Proliferation, oil, and climate: solving for pattern

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These three formidable problems, though treated as disjunct, share common causes and solutions. New energy and climate solutions can strengthen security and prosperity by shifting strategy for the NPT Review Conference. Nuclear power's astonishing eclipse by cheaper, faster, more climate-protective competitors—if acknowledged and exploited—can simultaneously bolster nonproliferation, energy security, global development, and climate protection, all at a profit.

Three of the most daunting foreign-policy tangles that threaten security, prosperity, environment, and democracy—nuclear proliferation, climate change, and oil dependence—are normally thought of in separate boxes, discussed in different fora, described in disparate language, analyzed with unrelated tools, and dealt with by diverse communities schooled in dissimilar disciplines. Yet these three problems hold in common three profound similarities.

All look intractable only because of a mistaken assumption about their economic fundamentals.

All share profitable, practical, proven solutions rooted in using energy in a way that saves money—solutions that simultaneously solve all three problems plus many more.

All have powerful establishments—informed more by economic theory than by empirical experience—whose immune systems reject those maverick solutions and default to familiar futility.

To escape this dysfunction, we must, as epistemologist Gregory Bateson and farmer/poet Wendell Berry put it, "solve for pattern." President Obama's Copenhagen speech did this by linking an efficient clean-energy economy not just to climate protection but also to economic gain, oil displacement, and national security. That was not a rhetorical flourish but a refreshing expression of solving multiple problems simultaneously without creating more.

Within that context, this essay emphasizes a unique but fleeting opportunity. Holistically applying to foreign policy some salutary recent shifts in civilian energy strategy could help stem what President George W. Bush rightly called the gravest threat to U.S. military security, one that the 2010 Nuclear Posture Review will reportedly rank equally with great-power threats: the spread of nuclear weapons to more states, terrorists, and substate actors.

One false assumption about energy can distort and even defeat policies vital to paramount national interests. The December 2009 Copenhagen climate conference proved again how

pricing carbon and winning international collaboration are hard if policymakers, pundits, and most citizens *assume* climate protection will be costly. That assumption focuses debate on cost, burden, and sacrifice: what will climate protection cost, is it worth it, and who will pay? Yet the assumption is backwards: business experience shows that climate protection is *not costly but profitable*, because saving fuel costs less than buying fuel. Changing the conversation to profits, jobs, and competitive advantage sweetens the politics so much that any remaining resistance will melt faster than the glaciers. Moreover, whether you care most about security, prosperity, or environment, and whatever you think about climate science, you should do exactly the same things about energy, so focusing on outcomes, not motives, can forge a broad consensus. The climate discussion is stranded far from this clarity, simplicity, and accuracy—because of that one wrong assumption.

The error has two main parts. First, many policymakers assume markets are nearly perfect and omnipresent, so whatever energy efficiency and alternative supplies haven't yet been bought must not be cost-effective, so their wide adoption will require high carbon prices (a correct and desirable internalization anyhow) or equivalent energy price distortions. In fact, 60–80 market failures in buying energy efficiency do greatly retard its adoption, but "barrier-busting" can turn each into a business opportunity. It's also better to name, shame, and abolish the roughly half-trillion dollars of annual subsidies to fossil fuel, as the G8 have agreed in principle, than to give smaller offsetting subsidies to efficiency and renewables (or larger ones to nuclear power).

Second, every official policy and study assumes diminishing returns to investments in energy efficiency: saving more makes savings costlier. Economists assume this so their models don't inconveniently blow up. Yet engineering reality differs: integrative design that yields multiple benefits from single expenditures can often make very large energy savings cost *less* than small or no savings. Explained in a 2005 white paper for now-Energy Secretary Steve Chu and in a 2007 Stanford Engineering School lecture series, this has been demonstrated in thousands of buildings, various vehicle designs, and over $30 billion worth of industrial redesigns in 29 sectors; yet the National Academies' 2009 study *America's Energy Choices* ignored it, and therefore found a smaller, though still important, U.S. energy-saving potential of 25–31% by 2030. Integrative design applies to saving both oil and electricity, which respectively cause 43% and 41% of U.S. fossil carbon emissions (as well as to the rest, which comes from directly used natural gas and coal). McKinsey & Company showed a year ago how to cut projected 2030 global greenhouse-gas emissions by 70% at a trivial average cost (€4 per tonne of CO_2), but integrative design and newer technologies could make even bigger savings cost less than zero—*i.e.*, be profitable—conservatively assuming that avoided climate change is worth zero.

Deployment speed requires attention but is manageable, just as it was in 1977–85 when U.S. GDP grew 27% while oil use fell 17%, oil imports fell 50%, and oil imports from the Persian Gulf fell 87%, all in just eight years, because oil intensity (barrels burned per dollar of real GDP) fell by 5.2% per year. Today, cutting global *energy* intensity (primary energy used per dollar of real GDP) by about 3–4% a year, *vs.* the historic 1%, could rapidly abate further climate damage. This looks feasible: the U.S. has long achieved annual intensity reductions of 2–4% without paying attention; China, over 5% for 25 years through 2001 and on track for 4% during 2005–10; and attentive firms, 6–16%, often profiting billions by substituting efficiency for fuel. Sustained effort pays off. In 1990–2006, California shrank greenhouse-gas emissions per dollar of GDP by

30%. In 1980–2006, Denmark shrank its energy intensity 39% and its carbon intensity 50%, made its electricity 28% renewable and three-fourths micropower (defined below), and thereby created a world-class energy-technology industry that by 2007 exceeded 9% of total exports.

Why, then, should a 3–4% annual global energy intensity reduction be hard—especially with most of the growth in countries like China and India that can make their infrastructure efficient from scratch? Since everyone who does energy efficiency makes a net profit from its avoided energy cost, why should this be costly? And why should the climate conversation adopt economists' theoretical assumption of cost rather than business leaders' empirical experience of profit? Climate negotiations will get vastly easier once we get the sign right—and less necessary if informed economic self-interest is the theme rather than shared sacrifice. Markets adeptly pursue profits and ultimately tend to choose best buys—fastest when policy busts barriers too.

On the same invalid assumptions, many policymakers suppose U.S. oil dependence and imports are ineluctably permanent: resistance is futile. Yet the DoD-cosponsored 2004 independent study *Winning the Oil Endgame* provided a detailed roadmap for *eliminating* U.S. oil use by the 2040s, led by business for profit, at an average cost of $15 per barrel (in 2000 $—that's $18.5/bbl in 2009 $). Implementation first launched by "institutional acupuncture"—spurred by the 2008 price shock, supported by 2009 policy shifts, and accelerated by military innovation for more capable warfighting at lower cost in blood and treasure—now looks on or ahead of schedule.

A few straws in the wind: Wal-Mart saved 38% of its heavy-truck fleet's fuel per ton-mile during 2005–08 and aims for 50% by 2015; 67% savings look feasible. Boeing's *787 Dreamliner*, with 865 firm orders, saves 20% of the fuel at no extra cost, a leapfrog that's turning into a break-through competitive strategy. A radically new design that could ultimately save severalfold more fuel has undergone 50 scale-model test flights. Ford poached its CEO from Boeing, escaped GM's and Chrysler's fate, and is becoming a leader in lightweighting, drag reduction, and advanced powertrains. These gamechangers are entering major automakers' production plans in the U.S., Europe, Japan, and China. Since 2000, when an uncompromised midsize SUV design getting 67 mpg with a one-year payback couldn't raise production capital, automotive innovation has dramatically accelerated and spread. Bright Automotive's 2009 *IDEA* commercial van—a plug-in hybrid with fuel and carbon savings around 60–80%—needs no subsidy because its lighter weight and lower drag eliminate most of the costly batteries. Toyota's 2007 *1/X* carbon-fiber concept car achieves the interior space of a *Prius* with half its fuel use and one-third its weight. Ultralighting with such costly materials has turned out to be free—offset by smaller powertrain and simpler manufacturing—and a new process for making ultrastrong carbon-fiber structures in less than a minute has been commercialized, awaiting scaleup to automaking.

Even at this early stage, these and many other innovations have triggered an epochal shift: "peak oil" is quietly emerging on the *demand* side. Exxon-Mobil and "many private analysts and government…forecasters" concur that U.S. gasoline demand, 11% of the world oil market, peaked in 2007 and is headed down. Cambridge Energy Research Associates doubts OECD oil demand will ever regain its 2005 peak. Deutsche Bank forecast light-vehicle electrification will turn *world* oil demand downward from 2016, falling by 2030 to 8% below current levels or 40% below consensus forecasts. China, which most forecasters expect will account for over two-fifths of global growth in oil demand to 2030, plans to electrify 80% of new cars by 2020. Deutsche

Bank conservatively assumed 26%, with no cuts in any cars' weight and drag nor in trucks' and planes' energy losses. Suburban sprawl is starting to reverse, too, and policy innovations are complementing the technological ones: in 2008, France's first year of "feebates" (a 1970s idea) cut inefficient cars' sales 42% and raised efficient cars' sales 50%. Add it all up and it's looking like oil, as I've been predicting for two decades, is becoming uncompetitive even at low prices before it becomes unavailable even at high prices.

Most oil experts have assumed that major savings or substitutions to change old oil-intensive patterns need high oil prices—either stiff taxes paid to the Treasury or price hikes paid to OPEC, or equivalent subsidies or mandates. Yet *Winning the Oil Endgame*'s technology analyses documented that redoubling U.S. oil-using efficiency (already more than doubled since 1975) would cost an average of just $12 per barrel (2000 $), while displacing the other half of the oil with alternative supply—three-fifths saved natural gas, two-fifths advanced biofuel unrelated to food crops—would cost an average of $18 and always below $26. Against 2004's official forecast oil price ($26 in 2025, in 2000 $)), a $180-billion investment to get the U.S. permanently off oil—equivalent to just seven months' 2008 net oil imports—would annually return $155 billion gross and $70 billion net. It would also cut CO_2 emissions 26%, create a million jobs, and potentially save a million at-risk jobs, mainly in automaking. Now these 2004 conclusions look conservative.

Nobody has seriously disputed that widely read 2004 analysis. Many industry strategists drew similar conclusions and are acting accordingly. The study's Forewords were by former Secretary of State George Shultz and ex-Royal Dutch/Shell Group Chairman Sir Mark Moody-Stuart. Former National Security Advisor Robert C. McFarlane called it "perhaps the most rigorous and surely the most dramatic analysis" of a world beyond oil; President Jimmy Carter, "persuasive… could be the most important step in many years toward secure and affordable energy"; *Time*, "one of the best analyses of energy policy yet produced"; *The Economist*, "sharp and sensible"; and former Deputy Secretary of Energy and National Security Council Staff Director William F. Martin, "one of the most important energy studies in decades." It was presented to the Council on Foreign Relations in New York and Washington (the latter hosted by Mr. Martin, who chaired CFR's Energy Security Group). Yet it was not cited nor apparently considered in CFR's 2006 *Energy Security Task Force Report*, nor the National Petroleum Council's 2007 *Facing the Hard Truths About Energy*, nor the National Academies' 2009 *America's Energy Future*, whose kickoff summit included an invited talk featuring it. They were all well aware of it, but presumably found it too detailed, novel, disruptive, or disturbing to contemplate. Five years on, official U.S. oil strategy remains incremental and has not yet considered most of the study's proposed innovations; most of the action remains in the private sector.

Similar adherence to orthodox but outmoded assumptions about technology and economics now cripples efforts to stop the spread of nuclear weapons. Most policymakers agree this threat is cataclysmic and undercuts deterrence. Yet U.S. and global nonproliferation policy still rests on the counterfactual and fatally contradictory assumption that nuclear *power* is economic, necessary, and reviving. That assumption makes the proliferation problem insoluble. Correcting it, even three decades late, can still make the proliferation problem largely soluble. Here's how.

In Summer 1980, I coauthored a terse but record-length (41-page) *Foreign Affairs* article that may still be the first and only economically based and logically consistent approach to nonproliferation. Had its recommendations been adopted at the time, we would probably not now be worrying about Iran and North Korea. Regrettably, it was brushed aside by a reigning nuclear theology, whose recent resurgence among a new generous of the credulous risks intensifying that error's damage to national and global security. Yet the 1980 paper remains sound in logic and has greatly strengthened in empirical persuasiveness. Eerily presaging today's conditions, it said:

> …For fundamental reasons…nuclear power is not commercially viable, and questions of how to regulate an inexorably expanding world nuclear regime are moot….
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> [T]he collapse of nuclear power in response to the discipline of the marketplace is to be welcomed, for nuclear power is both the main driving force behind proliferation and the least effective known way to displace oil: indeed, it *retards* oil displacement by the faster, cheaper and more attractive means which new developments in energy policy now make available to all countries. So far, nonproliferation policy has gotten the wrong answer by persistently asking the wrong questions, creating "a nuclear armed crowd" by assuming its inevitability. We shall argue instead that acknowledging and taking advantage of the nuclear collapse, as part of a pragmatic alternative program, can offer an internally consistent approach to nonproliferation, as well as a resolution to the bitter dispute over Article IV of the Non-Proliferation Treaty (NPT).
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> On the eve of the second NPT Review Conference, to be held in Geneva in August 1980, fatalism is becoming fashionable as the headlines show proliferation slipping rapidly out of control. Yet…an effective nonproliferation policy, though impossible with continued commitments to nuclear power, may become possible without it—if only we ask the right questions.

Thirty years later, as the eighth NPT Review Conference prepares to convene in Vienna on 30 April 2010, only one word needs updating: now that oil generates less than 6% of the world's electricity, today's rationale for nuclear expansion is to displace *coal* to protect the Earth's climate. But that rationale is equally unsound, for similar reasons. In principle, quadrupling today's global nuclear power capacity—to replace and then triple retiring units—could provide up to one-tenth of needed carbon reductions. But nuclear power is about the least effective method: it does save carbon, but *about 2–20 times less per dollar and 20–40 times less per year than buying its winning competitors* (described below). Nuclear expansion would thus *reduce and retard* climate protection. If climate is a problem, we must invest judiciously, not indiscriminately, to get the most solution per dollar and per year. Nuclear power does just the opposite.

Choosing the best energy buys first then triggers the astonishingly timeless and still-valid logic of the 1980s article's nonproliferation analysis:

1. We can have proliferation with nuclear power, via either end of any fuel cycle: "*every* form of *every* fissionable material in *every* nuclear fuel cycle can be used to make military bombs, either on its own or in combination with other ingredients made widely available by nuclear power."
2. We cannot have nuclear power without proliferation, because its vast flows of materials, equipment, skills, knowledge, and skilled people create do-it-yourself bomb kits wrapped in innocent-looking civilian disguise. Safeguards to prevent that misuse "cannot succeed either in principle or in practice," because as the Acheson-Lilienthal report foresaw in 1946, treaties and policing have proven weaker than national rivalries, subnational instabilities, and human frailties.

3. We can have proliferation without nuclear power—but needn't if we do it right: with trivial and unimportant exceptions, "*every* known civilian route to bombs involves *either* nuclear power *or* materials and technologies whose possession, indeed whose existence in commerce, is a direct and essential consequence of nuclear fission power."
4. Most importantly, in a world *without* nuclear power, the ingredients needed to make bombs by any known method would no longer be ordinary items of commerce. They would become harder to get, more conspicuous to try to get, and politically costlier to be caught trying to get (or supply), because their purpose would be *unambiguously* military. This disambiguation wouldn't make proliferation impossible, but would make it far harder—and easier to detect timely, because intelligence resources could focus on needles, not haystacks. Thus phasing out nuclear power is both a necessary and a nearly sufficient condition for nonproliferation.

This thesis was apparently not considered by the American Academy of Arts and Sciences' 2009 study *The Global Nuclear Future*. Confident of nuclear power's importance and necessity, its organizers included only minor, mild, and qualitative skepticism, and declined to consider adding a quantitative, economics-based treatment. Yet the global evidence shows beyond doubt that nuclear power is continuing its decades-long pattern of collapse throughout the world's market economies, due to unsupportable economic costs and financial risks. These are independent of public or political attitudes and noneconomic issues, starting with proliferation; if nuclear power isn't necessary, economic, or financeable, one needn't inquire further.

The American Academy study's basic assumption seems so irreconcilable with observed market costs and choices that it's worth summarizing some data that all but a few of its 30-odd eminent authors seem to have overlooked and none of them clearly expressed:

- At 15 November 2009, the world operated 370 billion watts (GW) of nuclear capacity, about 8% of the IAEA's 1970s upper capacity forecast for 2000. Eight fewer units operated than in 2002. Nuclear output shrank in 2007 to 13.8%, and today is below 13%, of the world's electricity; the International Energy Agency projects 10% by 2030. Only ~4.4% of the global generating capacity under construction in 2008 was nuclear. Inevitable nuclear retirements mean that heroic efforts might sustain global nuclear capacity after 2015, but probably can't raise it for the next few decades.
- Of the 53 nuclear power plants that the IAEA reported on 15 November 2009 as "under construction"—23% of the 1979 peak—13 have been so listed for more than 20 years, 24 have no official start date, over half are late, 37 (70%) are in just four centrally planned and non-transparent power systems (China, Russia, India, and South Korea), and none are conventional free-market transactions. All 53 were bought by central planners, generally with a draw on the public purse. No nuclear power plant has ever been ordered in, nor subjected to, free and fair competition with all other ways to provide the same electrical services. None has ever been bid into the world's thousands of power-supply auctions.
- No nuclear plant under construction or proposed worldwide has been able to attract equity investment. In the U.S. this market rejection befell all 33 proposed projects despite new subsidies, added in August 2005, equivalent to roughly 100+% of construction cost (on top of old subsidies), plus three years of the most robust capital markets and nuclear politics in history. Nuclear power is generally far more subsidized than its competitors,

yet is urgently seeking even greater subsidies—in current U.S. Senate language, an open-ended and unaccountable blank check—to forestall an embarrassing collapse.

- The main U.S. substitute for the missing equity is coerced capital from taxpayers and utility customers. The nuclear industry insists on, and often gets, new state laws that bar or restrict competition by alternatives and make customers buy new nuclear plants in advance—whether they ever run or not, whatever they cost, no questions asked—plus a return to compensate utilities for the risks they've just transferred to customers. This approach scraps all five bedrock principles of utility regulation—payment on delivery, only for "used and useful" assets, at a "just and reasonable" level commensurate with risk, only if prudently bought, with no Commission able to bind its successors. It creates in utility investment the same moral hazard that just brought down the financial system.
- The capital markets offer new reactors no equity investment because there's no business case. Utility bids and Wall Street assessments show new nuclear electricity in the United States would cost roughly three times as much as new windpower, "firmed" so you can have it whether or not the wind is blowing. (Firming raises cost by only a few percent—probably less than offsetting the awkward intermittence of coal and nuclear plants, which are down 10–12% of the time; in 2008, global nuclear plants failed without warning 5.3% of the time. Concerns often raised about reliably integrating large amounts of variable renewables into the grid have withstood neither analytic scrutiny nor the test of experience: 30–40% annual windpower fractions in five German states are accommodated without difficulty and aren't a practical or economic limit.) New nuclear electricity can compete neither with new fossil-fueled plants nor with most or all renewables—probably even including photovoltaics, in some places today and nearly everywhere before a nuclear plant could be built. Wind and photovoltaic power also use less land than nuclear power.
- Even France's impressive 78%-nuclear-power program, the world's most intensive and *dirigiste*, suffered 3.5-fold escalation in real capital cost per kilowatt and nearly doubled construction time during 1970–2000, plus acute economic and operational strains. Doing nuclear power exactly as its advocates urge, with no market or political accountability, evidently doesn't immunize it from bad economics.

Nuclear power's most potent competitors are no longer other central power plants—coal-fired or combined-cycle gas. Instead, they've *all* been reduced to a minority total share of the global power market by cheaper, faster, less financially risky competitors that *The Economist* calls "micropower." Micropower has two parts: cogeneration (combined-heat-and-power)—making electricity together with useful heat in factories or buildings—plus renewable sources except big hydroelectric dams. Micropower ranges from decentralized, like rooftop solar cells or small hydro, to concentrated, like solar- or windfarms producing hundreds of megawatts, but however clumped or dispersed, its economies come from mass-produced modules more than from unit size, so it deploys more like cellphones or cars than like cathedrals. Carbon pricing will advantage these low- or no-carbon generators as much as nuclear power (partly so for fueled cogeneration), so whatever the carbon price, both fossil-fueled *and* nuclear plants will continue to lose market share. This is clearly happening:

- In 2006, micropower produced one-sixth of the world's total electricity (slightly more than nuclear did), one-third of the world's new electricity, and 16–52% of all electricity

in a dozen industrial countries—not including the U.S. (7%), whose rules favor incumbents and their giant plants. Nuclear power worldwide added 1.44 GW (one big reactor's worth) of net capacity—more than all of it from uprating old units, since retirements exceeded additions. But photovoltaics added even more capacity; windpower, ten times more; micropower, 30–41 times more. Micropower plus efficiency probably provided over half the world's new electrical services. In China, the world's most ambitious nuclear program achieved one-seventh the installed capacity and growth rate of China's distributed renewables.

- In 2007, the U.S., Spain, and China each added more wind capacity than the world added nuclear capacity, and the U.S. added more wind capacity than it added coal-fired capacity during 2003–07 inclusive. China beat its 2010 windpower target.
- In 2008, China doubled its windpower for the third year in a row and looked set to beat its 202*0* windpower target in 20*10*. Windpower pulled ahead of gas-fired capacity additions for the first year in the U.S. and the second year in the EU; in both, renewables added more capacity than nonrenewables. For the first time since the dawn of nuclear power in 1956, no new nuclear units came online worldwide. While nuclear power lost capacity and got zero equity investment from the private capital markets, distributed renewables worldwide in 2008 added 40 GW and got $100 billion of private investment. That plus ~$40 billion for big hydro dams brought renewable power production, for the first time in about a century, more investment than the ~$110 billion invested in all fossil-fueled power stations. Preliminary data suggested that micropower roughly doubled, to two-thirds, its 2006 share of the world's new electricity generation.
- Developing countries in 2008 had 43% of renewables' global capacity (excluding big hydro), heading for the majority. A major Asian shift to renewables could shrink global coal use, because 97% of incremental coal demand is in Asia: China and India use nearly half of world coal and had 75% of world coal-fired capacity under 2008 construction. This shift is starting to emerge: China's rate of adding coal plants fell by two-thirds during 2006–9. China also shut down 54 GW of inefficient old coal plants during 2005–9, plans to close 31 GW more by 2011, and appears to be cooling its overheated nuclear ambitions while accelerating efficiency and renewables. The new 2020 wind-and-PV target is 120 GW, and a Tsinghua/Harvard team found China can cost-effectively and practically provide twice as much windpower as its *total* current electricity use.

The popularly promoted vision of a nuclear renaissance thus diverges sharply from reality. The rout of nuclear power in the global marketplace, and its inability to persuade private investors anywhere to risk their money on its equity, mark the greatest collapse of any industrial enterprise in the history of the world. Even photovoltaics, the costliest renewable, have added more global capacity and output than nuclear has added in each of the past two years; nuclear may never catch up (see Fig. 1), and in 2010 will struggle to regain the capacity it had in 2007. No wonder the German Environment Minister stated on 27 August 2009 in releasing the authoritative *World Nuclear Industry Status Report 2009*:

> The renaissance of nuclear energy, much trumpeted by its supporters, is not taking place. The only thing frequently revived is the announcement. The study shows: the number of old nuclear power plants which are decommissioned worldwide is greater than the number of new ones taking up operation. Available resources, engineering performance and funds are not even enough to stop the downward trend, let alone increase the number of reactors. All the facts are in favour of

phasing out this technology while at the same time expanding the use of renewable energies and energy efficiency, as this is a promising option for the future.

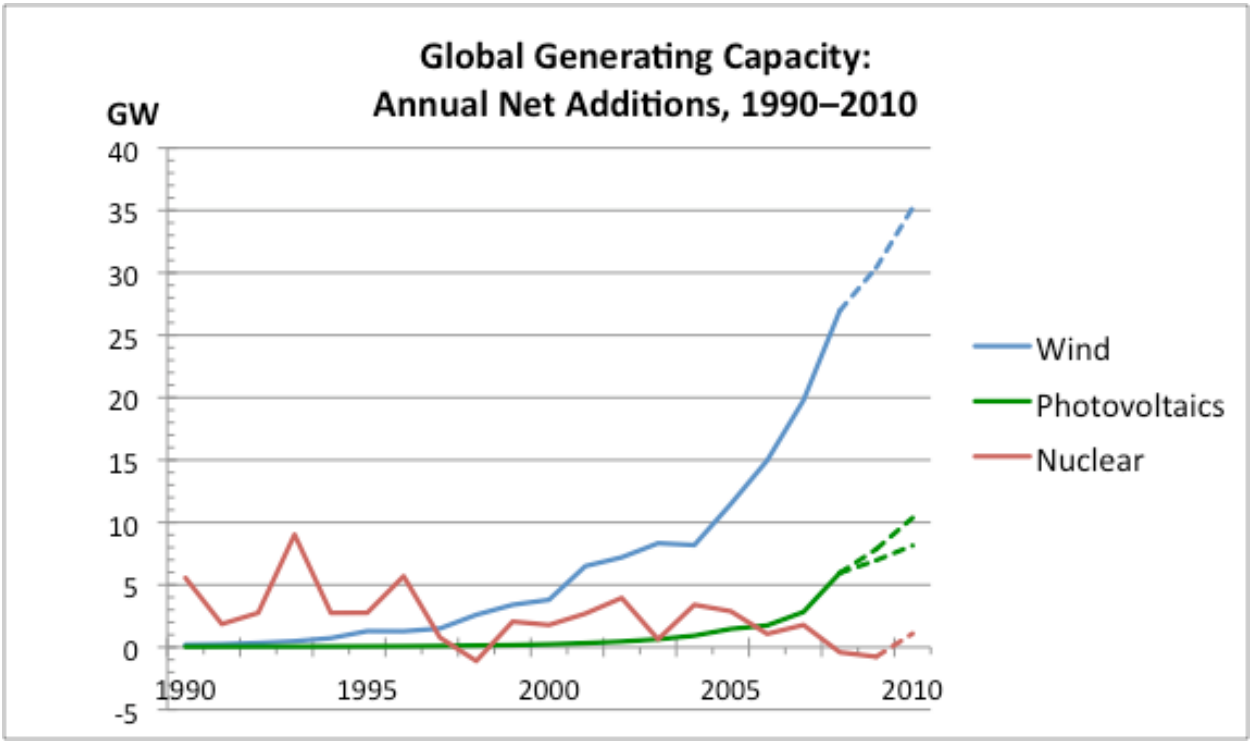

Fig. 1. Worldwide net additions of capacity (new grid connections, less retirements, adjusted for up- and down-ratings of old units) for wind, photovoltaic, and nuclear generating plants. Other renewables (comparable in total) and cogeneration (larger) are not shown. In round numbers, 1 GW (billion watts) of generating capacity yields ~2–3 times less electricity from a well-sited wind plant or 3 times less from an average-U.S.-sited commercial PV plant than from a well-running nuclear plant, but this ratio is nearly unity for the micropower technologies not shown.

No technical or institutional developments in sight could change these fundamental trends: "new" reactor types aren't materially different (except that most are more proliferative), and no new central thermal power plant can compete with micropower, let alone efficiency, even if its steam source is *free*. Thus my 1980 article's conclusion has only strengthened:

> Nuclear power has been promoted worldwide as both economically advantageous and necessary to replace oil [today, read "coal"]. Potential proliferation, in this view, is either a small price to pay for vast economic advantages or an unavoidable side effect which we must learn to tolerate out of brutal necessity. But rational analysis of energy needs and economics strongly favors stopping and even reversing nuclear power programs. Their risks, including proliferation, are therefore not a minor counterweight to enormous advantages but rather a gratuitous supplement to enormous disadvantages.

Consistent trends reinforce these economic fundamentals. More-competitive electricity markets and more-transparent decisionmaking bode ill for nuclear power. Distributed generators can capture 207 hidden economic benefits that can often boost economic value by about tenfold. In general, central stations are getting costlier and decentralized generators cheaper. The cost comparisons here omit efficiency's side-benefits—often worth 1–2 orders of magnitude more than the saved energy—and important synergies from combining renewables with each other and with efficient use. The biggest, cheapest competitor—efficient end-use technologies that wring

severalfold more work from each kilowatt-hour—keeps improving faster than it's being applied. As mentioned earlier, "integrative design," which optimizes whole buildings or factories (respectively using about 70% and 30% of U.S. electricity), often yields not diminishing but expanding returns—the next energy revolution. All this is not theory but hard-nosed business practice, which large firms hire designers like my team to help them adopt.

These market realities present a remarkable, but short-lived, opportunity to align U.S. nonproliferation policy with the Obama Administration's emphasis on efficient use and on renewable and distributed sources. Example is powerful: if even a country with the wealth, infrastructure, skill, and fuels of the United States claims it needs more nuclear power, all other countries gain a cast-iron excuse to follow suit. But if the U.S. finds non-nuclear alternatives work better and cost less, as the market confirms daily, then less richly endowed countries can more readily concur, seeking their own profit and prestige from similar modernity. Aligning what America says, does, and offers can turns her market or regulatory rejection of fossil fuels from some dark plot to choke global development into the mere routine pursuit of economic rationality in ways all can advantageously emulate and improve upon.

Reconciling foreign with domestic energy policy doesn't require anyone to be or to sound anti-nuclear: the issue, as we wrote in 1980, "is not whether to maintain a thriving [nuclear] enterprise, but rather whether to accept the verdict of the very calculations on which free market economies rely." (When the City of London wouldn't pay for Mrs. Thatcher's nuclear-power ambitions, she dropped them because she liked free markets even more. Would that all U.S. policymakers were so consistent.) Making nuclear power compete, after 56 years' largesse, would be a good start, desubsidizing the entire energy system even better—an impeccably conservative notion.

If the U.S. can propose nuclear fuel security initiatives, why not broader energy security initiatives? What if the United States went beyond merely setting a good example and announced it will help spread the best buys it's adopting—efficiency, renewables, and distributed energy systems—to all developing countries wanting them, unconditionally and nondiscriminatorily? Most such countries are rich in renewable energy flows, and are now building their infrastructure from scratch—far easier to do right the first time than to fix later. They could welcome "Sunbeams for Peace" for the same pragmatic reason China has become the world leader in five renewable technologies and made energy efficiency its top strategic priority—not because a treaty required it, but because leaders like Wen Jiabao understand that China can't otherwise afford to develop. There can be commercial opportunity here too: the U.S. first invented many of these now-vibrant markets, then abrogated them, so why not try to regain some in the service of vital and widely shared global goals? Surely Chinese exporters needn't own the entire market.

At the 2010 NPT Review Conference, long-simmering tensions will doubtless re-erupt over two issues about Treaty implementation: weapons states' underfulfilled obligation under Article VI to pursue nuclear disarmament, and developing-country signatories' right under Article IV to access nuclear technology for exclusively peaceful purposes. Progress in and beyond the new round of Strategic Arms Reduction Treaty talks between the United States and Russia should help on Article VI; policy shifts building on President Obama's Nobel Peace Prize speech can help too. Both approaches are usefully augmentable by shifts in rhetoric, ritual, symbolism, and

doctrine, recognizing bombs' limited military utility and reversing the U.S. habit of attaching prestige to their possession. A new "strategic triad" of conflict prevention, conflict resolution, and nonprovocative defense—concepts already starting to enter U.S. military doctrine—could help too. The civil and military elements of global denuclearization remain today as linked and synergistic as they were in 1980. But progress on Article IV depends on recognizing one simple fact that remains nearly unnoticed by policymakers so steeped in nuclear matters that they haven't yet noticed the rapid shifts in electricity's competitive landscape.

When the Treaty was drafted in 1958–68, nuclear power was widely expected to be cheap, easy, abundant, and indispensable. Rewards to non-weapons states for forgoing nuclear weapons were framed *in terms of* access to nuclear power, as we wrote in 1980, only

> …because of the nuclear context and background of the negotiators, not as an expression of the essential purpose of Article IV….The time is therefore ripe to reformulate the bargain in the light of new knowledge. Instead of denying or hedging their obligations, the exporting nations should fulfill it—in a wider sense based on a pragmatic reassessment of what recipients say their real interests are.

Having adjured bombs, which Article II forbids them from trying to get and Article I bars suppliers from helping them "in any way" to get, the developing-country signatories to the Treaty say they want reliable and affordable *energy for development*. The past half-century has changed our understanding of energy options. Now we have cheaper, faster, surer ways than nuclear power to meet those expressed energy goals. Therefore "recipients should insist on aid in meeting their declared central need: not nuclear power *per se* but rather *oil [and now coal] displacement and energy security*." U.S. endorsement and help could elicit such requests, and could even help confer the prestige some now seek from nuclear power.

Reinterpreting Article IV in light of modern energy experience would isolate legitimate from illegitimate motives and help smoke out proliferators, advancing the Treaty's central goal. Let countries that want specifically *nuclear* energy explain why they prefer this costliest, slowest, most demanding alternative over cheaper, faster, inherently nonviolent ones.

And now let's solve for pattern. The help that developing countries expect under Article IV of the NPT *is exactly the same help they sought in Copenhagen to get off fossil fuels*, and the same that many want to help relieve their oil dependence. Helping provide that help would achieve many goals for the price of one, and remove the contradiction that makes the NPT ineffectual.

The challenges and the tedious pace of nuclear disarmament are no reason to delay the immediate reframing of Article IV to reflect modern energy knowledge. If the Review Conference doesn't launch this new energy conversation, the U.S. will miss its most important opportunity yet to inhibit the spread of nuclear bombs—and simultaneously to break the Copenhagen political logjam on climate justice.

U.S. support for expanding nuclear power—often, it seems, not just to buy Senate climate-bill votes but out of a sincere if mistaken belief that it will help protect the climate—now creates a lose-lose policy framework by encouraging a climate nonsolution that also makes proliferation insoluble. In practice, it is also incompatible with deeply valued American traditions of free

markets and a free society. Yet applying internationally the generally sound *non*-nuclear elements of current domestic energy policy could go far towards solving the proliferation, oil, *and* climate problems, all at once, and all at a profit.

This policy shift would speed global development, for two main reasons: (1) as leapfroggers like Kenya and Mongolia demonstrate, many small devices accessible to numerous market actors add up to more total capacity sooner than a few big, slow devices requiring specialized institutions; and (2) investing to save rather than produce electricity takes about a thousand times less capital and repays it about tenfold faster—a roughly 10,000-fold reduction in the capital needed by the power sector, turning it from a sink for one-fourth of the world's development capital to a net *source* of capital to fund other development needs. This may be the strongest, yet least recognized, macroeconomic lever there is for global development.

Further, more granular energy investments would reduce procurement corruption, increase transparency, strengthen the social periphery *vis-à-vis* the center, and slow or reverse rural-to-urban migration. The inherently resilient architecture of distributed energy systems would change major supply failures from inevitable by design to impossible by design, and turn energy infrastructure from a magnet for attackers to a bulwark against them. And shifting the world from oil and coal to efficiency and renewables—"Reinventing Fire"—can wind down regional arms races, delink global tensions and military missions from oil, defund terrorism and tyranny, and reduce energy price volatility, trade imbalances, and economic stress. All this makes sense and makes money. It would expose and discomfit only those who lack competitive offerings or harbor ulterior motives.

The surest path to a richer, fairer, cooler, safer world—where the energy security, oil, climate, most proliferation, and many development problems fade away—would thus be a U.S. energy policy that takes economics seriously. It would let all ways to save or produce energy compete fairly, at honest prices, no matter which kind they are, what technology they use, where they are, how big they are, or who owns them. Who wouldn't be in favor of that? Why don't we find out? And why can't such a least-cost domestic energy strategy inform and inspire foreign policy too?

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A condensed version of this paper, citing it, is to be posted in mid-January 2010 at www.foreignpolicy.com and will be subsequently posted at /or linked to www.rmi.org, where many other relevant papers are posted for free public access, chiefly under Resources / Library.