director of the computation center. He graduated from Brown University (PhD Physics 1967) and Dartmouth College (AB Mathematics and Physics 1961). THORIUM: energy cheaper than coal, ISBN: 1478161299, purchased online at Amazon.com]

Advanced nuclear power must be proliferation resistant. Nuclear weapons can cause terrible destruction of whole cities and contaminate entire regions, so expansion of nuclear power must come with assurances that the risk of proliferation of nuclear weapons is not increased. The technology for making such weapons is widely known, although the process is difficult and expensive. Building commercial nuclear power plants has not led to weapons development; nations that have nuclear weapons have developed them with purposeful programs and facilities. However dual-use technologies such as centrifuge enrichment of U-235 that can make fuel for PWRs can be adapted to make highly enriched uranium for weapons. After President Eisenhower’s Atoms for Peace speech the US helped nations to acquire the knowledge and materials to use nuclear technology for peaceful purposes. Unexpectedly this knowledge led India to develop nuclear weapons instead. Selling advanced nuclear power plants worldwide does not require providing each nation with the technical skills and materials to build nuclear power plants or nuclear weapons. Consider the airplane and jet engine industry: nations want prestigious national airlines. Fully 83 countries, from Algeria to Yemen, operate airlines using the Boeing 747 airliner, yet these nations do not have their own airframe or engine production or maintenance capabilities. General Electric makes a business of maintaining and overhauling engines at GE’s own service centers. This is a technology-transfer-resistant model suitable for LFTR installation and maintenance. The liquid fluoride thorium reactor is proliferation resistant. LFTR requires fissile material to be transported to the site for startup, but not thereafter. LFTR then creates and burns fissile U-233 that conceivably could be used instead for a nuclear weapon. Would this ever happen? China, USA, Russia, India, UK, France, Pakistan, and Israel, which account for 57% of global CO2 emissions, already have nuclear weapons and no incentive to subvert LFTR technology. So just implementing LFTRs in these nations would be a big step in addressing global warming. Many additional nations, such as Canada, Japan, and South Africa, have the capability to build nuclear weapons but have chosen not to, so there is no incentive for them to subvert LFTR technology for this purpose. Should LFTRs be implemented in other non-weapons states? Certainly terrorists could not steal this uranium dissolved in a molten salt solution along with even more radioactive fission products inside a sealed reactor. IAEA safeguards include physical security, accounting and control of all nuclear materials, surveillance to detect tampering, and intrusive inspections. LFTR’s neutron economy contributes to securing its inventory of nuclear materials. Neutron absorption by uranium-233 produces about 2.4 neutrons per fission—one to drive a subsequent fission and another to drive the conversion of Th-232 to U-233 in the blanket molten salt. Taking into account neutron losses from capture by protactinium and other nuclei, a well-designed LFTR reactor will direct just about 1.00 neutrons per fission to thorium transmutation. This delicate balance doesn’t create excess U-233, just enough to generate fuel indefinitely. If this conversion ratio could be increased to 1.01, a 100 MW LFTR might generate kilogram of excess U-233 per year. If meaningful quantities of uranium-233 are misdirected for non-peaceful purposes, the reactor will report the diversion by stopping because of insufficient U-233 to maintain a chain reaction. Yet a sovereign nation or revolutionary group might expel IAEA observers, stop the LFTR, and attempt to remove the U-233 for weapons. Accomplishing this would require that skilled engineers, working in a radioactive environment, modify the reactor's fluorination equipment to separate uranium from the fuel salt instead of the thorium blanket salt. What would happen to them? The neutrons that produce U-233 also produce contaminating U-232, whose decay products emit 2.6 MeV penetrating gamma radiation, hazardous to weapons builders and obvious to detection monitors. The U-232 decays via a cascade of elements to thallium- 208, which builds up and emits the radiation. Depending on design specifics, the proportion of U-232 would be about 0.13% for a commercial power reactor. A year after separation, a weapons worker one meter from a subcritical 5 kg sphere of such U-233 would receive a radiation dose of 43 mSv/hr, compared to 0.003 mSv/hr from plutonium, even less from U-235. Death becomes probable after 72 hours exposure. After ten years this radiation triples. A resulting weapons would be highly radioactive and therefore dangerous to military workers nearby. The penetrating 2.6 MeV gamma radiation is an easily detected marker revealing the presence of such U-233, possibly even from a satellite. U-232 can not be removed chemically, and centrifuge separation from U-233 would make the centrifuges too radioactive to maintain. Conceivably, nuclear experts might try to stop the reactor, chemically extract the uranium, and devise chemistry to remove the intermediate elements of the U-232 decay chain before the thallium is formed, except that the isotopes are continually replaced by U-232 decay. They might try to quickly separate the small amount of Pa-233 from the uranium and let it decay to pure U-233, but they would have to design and build a special chemical plant within the radioactive reactor. Bomb-makers might attempt quickly fabricate a weapon from newly separated U-233 before radiation hazards become lethal; even so there will be sufficient U-232 contamination that penetrating 2.6 MeV gamma rays will be readily detected. The challenge of developing and perfecting such new processes will be more difficult and expensive than creating a purpose-built weapons factory with known technology, such as centrifuge enrichment of U-235 conducted in Iran or PUREX for extracting plutonium from solid fuel irradiated in LWRs. Bruce Hoglund wrote a fuller report of the challenges to would-be bomb makers, and there is a discussion in the comments of the energy from thorium blog, both linked in the references section. A LFTR operating under IAEA safeguards might additionally be protected by injecting U-238 from a remotely controlled tank of U-238. The U-238 would dilute (denature) the U-233 to make it useless for weapons, but it would also stop the reactor and ruin the fuel salt for further use. For personnel safety, any U-233 material operations must be accomplished by remote handling equipment within a radioactively shielded hot cell. This can be designed to make it very hard for any insiders or outsiders to remove material from the hot cell. Another hurdle for the would-be pilferer uranium from 700° C molten salt is the retained radioactive fission products. Even with a l-hour cooling period to allow decay of the short-lived isotopes, the salt still releases ~350 W/liter of heat. That heat comes from deadly ionizing radiation that would kill a nearby pilferer in minutes unless shielded by meters of concrete or water or heavy lead. This fission product radiation is the same self protection that protects spent LWR fuel from theft. The single-fluid DMSR is highly proliferation resistant. The DMSR contains enough U-238 mixed with fissile U-233 and U-235 that the uranium can not sustain the rapid fission reaction necessary for a nuclear weapon. Uranium enriched to less than 20% U-235 is termed LEU, low-enriched uranium. The LEU fuel is not suitable for a nuclear weapon, which typically requires over 90% U-235. The DMSR with at least 80% U-238 is said to be denatured with it. The DMSR has less chemical processing equipment than the two- fluid LFTR, which uses fluorine chemistry to direct U-233 generated in the thorium blanket to the core. The DMSR has no chemical processing equipment in the reactor plant that might somehow be modified to divert U-233 for a weapons program. Because of the substantial amount of U-238 in the DMSR, it does breed plutonium from neutron capture, just as does a standard LWR. Some Pu-239 fissions. However the fissile Pu-239 isotope that might be desired for a weapon is only 31% of the plutonium, mixed with other isotopes (Pu-238, 240, 241, 242) that make the plutonium unsuitable for a weapon. Because the plutonium is dissolved in the fuel salt, there is no opportunity to remove it early to obtain weapons grade Pu-239 before neutrons convert it to other isotopes, as in a LWR, CANDU, RBMK, or military plutonium production reactor. Further, plutonium’s chemistry makes it difficult to remove from the salt. Also, the salt contains highly radioactive fission products as well as U-232, whose decay daughters emit a penetrating 2.6 MeV gamma ray. DMSR is the most proliferation-resistant nuclear reactor. There are easier paths than U-233 to make nuclear weapons. Pakistan has illustrated how a developing nation can make uranium weapons using centrifuge enrichment; in a dual path it simultaneously developed the methods to extract weapons grade plutonium from uranium reactors. India and North Korea developed plutonium weapons from heavy water or graphite moderated reactors with online fuel exchange capability. Iran has built centrifuge enrichment plants capable of making highly enriched U-235 for nuclear weapons. These proven weapons paths eliminate the incentive for nations to try to develop nuclear weapons via the technically challenging and expensive U-233 path. Only a determined, well-funded effort on the scale of a national program could overcome the obstacles to illicit use of uranium- 232/233 produced in a LFTR reactor. Such an effort would certainly find that it was less problematic to pursue the enrichment of natural uranium or the breeding of plutonium. LFTR reduces existing weapons proliferation risks. Deploying LFTRs on a global scale will not increase the risk of nuclear weapons proliferation, but rather decrease it. Starting up LFTRs with existing plutonium can consume inventories of this weapons-capable material. The thorium-uranium fuel cycle reduces demand for U-235 enrichment plants, which can make weapons material nearly as easily as power reactor fuel. Abundant energy cheaper than coal can increase prosperity and enable lifestyles that lead to sustainable populations, reducing the potential for wars over resources.

### 1ac china

#### Advantage Two: China

#### Current Chinese investments make thorium development inevitable, the plan prevents a monopoly through intellectual property control

**Martin, 12** [May 8th, Richard, A contributing editor for Wired since 2002, he has written about energy, for Time, Fortune, The Atlantic, and the Asian Wall Street Journal, editorial director for Pike Research, the leading cleantech research and analysis firm, former Technology Producer for ABCNews.com, Technology Editor for The Industry Standard (2000-2001), and Editor-at- Large for Information Week (2005-2008), recipient of the “Excellence in Feature Writing" Award from the Society for Professional Journalists and the White Award for Investigative Reporting, Educated at Yale and the University of Hong Kong, , “SuperFuel: Thorium, the Green Energy Source for the Future”, ISBN 978—0»230-116474]

GIVEN ALL THIS, I HAD TO ASK, why bother? Blessed with large¶ thorium reserves and an existing nuclear R&D capacity that,¶ operational snafus notwithstanding, is world class, India, rather than¶ taking a laborious three-stage route to thorium-based nuclear power,¶ could start building thorium reactors—most simply and inexpensively,¶ liquid fluoride thorium reactors—tomorrow. The reasons it’s not doing¶ so have to do with institutional inertia, national pride, and supposed¶ national security concerns~such as, for instance, building its nuclear¶ arms stockpile. China, meanwhile, is taking a more catholic approach¶ to its nuclear power program, including investigating LFTRs.¶ In a development heralded by thorium advocates around the world,¶ China officially announced in February 2011 at a Shanghai scientific¶ conference that it will begin a program to develop a thorium-fueled¶ molten salt reactor (MSR), aka an LFTR. The project was first reported¶ on the mainland in the Wen Hui Baa newspaper. I broke the news in¶ the West in a story for Wired.com. I first heard about it at a conference¶ in Oak Ridge with Sorensen and other thorium activists. The phrase¶ “Sputnik moment” was used freely. The world’s most dynamic¶ economyhad **thrown down the thorium gauntlet**. While India chose to¶ slog up the long hill of its three-stage program, China was going straight¶ for the prize.¶ India’s three-stage program calls for gradually phasing in thorium¶ fuel rods in advanced heavy-water reactors. The Chinese program, in¶ contrast, marks the largest national initiative to pursue thorium MSRs¶ to date. One of the world’s largest consumers of coal for electricity, the¶ People’s Republic has embarked on a public campaign to shift toward¶ less noxious energy sources, including nuclear power. The massive¶ Three Gorges dam project, one of the largest public works projects in¶ history, was designed to produce 18.2 gigawatts of electricity and has¶ also engendered fierce criticism and internal protest. Electricity¶ demand is growing at nearly 10 percent a year, and Chinese officials,¶ often willing to ignore international objections to its domestic policies,¶ are committed to using nuclear power as a source of clean, inexpensive¶ energy.¶ The nuclear ambitions of India and China are similarly outsized, but¶ the cultures and capabilities of the two countries are quite different. I¶ used to live in Hong Kong, and I’ve traveled extensively in both¶ northern India and southeastern China. The differences in the¶ countries, for me, can be summed up with a glance at their railways:¶ The Indian rail system, a source of national pride since the days of the¶ raj, is known neither for its modernity nor its efficiency. In September¶ 2011 the passengers on a cross-country journey were surprised to learn¶ that their train had somehow traveled more than 600 miles in the¶ wrong direction. This was treated as a newsworthy but not completely¶ unheard-of experience. The passengers, suitably outraged, stormed the¶ depot.¶ In China the government completed the Beijing-to-Tibet railway in¶ 2006, a dream since the days of Sun Yat-sen. Totaling 2,526 miles, it¶ includes tracks, from Golmud to Lhasa, at the highest altitude of any¶ railway in the world. The two-day journey, which passes through the¶ world’s highest-altitude railway tunnel and uses many sections of¶ elevated track passing over permafrost, costs about $160, or about¶ what it costs to go from Boston to Washington, D.C., on the relatively¶ low-tech Acela train. The new Chinese line has engendered plenty of¶ criticism regarding fears of cultural hegemony and the loss of Tibetan¶ autonomy, but no reports of wrong-way trains have surfaced. In the¶ realm of public infrastructure, India is a great producer of think-tank¶ studies, government reports, and beard-stroking orations. China,¶ unimpeded by the hurly-burly of parliamentary democracy, is a better¶ place for actually accomplishing things. If you are betting on which¶ country will build a thorium power reactor first, the choice is not¶ tough. (A July 2011 crash on a high-speed rail line near Wenzhou, on¶ the southern coast, killed 39 people and sparked a level of public outcry¶ seldom seen under communist rule on the mainland. In public¶ statements after the accident, Chinese premier Wen Jibao vowed to¶ toughen safety standards in China’s rapid industrialization—but the¶ crash did little to slow China’s drive to modernize its energy and¶ transportation infrastructure.)¶ China has 14 nuclear power reactors in operation on the mainland¶ today, with more than 25 under construction and more soon to get¶ under way. For many years a consumer of reactor technology and¶ components from the West, and from Russia, China will soon be¶ building fully homegrown reactors. The development of liquid fluoride¶ thorium reactors would make China the most advanced nuclear power¶ nation on Earth—and could well give it yet another source of high-tech¶ products to **pad its export surplus**.¶ Comparing nuclear reactors to humble kitchen appliances, Xu¶ Hongjie, a research scientist at the Shanghai Institute of Applied¶ Physics, said, “We need a better stove that can burn more fuel.”11 It¶ was a line reminiscent of Chairman Mao’s finest exhortations.¶ Like many nuclear nations, China declared a pause to review and¶ reassess its nuclear development plans after Fukushima. This was only a breather; Chinese officials made it clear that the Japanese accident¶ would not affect their long-range plans. And they scoffed at the German¶ decision to get out of nuclear power altogether. The comments of¶ Chinese officials did not inspire confidence. Dr. Liu Changxin, vice¶ general secretary of the China Nuclear Society, remarked that such¶ natural disasters “don’t happen in China”—a startling claim given the¶ devastation wrought by the 2008 earthquake in Sichuan Province,¶ which killed 69,000 people and left nearly five million homeless.¶ The Chinese thorium program is headed by Jiang Mianheng, an¶ electrical engineer and the son of the former Chinese president Jiang¶ Zemin (see chapter 1). Jiang Mianheng, who is also a vice president of¶ the Chinese Academy of Sciences, headed a Chinese delegation that¶ visited Oak Ridge in the fall of 2010. The Chinese politely listened to the¶ research presentations, and patiently endured the facilities tour, before¶ revealing that what they were really there for was to soak up as much¶ information on thorium MSRs as they could. “They were quite open¶ about it,” a person present at those discussions told me. In early 2012¶ Western observers of the Chinese nuclear effort stated that the¶ Shanghai Institute of Applied Physics, with around 400 people and a¶ budget of $400 million, planned to build two prototype molten salt¶ reactors by 2015.¶ Like India, China needs to shift to nuclear from coal to avoid adding¶ catastrophic levels of carbon to the atmosphere. At the same time¶ many in the U.S. thorium movement regard the development of¶ Chinese LFTRs as a direct threat to U.S. economic competitiveness. The¶ specter of Chinese competitiveness with the United States is often¶ overblown; in general, China’s prosperity and the well-being of its¶ people, are good things for the world, particularly for Americans. That¶ won’t make it feel any better when we are buying LFTRs with “Made in¶ Shanghai” stamped on the side.¶ The alarmist version of China’s next-generation nuclear strategy¶ comes down to this: if you like foreign oil dependency, you’re going to¶ love foreign nuclear dependency.¶ While various international efforts, including the Gen IV nuclear R&D¶ initiative, include a thorium MSR component, China has made clear its¶ intention to go it alone. The announcement from the Chinese Academy¶ of Sciences states explicitly that the People’s Republic plans to develop¶ and control intellectualproperty with regard to thorium for its own¶ benefit. “This will enable China to firmly grasp the lifeline of energy in¶ its own hands,” Wen Hui Baa reported.”¶ The plans for China’s lifeline include not only thorium but also¶ critical materials that have increased in value at a startling rate since¶ 2010 and of which China now has a monopoly: rare earth elements.¶

#### And, Chinese market dominance collapse US competitiveness

Wash Post 12 [Washington Post, 3-14, “America Is Letting China Steal Our Valuable Nuclear Innovations,” http://www.washingtonsblog.com/2012/03/america-is-letting-china-steal-our-valuable-nuclear-innovations.html]

The U.S. Is Letting China Steal Its Nuclear Innovations … Just Like Xerox Let Apple and Microsoft Steal Its Valuable Breakthroughs Microsoft and Apple grew rich by using Xerox’s innovation. Xerox’s research arm (called Xerox Parc) invented the “graphical user interface” used by all modern computers. Bill Gates famously admitted to Steve Jobs that both Microsoft and Apple had ripped of Xerox’s GUI. Xerox could have made a fortune on its innovation. But it didn’t realize what it had … and failed to capitalize on its breakthroughs (Xerox tried to sue to protect its invention … but years too late, and the lawsuit was thrown out because Xerox had missed the deadline for suing). The same dynamic is playing out in the nuclear industry. Specifically, the U.S. created a safer, more efficient form of nuclear energy running on thorium. But – like Xerox Parc – America isn’t doing anything with its innovation, and China is running off with prize. The Telegraph’s Ambrose Evans-Pritchard notes: If China’s dash for thorium power succeeds, it will vastly alter the global energy landscape …. China’s Academy of Sciences said it had chosen a “thorium-based molten salt reactor system”. The liquid fuel idea was pioneered by US physicists at Oak Ridge National Lab in the 1960s, but the US has long since dropped the ball. Further evidence of Barack `Obama’s “Sputnik moment”, you could say. Chinese scientists claim that hazardous waste will be a thousand times less than with uranium. The system is inherently less prone to disaster. “The reactor has an amazing safety feature,” said Kirk Sorensen, a former NASA engineer at Teledyne Brown and a thorium expert. “If it begins to overheat, a little plug melts and the salts drain into a pan. There is no need for computers, or the sort of electrical pumps that were crippled by the tsunami. The reactor saves itself,” he said. “They operate at atmospheric pressure so you don’t have the sort of hydrogen explosions we’ve seen in Japan. One of these reactors would have come through the tsunami just fine. There would have been no radiation release.” The Telegraph continues: Professor Robert Cywinksi from Huddersfield University said thorium must be bombarded with neutrons to drive the fission process. “There is no chain reaction. Fission dies the moment you switch off the photon beam. There are not enough neutrons for it continue of its own accord,” he said. Dr Cywinski, who anchors a UK-wide thorium team, said the residual heat left behind in a crisis would be “orders of magnitude less” than in a uranium reactor. The earth’s crust holds 80 years of uranium at expected usage rates, he said. Thorium is as common as lead. America has buried tons as a by-product of rare earth metals mining. Norway has so much that Oslo is planning a post-oil era where thorium might drive the country’s next great phase of wealth. Even Britain has seams in Wales and in the granite cliffs of Cornwall. Almost all the mineral is usable as fuel, compared to 0.7pc of uranium. There is enough to power civilization for thousands of years. \*\*\* US physicists in the late 1940s explored thorium fuel for power. It has a higher neutron yield than uranium, a better fission rating, longer fuel cycles, and does not require the extra cost of isotope separation. The plans were shelved because thorium does not produce plutonium for bombs. As a happy bonus, it can burn up plutonium and toxic waste from old reactors, reducing radio-toxicity and acting as an eco-cleaner. Dr Cywinski is developing an accelerator driven sub-critical reactor for thorium, a cutting-edge project worldwide …. The idea is to make pint-size 600MW reactors. Popular Science reports: It would be based on thorium, a radioactive element that is much more abundant, and much more safe, than traditional sources of nuclear power. Some advocates believe small nuclear reactors powered by thorium could wean the world off coal and natural gas, and do it more safely than traditional nuclear. Thorium is not only abundant, but more efficient than uranium or coal — one ton of the silver metal can produce as much energy as 200 tons of uranium, or 3.5 million tons of coal, as the Mail on Sunday calculates it. \*\*\* Thorium reactors would not melt down, in part because they require an external input to produce fission. Thorium atoms would release energy when bombarded by high-energy neutrons, such as the type supplied in a particle accelerator. Wired points out: “President Obama talked about a Sputnik-type call to action in his [State of the Union] address,” wrote Charles Hart, a a retired semiconductor researcher and frequent commenter on the Energy From Thorium discussion forum. “I think this qualifies.” While nearly all current nuclear reactors run on uranium, the radioactive element thorium is recognized as a safer, cleaner and more abundant alternative fuel. Thorium is particularly well-suited for use in molten-salt reactors, or MSRs. Nuclear reactions take place inside a fluid core rather than solid fuel rods, and there’s no risk of meltdown. In addition to their safety, MSRs can consume various nuclear-fuel types, including existing stocks of nuclear waste. Their byproducts are unsuitable for making weapons of any type. They can also operate as breeders, producing more fuel than they consume. In the 1960s and 70s, the United States carried out extensive research on thorium and MSRs at Oak Ridge National Laboratory. That work was abandoned — partly, believe many, because uranium reactors generated bomb-grade plutonium as a byproduct. Today, with nuclear weapons less in demand and cheap oil’s twilight approaching, several countries — including India, France and Norway — are pursuing thorium-based nuclear-fuel cycles. (The grassroots movement to promote an American thorium power supply was covered in this December 2009 Wired magazine feature.) China’s new program is the largest national thorium-MSR initiative to date. The People’s Republic had already announced plans to build dozens of new nuclear reactors over the next 20 years, increasing its nuclear power supply 20-fold and weaning itself off coal, of which it’s now one of the world’s largest consumers. Designing a thorium-based molten-salt reactor could place China at the forefront of the race to build environmentally safe, cost-effective and politically palatable reactors. \*\*\* A Chinese thorium-based nuclear power supply is seen by many nuclear advocates and analysts as a threat to U.S. economic competitiveness. During a presentation at Oak Ridge on Jan. 31, Jim Kennedy, CEO of St. Louis–based Wings Enterprises (which is trying to win approval to start a mine for rare earths and thorium at Pea Ridge, Missouri) portrayed the Chinese thorium development as potentially crippling. “If we miss the boat on this, how can we possibly compete in the world economy?” Kennedy asked. “What else do we have left to export?” According to thorium advocates, the United States could find itself 20 years from now importing technology originally developed nearly four decades ago at one of America’s premier national R&D facilities. The alarmist version of China’s next-gen nuclear strategy come down to this: If you like foreign-oil dependency, you’re going to love foreign-nuclear dependency. \*\*\* While the international “Generation IV” nuclear R&D initiative includes a working group on thorium MSRs, **China has made clear its intention to go it alone. The Chinese Academy of Sciences announcement explicitly states that the PRC plans to develop and control intellectual property around thorium for its own benefit**. “This will enable China to firmly grasp the lifeline of energy in its own hands,” stated the Wen Hui Bao report. The U.S. is acting just like Xerox Parc, letting others steal its innovations … and losing entire markets in the process. If America fails to capitalize on its breakthrough, and let’s China obtain all of the relevant thorium energy patents, we could lose the entire market. Too bad the U.S. government – instead of developing the thorium concept which it innovated decades ago – is protecting an obsolete uranium model which was chosen only because produced plutonium for nuclear warheads and powered nuclear submarines. Indeed, our government is doubling-down on archaic and unsafe technology: the Nuclear Regulatory Commission has approved construction of new nuclear plants which do not incorporate the safety measures needed to prevent a Fukushima meltdown here … and the same companies which built and operated Fukushima will build and run the U.S. plants as well.

#### The impact is heg

Martino 7 – founder and chairman of the board of Cyber Technology Group, author of numerous books on finance (Rocco, A Strategy for Success: Innovation Will Renew American Leadership, <http://www.fpri.org/orbis/5102/martino.innovationamericanleadership.pdf>,)

The United States of course faced great challenges to its security and economy in the past, most obviously from Germany and Japan in the first half of the twentieth century and from the Soviet Union in the second half. Crucial to America’s ability to prevail over these past challenges was our technological and industrial leadership, and especially our ability to continuously recreate it. Indeed, the United States has been unique among great powers in its ability to keep on creating and recreating new technologies and new industries, generation after generation. Perpetual innovation and technological leadership might even be said to be the American way of maintaining primacy in world affairs. They are almost certainly what America will have to pursue in order to prevail over the contemporary challenges involving economic competitiveness and energy dependence. 

#### Technical competitiveness is key to primacy—the impact is great power war

Baru 9 - Visiting Professor at the Lee Kuan Yew School of Public Policy in Singapore (Sanjaya, “Year of the power shift?,”

http://www.india-seminar.com/2009/593/593\_sanjaya\_baru.htm

In the modern era, the idea that strong economic performance is the foundation of power was argued most persuasively by historian Paul Kennedy. ‘Victory (in war),’ Kennedy claimed, ‘has repeatedly gone to the side with more flourishing productive base.’6 Drawing attention to the interrelationships between economic wealth, technological innovation, and the ability of states to efficiently mobilize economic and technological resources for power projection and national defence, Kennedy argued that nations that were able to better combine military and economic strength scored over others.

‘The fact remains,’ Kennedy argued, ‘that all of the major shifts in the world’s *military-power* balance have followed alterations in the *productive* balances; and further, that the rising and falling of the various empires and states in the international system has been confirmed by the outcomes of the major Great Power wars, where victory has always gone to the side with the greatest material resources.’7

**I**n Kennedy’s view the geopolitical consequences of an economic crisis or even decline would be transmitted through a nation’s inability to find adequate financial resources to simultaneously sustain economic growth and military power – the classic ‘guns vs butter’ dilemma.

#### Hegemonic decline in the context of competitiveness causes global war

**Zhang and Shi, 2011** – \*Yuhan Zhang is a researcher at the Carnegie Endowment for International Peace, Washington, D.C.; Lin Shi is from Columbia University. She also serves as an independent consultant for the Eurasia Group and a consultant for the World Bank in Washington, D.C. (America’s decline: A harbinger of conflict and rivalry, http://www.eastasiaforum.org/2011/01/22/americas-decline-a-harbinger-of-conflict-and-rivalry/)

This does not necessarily mean that the US is in systemic decline, but it encompasses a trend that appears to be negative and perhaps alarming. Although the US still possesses incomparable military prowess and its economy remains the world’s largest, the once seemingly indomitable chasm that separated America from anyone else is narrowing. Thus, the global distribution of power is shifting, and the inevitable result will be a world that is less peaceful, liberal and prosperous, burdened by a dearth of effective conflict regulation. Over the past two decades, no other state has had the ability to seriously challenge the US military. Under these circumstances, motivated by both opportunity and fear, many actors have bandwagoned with US hegemony and accepted a subordinate role. Canada, most of Western Europe, India, Japan, South Korea, Australia, Singapore and the Philippines have all joined the US, creating a status quo that has tended to mute great power conflicts. However, as the hegemony that drew these powers together withers, so will the pulling power behind the US alliance. The result will be an international order where power is more diffuse, American interests and influence can be more readily challenged, and conflicts or wars may be harder to avoid. As history attests, power decline and redistribution result in military confrontation. For example, in the late 19th century America’s emergence as a regional power saw it launch its first overseas war of conquest towards Spain. By the turn of the 20th century, accompanying the increase in US power and waning of British power, the American Navy had begun to challenge the notion that Britain ‘rules the waves.’ Such a notion would eventually see the US attain the status of sole guardians of the Western Hemisphere’s security to become the order-creating Leviathan shaping the international system with democracy and rule of law. Defining this US-centred system are three key characteristics: enforcement of property rights, constraints on the actions of powerful individuals and groups and some degree of equal opportunities for broad segments of society. As a result of such political stability, free markets, liberal trade and flexible financial mechanisms have appeared. And, with this, many countries have sought opportunities to enter this system, proliferating stable and cooperative relations. However, what will happen to these advances as America’s influence declines? Given that America’s authority, although sullied at times, has benefited people across much of Latin America, Central and Eastern Europe, the Balkans, as well as parts of Africa and, quite extensively, Asia, the answer to this question could affect global society in a profoundly detrimental way. Public imagination and academia have anticipated that a post-hegemonic world would return to the problems of the 1930s: regional blocs, trade conflicts and strategic rivalry. Furthermore, multilateral institutions such as the IMF, the World Bank or the WTO might give way to regional organisations. For example, Europe and East Asia would each step forward to fill the vacuum left by Washington’s withering leadership to pursue their own visions of regional political and economic orders. Free markets would become more politicised — and, well, less free — and major powers would compete for supremacy. Additionally, such power plays have historically possessed a zero-sum element. In the late 1960s and 1970s, US economic power declined relative to the rise of the Japanese and Western European economies, with the US dollar also becoming less attractive. And, as American power eroded, so did international regimes (such as the Bretton Woods System in 1973). A world without American hegemony is one where great power wars re-emerge, the liberal international system is supplanted by an authoritarian one, and trade protectionism devolves into restrictive, anti-globalisation barriers. This, at least, is one possibility we can forecast in a future that will inevitably be devoid of unrivalled US primacy.

### 1ac solvency

#### Small modular thorium reactors are key – the tech is ready

**Martin, 12** [May 8th, Richard, A contributing editor for Wired since 2002, he has written about energy, for Time, Fortune, The Atlantic, and the Asian Wall Street Journal, editorial director for Pike Research, the leading cleantech research and analysis firm, former Technology Producer for ABCNews.com, Technology Editor for The Industry Standard (2000-2001), and Editor-at- Large for Information Week (2005-2008), recipient of the “Excellence in Feature Writing" Award from the Society for Professional Journalists and the White Award for Investigative Reporting, Educated at Yale and the University of Hong Kong, , “SuperFuel: Thorium, the Green Energy Source for the Future”, ISBN 978—0»230-116474]

SO, IF YOU WERE GOING TO DESIGN and build a new nuclear reactor from scratch, what would it look like? First of all, you’d make it small. The old antinuke saw says, “Nuclear reactors come in only one size: extra large.” But compact modular reactors that can be prefabricated, transported by shipping container, and assembled on site are now seen by many experts as the future of nuclear energy. “If you go small, and manufacture reactors like Henry Ford did cars, there’s a host of advantages,” Tom Sanders told me shortly before he took over as president of the American Nuclear Society in 2009. (He is now its president emeritus.) “You could use automated manufacturing processes instead of doing every weld individually, you could get the plants licensed in a two-year time frame instead of seven, and it’d be much cheaper on a per-kilowatt basis.” Virtually all the major nuclear vendors, including GE-Hitachi Nuclear Energy, Bechtel (a company not exactly renowned for miniaturization), Babcock & Wilcox, and Westinghouse (now owned by the Korean tech giant Toshiba) are developing small modular reactors (SMRs). These reactors can use uranium or thorium (or even plutonium), but thorium, with its higher efficiency, offers unique qualities that make it well suited for miniaturization. They produce less than 300 megawatts, the limit for an officially small reactor. Future versions that could fit on the back of a flatbed truck are envisioned at 60 or even 30 megawatts. Like mobile homes, SMRs can be manufactured centrally and assembled on site, facilitating financing and shortening the time to production; in theory, multiple SMRs could be combined to create a large generating station. Keeping the plants small and dispersed, though, makes them less tempting targets for would-be terrorists—as does fueling them with thorium. More important, they could produce energy at a lower price per kilowatt than conventional nuclear plants, bringing the cost of nuclear power more into line with low-cost coal production. Newly infatuated with what’s known as distributed power generation (lots of smaller reactors scattered in lots of places), the nuclear industry has finally realized that bigger is not always better. More compact and more affordable are good things; even better is the prospect that thorium-powered SMRs could help solve the problem of nuclear waste storage and disposal. Some ambitious nuclear designers have even started to dream up small, modular fast breeder reactors, which is a bit like trying to control a tiger by putting it in a smaller cage. Bringing these designs into commercial production could take a decade or more. The three main barriers to widespread deployment, as Philip Moor puts it, are the same that face any new nuclear plant: “Dirt, licensing, and money,” he told me. Moor heads up a special committee of the American Nuclear Society formed to examine the business and manufacturing issues around SMRs. The Savannah River Site, a nuclear industrial complex operated by the DOE near Augusta, Georgia, will supply the dirt (the real estate and infrastructure), and industry heavyweights like GE, Westinghouse, and Bechtel are lining up to provide the money, at least for demonstration projects. That leaves licensing. “Once we start the demonstration projects, we can start pursuing the license application,” said Sanders of the American Nuclear Society. But “we need something operating on the ground.” That’s hardly a slam dunk. It’s worth noting that building minireactors is not a new concept. GE actually started the Power Reactor Innovation Small Modular (PRISM) program back in 1981, and in 1994 the NRC issued a report that said the commissioners foresaw no impediments to licensing. The project was abandoned in 2001 and then got a second life in 2006. With huge new supplies of natural gas starting to reach the market, and coal plants still the least expensive form of power generation, new nuclear plants will continue to look expensive. And investors looking back at 30 years of nuclear dead ends are sure to be wary of new technological marvels, however promising. The history of nuclear power demonstrates that nothing is truly viable until the core starts chain-reacting. Still, thorium-powered SMRs offer the best way forward for new nuclear power and a potential solution for global warming. Smaller is beautiful, and in this case it could be more profitable as well. ---- SECOND, YOU’D MAKE YOUR NEW REACTOR a breeder, preferably a thermal breeder. The failure of fast breeders to fulfill their promise has not erased their appeal; it has just caused the quest for a fast breeder to go in (slightly) new directions. Breeders would be advantageous not only because, theoretically, you’d never run out of fuel, but also because you can use them to process nuclear waste from conventional reactors. At least in the United States, the question of how to store nuclear waste has no clear answer, and there may not be one for the next decade. Building self-sustaining breeder reactors would, as the nuclearati like to say, “close the fuel cycle”; little radioactive material would be left over to dispose of. Then you’d want to make your reactor inherently safe. Inherent safety — not to be confused with passive safety, a very different thing — is a term much beloved by nuclear engineers‘; It has been applied to just about every reactor design, including the uranium-fueled lightwater reactor and the sodium-cooled fast breeder, machines whose inherent safety is, to say the least, questionable. Traditionally, the solution to this problem has been external safeguards, also called overengineering: add more controls, more redundancy, more miles of piping, more plumbing and alarms and sensors and gauges, and the inherent twitchiness of the world’s most volatile energy source could be contained and controlled. Unfortunately, all that engineering brings more complexity, and complexity in itself adds risk. Virtually all the reactor accidents that have ever occurred have had one of two causes: either a fiendishly complex mechanism failed because of a simple mishap (like a loose chunk of zirconium) or a human being failed at the task of monitoring and managing a fiendishly complex mechanism. The only truly inherently safe reactor is a liquid-core reactor, like the molten salt reactor that was created at Oak Ridge in the 1960s. For the purposes of a reactor designer, liquid—whether it’s water, liquid metal, or some type of liquid fluoride — has a marvelous characteristic: it expands rapidly when it gets hot. All materials expand when heated, of course. In a liquid-core reactor, as the energy of the liquid rises, it expands and naturally, passively, slows down the reaction, making a runaway accident nearly impossible. In technical terms, this is known as a “negative temperature coefficient of reactivity.” That means that as the temperature rises (which typically is what happens when something goes wrong in a nuclear reactor), the reactivity goes down. When the reactivity goes down, the reactor is essentially turning itself off. Liquid fuels have several other characteristics that make them safer than conventional solid fuel reactors. This is where the benefits of thorium, which for a variety of reasons is uniquely well suited to liquid fuel reactors, extend beyond the nature of the element itself. No matter how you use it—in a light-water reactor, in a pebble bed reactor— thorium offers advantages over uranium. But in a liquid fuel reactor, that advantage is magnified. If you put high-octane gas in a 1975 Ford Pinto, you’ll see some marginal performance enhancement. To get the full benefit, though, you should put it in a Ferrari Testarossa. Using thorium in a liquid fuel reactor is similar: its unique qualities as an energy source are fully exploited. For example, in liquids—particularly in molten salts—fission products tend to be stable, making it easier to isolate and remove them. One of these fission products, xenon-135, is a nuclear poison that tends to build up in conventional reactors, slowing down the reactions. It renders the fuel unusable after only a small percentage of the potential energy has been used, and it’s hideously difficult to handle as part of the nuclear waste stream. In fluid fuels, because xenon forms a noble gas (one that is impervious to chemical reactions), xenon is easy to remove. In a LFTR it can be boiled off as a gas and processed while the reactor continues operating, reducing downtime and increasing the amount of the potential energy that can be extracted from the thorium fuel. A ton of thorium can produce energy equivalent to that produced by 200 tons of uranium in a conventional light-water reactor. Liquid fuels are also impervious to radiation damage, solving one of the thorniest problems in solid fuel reactors. Continuous bombardment by neutrons over periods of weeks or months wears down not only the solid uranium pellets in a light-water reactor but also the cladding (usually made of zirconium) that contains them. Because of radiation damage and the buildup of fission poisons like xenon, fuel rods age quickly; they have to be replaced every few years, even though only 3 to 5 percent of their energy has been consumed. Liquid fuels have one other characteristic that makes them ideal for reactor cores: they flow. Gravity, not elaborate control systems or socalled passive safety systems, gives LFTRs their ultimate protection against a serious nuclear accident. In a criticality accident (i.e., if the fission reaction in the core starts to get out of control), a specially designed freeze plug in the reactor vessel melts and the liquid core simply drains out of the reactor into an underground shielded container, like a bathtub when the drain plug is pulled. The fission reactions quickly cease, and (thanks to the expansive quality noted earlier) the fluid cools rapidly. Decay heat is contained harmlessly. Meltdown is impossible, and there are no solid fuel rods too radioactive to remove. Inherently safe, LFTRs pose less threat than light-water reactors, coal-fired power plants, oil refineries, or just about any other form of large energy or chemical plant. Built small and modular, they will be less expensive to build and operate than just about any other energy source. ---- FINALLY YOU’D FUEL YOUR SMALL, breeding, inherently safe, liquidcore reactor with thorium. I mentioned in chapters 1 and 2 many of thorium’s sterling qualities as a nuclear fuel; they bear reviewing. It is abundant. In fact, used properly, it’s effectively inexhaustible. It requires no special refining or processing beyond purifying it from the monazite ore in which it is most commonly found. It can be mined safely, with none of the tailings and other results of uranium mining that, in the early years of the Atomic Age, poisoned whole communities in Russia and the United States. It’s no good for making weapons. In fact, it’s not fissile at all. It requires a kind of nuclear alchemy to be transmuted into uranium-233, which is a more efficient and safe source of energy than U-235. Finally reactors based on thorium—or, rather, U-233, into which thorium transforms in a nuclear reactor—consume far more of the latent energy trapped inside the fuel, vastly reducing or even eliminating the problem of nuclear waste. In short, you’d build a liquid fluoride thorium reactor, or LFTR. LFTRs are the first truly revolutionary reactor design to come along since the development in the 1960s of the molten salt reactor, progenitor of the LFTR. LFTRs are designed with an outer blanket of liquid fluoride that contains dissolved thorium-232—thorium tetrafluoride, to be precise (a fluoride is simply a combination of fluorine and another element; tetrafluoride means four atoms of fluorine). The thorium is borne in a solution of lithium and beryllium fluorides that has maximum heat-transfer properties, making it a supremely efficient coolant. This radioactive cocktail surrounds a core of uranium-233 that is produced from the natural decay of Th-232 bombarded by neutrons. The neutron source, to start the reaction, is typically a small amount of fissile uranium, although the neutrons can also come from a particle accelerator, of the sort used in physics experiments to smash particles together. The blanket and inner core are in two concentric containers. It’s essentially a double boiler: the inner core, sheathed in an exotic alloy of a metal such as zirconium, contains the fissile U-233, and the outer shell, or blanket, contains the fertile thorium. In this simplified diagram of a liquid fluoride thorium reactor, thorium is converted to uranium-233, which sustains the fission reaction, heating a secondary liquid that powers a turbine to create electricity. (Brad Nielsen) Once the reactor core goes critical, the fission reactions in the core continuously throw off neutrons that keep the thorium, in the blanket, in a constant state of transformation, creating a virtuous cycle. Such a plant has two separate loops of piping: one carries the fertile thorium tetrafluoride salt, once it has been sufficiently bombarded to start the decay chain, into a decay tank from which U-233 can be transferred to the inner core; the other sends the hot U-233 salt from the core to a heat exchanger to drive a steam turbine.7 There are several variations on this basic design, which use various fluids to transfer heat from the reactor core to the turbine; suffice it to say that whichever is chosen, it will be significantly more efficient than a conventional nuclear plant. After passing through the heat exchanger, the second loop, carrying hot U-233 fuel salt, cycles back into the core, with a small secondary side stream passing through a reprocessor, where the fission products are removed, preventing them from poisoning the reaction, before being cycled back into the core for further fission reactions. Because the core is liquid, it operates at atmospheric pressure, meaning that the extremely thick-walled, pressurized vessels used in conventional reactors, which have an unfortunate tendency to blow their top, are unnecessary. Because LFTRs consume virtually all their nuclear fuel, the majority of the waste products are not long-lived fissile material but rather fission products, about 83 percent of which are safe within a decade. While LFTRs, like every other nuclear reactor, generate fission products that are highly radioactive, their half-lives tend to be measured in dozens of years, not thousands. The long-lived radioactivity of LFTR waste is one ten-thousandth that of a conventional reactor. The leftovers, a small fraction of the waste produced by conventional reactors, must be stored in radiation-proof geological sites for about three centuries, compared with ten thousand years for nuclear waste from conventional uranium reactors. In fact, LFTRs themselves make great garbage dumps for spent nuclear fuel: they can refine standard nuclear waste into LFTR by-products, essentially solving the currently intractable toxic waste storage problems that plague today’s nuclear power industry. Thorium Energy Alliance This schematic shows a full thorium power plant including a reactor vessel, drain tanks, and a Brayton-cycle turbine using supercritical carbon dioxide. (Thorium Energy Alliance) With their high negative temperature coefficient, LFTRs are impervious to sudden overheating. They’re also exquisitely tunable; the concentration of fuel in the outer blanket can be adjusted continually, making it easy to control the reactivity in the core. Finally, they can run practically forever. The reactions in a LFTR produce enough excess neutrons to breed their own fuel. LFTRs are the only type of reactor that can breed more fuel than they consume in the thermal, or lower-energy, spectrum. They have the virtues of fast breeders without the volatility. Here it is useful to think back to the nature of fission and neutron absorption. In today’s conventional reactors, the great majority of the fuel is U-238, which transmutes to the transuranic element plutonium- 239 when the U-238 absorbs a single neutron. Thorium-232, by contrast, requires five neutrons to become a transuranic (neptunium-237, which can be safely burned down, or processed, in the reactor). That too makes LFTRS inherently safer than solid-fuel uranium reactors. While liquid-core reactors can be built to operate without moderators, in some LFTR designs the core does use moderators — typically graphite rods, just as in a conventional uranium reactor. Just as the LFTR has unique qualities that make it superior to light-water reactors, though, U-233 has some distinct advantages over uranium- 235, the fissile material that runs the vast majority of the world’s nuclear power stations today. U-233 displays a quality that nuclear engineers love: high neutron economy, usually expressed as q in physics equations. That means that an atom of U-233, after absorbing a stray neutron and fissioning, produces on average 2.16 neutrons. Since one neutron is required to continue the chain reaction, 1.16 neutrons are freed up to produce new fuel. Overall, LFTRs are 200 to 300 times more fuel efficient than standard reactors. They are safer, simpler, smaller, less expensive to build, and less expensive to run to produce electricity on a cost-per-kilowatt basis.

#### And, new tech developments make thorium LFTR’s expandable

Hargraves, 12 [July, Robert, Robert Hargraves has written articles and made presentations about the liquid fluoride thorium reactor and energy cheaper than from coal – the only realistic way to dissuade nations from burning fossil fuels. His presentation “Aim High” about the technology and social benefits of the liquid fluoride thorium reactor has been presented to audiences at Dartmouth ILEAD, Thayer School of Engineering, Brown University, Columbia Earth Institute, Williams College, Royal Institution, the Thorium Energy Alliance, the International Thorium Energy Association, Google, the American Nuclear Society, and the Presidents Blue Ribbon Commission of America’s Nuclear Future. With coauthor Ralph Moir he has written articles for the American Physical Society Forum on Physics and Society: Liquid Fuel Nuclear Reactors (Jan 2011) and American Scientist: Liquid Fluoride Thorium Reactors (July 2010). Robert Hargraves is a study leader for energy policy at Dartmouth ILEAD. He was chief information officer at Boston Scientific Corporation and previously a senior consultant with Arthur D. Little. He founded a computer software firm, DTSS Incorporated while at Dartmouth College where he was assistant professor of mathematics and associate director of the computation center. He graduated from Brown University (PhD Physics 1967) and Dartmouth College (AB Mathematics and Physics 1961). THORIUM: energy cheaper than coal, ISBN: 1478161299, purchased online at Amazon.com]

Small modular LFTRs can be mass produced. Commercialization of technology leads to lower costs as the number of units increase. Experience benefits arise from work specialization, new processes, product standardization, new technologies, and product redesign. Business economists observe that doubling the number of units produced reduces cost by a percentage termed the learning ratio, seen in the early aircraft industry to be 20%. Today Moore’s law in the computer industry illustrates a learning ratio of 50%. In The Economic Future of Nuclear Power University of Chicago economists more conservatively estimate the learning ratio is 10% for nuclear power reactors. Units produced The learning curve In this illustration, the cost of the 1024th LFTR would be about 35% the cost of the first commercial LFTR. Some engineers advocate economy-of-scale to justify large reactors, but this analysis shows that 100 MW units would have a 30% costadvantage over 1000 MW units because of the ten times more production experiences. Boeing 737 production line Boeing made 477 airplanes in 2011 costing up to $330 million each. Boeing, capable of manufacturing $200 million units daily, is a model for LFTR production. Airplane manufacturing has many of the same critical issues as manufacturing nuclear reactors: life safety, reliability, strength¶ of materials, corrosion, regulatory compliance, documentation, design control, supply chain management, and cost, for example. Reactors of 100 MW size costing $200 million can similarly be factory produced. Manufacturing more, smaller reactors traverses the learning curve more rapidly. Producing one per day for 3 years creates 1,095 production experiences, reducing costs by 65%. Documentation control integrated with manufacturing saves costs and increases accuracy. New manufacturing techniques are enabled with CAM (computer aided manufacturing), automatically converting designs to manufacturing instructions for machine tools and industrial robots. CAM can vary manufacturing parts and processes to produce a variety of units on one production line. In the Boeing photograph above, observe that the wing tips are not identical on all units. Ongoing research will lead to lower LFTR costs. Cost reductions are presaged by current engineering research. Compact, thin-plate heat exchangers may reduce fluid inventories, size, and cost. Possible new materials include silicon-impregnated carbon fiber with chemical vapor infiltrated carbon surfaces, and higher temperature nickel alloys. Operating at 950°C can increase thermal/electrical conversion efficiency beyond 50%. Such high temperatures can improve efficiency for water dissociation to create hydrogen, to lower manufacturing costs of synthetic fuels such as methanol or dimethyl ether that can substitute for gasoline or diesel oil. Initial fissile material quantities and costs are low. A 100 MW LFTR requires only about 100 kg of fissile material, such as U-233 or U-235, to start up. Thereafter it is fueled by thorium, or thorium and enriched uranium in DMSR. A LWR or LMFBR requires 5 times this, adding to capital costs. Thorium fuel is plentiful and inexpensive. One ton of thorium can power a 1,000 megawatt LFTR for a year - enough power for a city. Just 500 tons would supply all US electric energy for a year. Fuel costs at $300,000 per ton for thorium would be $0.00004/kWh, compared to coal at $0.03/kWh. Uranium enrichment costs are low. The expanding worldwide fleet of LWRs increases demand for uranium and also for the enrichment services to convert it from 0.7% to 4% U-235. Some LFTRs may require enriched uranium only for startup. Designs such as DMSRs will require a continued supply of enriched uranium, but less than 25% of the amount used by LWRs. Fuel fabrication costs are low. Unlike LWRs, there are no costs for producing high quality zirconium tube fuel rods to contain UO2 pellets and their fission products for centuries. Unlike pebble bed reactors using TRISO particle fuel, there is no cost for triple-coating millions of UO2 particles designed to retain fission products within the three redundant layers. The LFTR fuel supply form might be solid UF4 crystals or gaseous UF6, which are already intermediate, steps in the production of solid UO2 used in LWRs. New control system technologies can reduce labor costs. The number of people required to operate today’s LWRs is higher than for other forms of power production. Nuclear power plants operate 24x7, and each job employs 6 people: 4 for the 4 work shifts per week, 1 for vacation and sick leave, and 1 for training time, so labor costs mount up. In my visits I observed there are more than 1000 employees per GW of power output, adding about 1 cent/kWh to electricity costs. Information systems and control systems technologies have improved immensely since LWRs were designed in the 1970s. Safety critical software techniques enable low-labor-cost operation of aircraft, helicopters, and rapid transit. Reducing direct operator control of reactors can also avoid mistakes, such as the series of operator errors that led to the Chernobyl disaster. Security guard costs should be proportional to the possible damage threat, much lower with a non-pressurized LFTR. Even US ICBMs in missile silos were guarded with remote electronic surveillance. Transmission line costs are less with distributed LFTRs. Much of the costs associated with multi-GW power plants are for transmission lines to transport power hundreds of miles on low- loss high-voltage direct-current (HVDC) lines. Fewer transmission lines are required when 100 MW power sources such as LFTRs are near cities and manufacturing centers. Costs for HVDC lines are roughly $1 million per mile, so the costs for energy transmission over 1,000 miles is roughly 1 cent/kWh. The program objective must be energy cheaper than coal. For all the above reasons, low costs of $2/W and 3 cents/kWh is an achievable objective. A $2/watt capital cost contributes $0.02/kWh to the power cost, assuming a 40 year life, 8% interest rate, and 90% capacity factor. With plentiful, inexpensive thorium fuel, LFTR can generate electricity at <$0.03/kWh, underselling power generated by burning coal. Producing one LFTR of 100 MW size per day could phase out all coal-burning power plants worldwide in 38 years, ending 10 billion tons of CO2 emissions from world coal plants now supplying 1,400 GW of electric power. Low LFTR costs are crucial to this coal replacement strategy, achievable if cost objectives are maintained at every design choice. Less expensive electric power will check global warming by dissuading all nations from burning coal. It will also help developing economies to improve their prosperity, encouraging lifestyles with sustainable birthrates. Keeping LFTR energy costs cheaper than coal is critical to achieving the social and environmental benefits. Cost challenges can be met at the R&D stage. There are cost challenges for LFTR development. Meeting the production cost objectives of $2/W and 3 cents/kWh requires a well-executed research and development program. Corporations with deep pockets may develop advanced nuclear power, as evidenced by Bill Gates’ investment in Terrapower’s LMFBR reactor, building on prior US $16 billion R&D expenditures. There is an opportunity for substantial government or philanthropic investment in LFTR R&D to keep ultimate production costs low by removing amortization of imprecise R&D costs. Public investment in energy R&D is a much more effective public policy than ongoing alternative energy production subsidies being paid today. ¶

#### Allocation levels are key

The Economist, 09 [Nuclear's next generation inside story: A group of six new blueprints for nuclear power stations promise advances in safety and efficiency. How do they differ from existing designs?, <http://www.economist.com/node/15048703>]

Dr Ferguson thinks the prospects of the entire generation-IV programme are contingent on the level of investment allocated to nearer-term projects. “Do we commit to generation III or do we leapfrog to generation IV?” he asks. Two important considerations for answering his question are regulatory compliance and economic viability. With regard to the former, the NEA's Multinational Design Evaluation Programme is considering an international licensing scheme to standardise safety requirements for the new reactors. As for the latter, the success of generation IV reactors is likely to hinge on large amounts of government support. In the near term this support should take the form of increased research-and-development funding, says Dr Stacey of Georgia Tech. In the longer term, governments have an important role to play in the provision of loan guarantees, which are vital for overcoming engineering and “first of a kind” risks, says Joe Turnage at Unistar, a commercial nuclear joint-venture between Constellation Energy, an American utility, and EDF, a French one. But whatever the next generation of nuclear power-stations looks like, it is clear that the research being done around the world to develop such a variety of new reactors, rather than new nuclear weapons, has fulfilled Eisenhower's wish, back in 1953, that “the miraculous inventiveness of man shall not be dedicated to his death, but consecrated to his life.”

#### Loan guarantees now, but they are insufficient

Squassoni 12 Sharon, Director and Senior Fellow of the Proliferation Prevention Program at CSIS, “NUCLEAR POWER IN THE GLOBAL ENERGY PORTFOLIO”, Federation of American Scientists, February, www.fas.org/pubs/\_docs/Nuclear\_Energy\_Report-lowres.pdf

The U.S. nuclear industry has singled out government loan guarantees as essential because the private market finds loans for nuclear power plants to be too risky, and U.S. utilities are too small to take on a bigger equity to debt ratio, which would lower the cost of capital, a key element in the cost of the new plants. Under the loan guarantee program, the U.S. Treasury will guarantee 100 percent of a loan which is limited to 80 percent of the construction costs. This effectively transfers the risk of cost overruns due to lengthier construction times from project owners to the taxpayer. Congress appropriated $18.5 billion in loan guarantees for nuclear power facilities, and President Obama has recommended tripling this to $54 billion. This still falls far short of the $122 billion in requests. Industry sources suggest DOE will be able to support no more than 2-4 reactors, given costs of $5 billion to $12 billion per reactor. e Department of Energy awarded the first loan guarantee to the Vogtle reactor project in Georgia (over $8 billion) in 2010.

Federal loan guarantees causes market expansion – catalyzes capital investment

I21CE 11 Institute for 21st Century Energy, Mission of the U.S. Chamber of Commerce Institute for 21st Century Energy is to unify policymakers, regulators, business leaders, and the American public behind a common sense energy strategy to help keep America secure, prosperous, and clean, "Commit to and Expand Nuclear Energy Use", 2011 is copyright date, www.energyxxi.org/commit-and-expand-nuclear-energy-use

Nuclear power is currently an emissions-free source of 20% of America’s electricity supply, despite our not having licensed the construction of a nuclear power facility in nearly 30 years. Expansion of new nuclear power assets is essential to meet our projected growing demand while mitigating our emissions of CO2. As required by law, the federal government must provide authorized fiscal incentives for new nuclear power plants. We must solve our long-term nuclear waste challenges and aggressively expand efforts to recycle used nuclear fuel. Nuclear power is the nation’s largest emissions-free source of electricity. From a life-cycle perspective—including the impacts of uranium mining, uranium enrichment, fuel fabrication, plant construction, and fuel disposal—nuclear power offers a huge emissions advantage over any other large-scale method of baseload power generation and is on par with renewable sources. Nuclear power currently supplies about 20% of America’s electricity supply. America’s 104 operating nuclear power reactors are also the cheapest source of baseload electricityon a per-kilowatt-hour basis because operational and fuel costs are comparatively low. Although the existing nuclear units are successfully renewing their operating licenses for an additional 20 years, new nuclear power plants are essential to meet growing demand while avoiding GHG emissions. New nuclear power plants are capital-intensive, requiring an estimated $6–8 billion (2008 dollars) per plant. The U.S. electric power sector consists of many relatively small companies that do not have the size, financing capability, or financial strength to fund power projects of this scale on their own, in the numbers required. Outside financial support is necessary. The loan guarantee program authorized by EPAct2005 is a crucial tool to enable utilities to finance the construction of new reactors by increasing access to capital and enabling a higher share of leveraged debt. DOE estimates that by enabling a utility to rely more heavily on private debt than more expensive equity, a federal loan guarantee may save the ratepayers nearly 40% in the cost of power from a new nuclear plant. A well-managed loan guarantee program will be funded by project applicants and not require any expenditure of government funds. Unfortunately, the loan guarantee program has not been implemented effectively by the DOE, and the $18.5 billion in loan volume authorized by Congress for nuclear power projects is inadequate, given the estimated cost of a new nuclear power plant. That loan volume will support, at best, two, or three new projects. The current program should be expanded, and at the appropriate time merged with the Clean Energy Bank of the United States discussed earlier. The time it takes to license and build a nuclear power plant—now estimated at a minimum of eight years—is one reason the financing costs are high. The Nuclear Regulatory Commission (NRC) estimates it will take three and one-half years to review the first wave of new license applications for new designs. This period must be reduced for subsequent applications without compromising safety, and Congress must ensure the NRC has adequate resources to process license applications as expeditiously as possible. The regulatory and licensing framework has improved significantly since the 1980s, when we saw completed plants sit idle while awaiting issuance of operating licenses, but the NRC has yet to issue a Construction and Operating License under the new process. Project sponsors and investors have significant questions about whether the new process will deliver timely approvals. Delays in starting up a completed plant will subject its owners to substantial financial costs. The standby support program, established in EPAct2005, could be an effective insurance policy for nuclear plant owners against delays in the regulatory process or from litigation outside of the plant owner’s control. While this is a potentially useful tool to encourage first-movers to test the process, several changes are necessary to broaden the scope of the coverage. As currently structured, the statutory liability cap is now too low and does not reflect today’s market costs.

#### Government support is vital-~--it overcomes financial barriers to nuclear that the market cannot

Yanosek 12 Kassia, entrepreneur-in-residence at Stanford University’s Steyer-Taylor Center for Energy Policy and Finance and a private equity investor in the energy sector as a principal at Quadrant Management and Founder of Tana Energy Capital LLC, " Financing Nuclear Power in the US", Spring, energyclub.stanford.edu/index.php/Journal/Financing\_Nuclear\_Power\_by\_Kassia\_Yanosek

Over the course of the last decade, it appeared that concerns about carbon emissions, aging coal fleets, and a desire for a diversified generation base were reviving the U.S. utility sector interest in building new nuclear plants. Government and companies worked closely on design certification for Generation III reactors, helping to streamline the licensing process. New loan guarantees from the federal government targeted for nuclear projects were created as part of the 2005 Energy Policy Act. Consequently, dozens of projects entered the planning stages. Following more than 30 years in which no new units were built, it looked as if the U.S. nuclear industry was making significant headway. However, it is yet to be seen how many new nuclear projects will actually make it beyond blueprints due to one of the largest barriers to new nuclear construction: financing risk. Large upfront capital costs, a complex regulatory process, uncertain construction timelines, and technology challenges result in a risk/return profile for nuclear projects that is unattractive for the capital markets without supplementary government or ratepayer support. To many investors, nuclear seems too capital-intensive. Nuclear energy has attractive qualities in comparison to other sources of electricity. A primary motivation to pursue the development of nuclear energy in the U.S. has been its low operating fuel costs compared with coal, oil, and gas-fired plants. Over the lifetime of a generating station, fuel makes up 78% of the total costs of a coal-fired plant. For a combined cycle gas-fired plant, the figure is 89%. According to the Nuclear Energy Institute, the costs for nuclear are approximately 14%, and include processing, enrichment, and fuel management/disposal costs. Today’s low natural gas prices have enhanced the prospects of gas-fired power, but utilities still remain cautious about over-investing in new natural gas generation given the historical volatility of prices. Furthermore, nuclear reactors provide baseload power at scale, which means that these plants produce continuous, reliable power to consistently meet demand. In contrast, renewable energies such as wind or solar are only available when the wind blows or the sun shines, and without storage, these are not suitable for large-scale use. Finally, nuclear energy produces no carbon emissions, which is an attractive attribute for utilities that foresee a carbon tax being imposed in the near future. Given nuclear’s benefits, one may wonder why no new nuclear units have been ordered since the 1970s. This hiatus is in great part due to nuclear’s high cost comparative to other alternatives, and its unique set of risks. As a result, financing nuclear has necessitated government involvement, as the cost of nuclear typically exceeds that of the cost of conventional generation technologies such as coal and natural gas fired generation on a levelized cost of energy (LCOE) basis. LCOE represents the present value of the total cost of building and operating a generating plant over its financial life, converted to equal annual payments and amortized over expected annual generation, and is used to compare across different power generation technologies. For both regulated utilities and independent power producers, nuclear is unattractive if the levelized cost exceeds that of other technologies, since state utility commissions direct regulated utilities to build new capacity using the technology with the lowest LCOE. Furthermore, capital costs are inherently high, ranging in the billions or tens of billions of dollars, and are compounded by financing charges during long construction times. Without government support, financing nuclear is currently notpossible in the capital markets. Recently, Constellation Energy and NRG separately pulled the plug on new multi-billion dollar plants, citing financing problems. Projects, however, will get done on a one-off basis. Southern Company’s Vogtle Plant in Eastern Georgia is likely to be the sponsor of the first new generation to be constructed, taking advantage of local regulatory and federal support. Two new reactors of next-generation technology are in the permitting stage, which will bring online 2,200 megawatts (MW) of new capacity, and will cost $14 billion. The project will take advantage of tax credits and loan guarantees provided in the 2005 Energy Policy Act.

#### And, loan guarantees reduce financial uncertainty and boost investment

Adams 10—Publisher of Atomic insights Was in the Navy for 33 years Spent time at the Naval Academy Has experience designing and running small nuclear plants (Rod, Concrete Action to Follow Strongly Supportive Words On Building New Nuclear Power Plants, atomicinsights.com/2010/01/concrete-action-to-follow-strongly-supportive-words-on-building-new-nuclear-power-plants.html)

Loan guarantees are important to the nuclear industry because the currently available models are large, capital intensive projects that need a stable regulatory and financial environment. The projects can be financed because they will produce a regular stream of income that can service the debt and still provide a profit, but that is only true if the banks are assured that the government will not step in at an inopportune time to halt progress and slow down the revenue generation part of the project. Bankers do not forget history or losses very easily; they want to make sure that government decisions like those that halted Shoreham, Barnwell’s recycling facility or the Clinch River Breeder Reactor program are not going to be repeated this time around. For the multi-billion dollar projects being proposed, bankers demand the reassurance that comes when the government is officially supportive and has some “skin in the game” that makes frivolous bureaucratic decisions to erect barriers very expensive for the agency that makes that decision. I have reviewed the conditions established for the guarantee programs pretty carefully – at one time, my company ([Adams Atomic Engines, Inc.](http://www.atomicengines.com)) was considering filing an application. The loan conditions are strict and do a good job of protecting government interests. They were not appropriate for a tiny company, but I can see where a large company would have less trouble complying with the rules and conditions. The conditions do allow low or no cost intervention in the case of negligence or safety issues, but they put the government on the hook for delays that come from bad bureaucratic decision making.

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