Implications of Scenario 3: Catastrophic Climate in 100 Years

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"… a tendency in our planning to confuse the unfamiliar with the improbable. The contingency we have not considered looks strange; what looks strange is therefore improbable; what seems improbable need not be considered seriously."

Thomas C. Schelling, Foreword to Roberta Wohlstetter, Pearl Harbor: Warning and Decision (1962)

"Year after year the worriers and fretters would come to me with awful predictions of the outbreak of war. I denied it each time. I was only wrong twice."

Senior British intelligence official, retiring in 1950 after 47 years of service.[1]

It can reasonably be contended that catastrophic climate change and catastrophic terrorist attacks, the latter quite possibly involving state support, will dominate U.S. concerns about security in this century. Climate change and intentional attack at first seem to be independent phenomena, calling for not only different expertise to understand them but separate measures to deal with them as well. This paper argues that the two threats, while quite different in origin, demand responses that are to a surprising degree mutually reinforcing.

To borrow a formulation suggested to me by Rachel Kleinfeld several years ago, climate change is a "malignant", as distinct from a "malevolent", problem – a problem of the sort Einstein once characterized as sophisticated (raffiniert) but, because it derived from nature, not driven by an evil-intentioned (boshaft) adversary. Yet sophisticated malignant problems can still be awesomely challenging. For example, because complex systems can magnify even minor disturbances in unpredictable ways – the so-called "butterfly effect" – a tree branch touching some power lines in Ohio during a storm can produce a cascading electrical grid failure. In 2003 such a tree-branch-power-line connection deprived the northeastern United States and eastern Canada of electricity for some days. Similarly, our purchases today of gas-guzzling SUV's can contribute to sinking portions of Bangladesh and Florida beneath the waves some decades hence.

Those individuals who didn't adequately prune Ohio tree branches or who drive SUVs have nothing against Canadian electricity consumers or the citizens of Bangladesh and Florida, any more than smokers are trying to increase cancer risks for those who breathe their smoke. Einstein would not have called any of these causes "boshaft". But as we learn more about complex, interrelated systems such as electricity grids and the ecosphere, we have to recognize that some human behaviors that seemed acceptable or at least insignificant in the past might now be most unwise, because they increase the chance of, essentially, metastasis in the system. Some of this increased risk of contributing to malignant threats may simply reflect our heightened awareness, as in the effects of passive smoke. Other behavior is riskier today because more complex networks are becoming more prone to disruption: in the years before electricity deregulation helped produce today's highly congested transmission lines, a tree branch touching power lines in Ohio might well have affected only the local utility.

Terrorism, however, is a malevolent, not a malignant problem. And terrorists sadly are much smarter than tree branches. They need not rely on random disruptions of power lines in a storm, but rather can study the systems that distribute electricity and learn of the vulnerabilities of, for example, transformers and Supervisory Control and Data Acquisition (SCADA) systems.[2] They can

then plan attacks to create system collapses much worse and much longer than would occur from natural disasters – for example taking a large share of the electricity grid down for months rather than taking down a small share for days, as might be the case with a naturally-caused disruption.

Before 9/11, for example, al Qaeda studied airport screening mechanisms, crew training, and aircraft cockpits. They learned that box cutters would get through baggage checks, that air crews were trained to be polite to hijackers to minimize the chance of accidents, and that cockpit doors were flimsy. The attacks were designed to exploit these weaknesses. There was nothing random or desperate about them. Nor were they impulsive acts by "the wretched of the earth"; they were overseen by an engineer (Khalid Sheikh Mohammed), led by a wealthy construction executive and a physician (Osama bin Laden and Ayman al-Zawahiri), and carried out primarily by citizens of one of the world's wealthiest countries – 15 of the 19 terrorists were from Saudi Arabia. As Sean Wilentz of Princeton wryly put it after the attack, "Now we know the root causes of terrorism: wealth, status, and education."

Due to well-funded Islamist terror we face a future in which there will be a continuous, conscious and carefully planned effort to destroy our society for decades. The effort is driven by a fanatic ideology that motivates an enemy whose fervor, willingness to die, and lust to maximize civilian death and destruction are unbounded. History has demonstrated on many occasions that there is no contradiction between being a shrewd planner and a fanatic. We assume that such a pairing is impossible at our peril.

In the United States there is some propensity to sidestep dealing with malignant problems and focus principally on malevolent ones. In Europe the opposite tends to be the case. Yet the world cannot afford to ignore either type of challenge. Our energy use and infrastructure face both major malignant and malevolent threats and we are already taking longer than we should to address them.

It is important to see how the malignant problem of climate change may present or exacerbate security concerns that have traditionally been the province of our armed forces. A recent report by the Center for Naval Analysis covers this terrain thoroughly and professionally, as do earlier chapters of this book. This chapter begins to deal with the next question: given that we face catastrophic threats of both malignant and malevolent nature in this century, how can we work to design policies that will increase our chances of prevailing against both?

Malignant Risks: Climate Change

Earlier chapters have dealt with the general phenomenon of climate change, the role of greenhouse gas emissions therein, and the regional consequences of smaller but substantial changes – up to a temperature rise of 1.6-2.8 degrees Celsius and sea level rise of approximately half a meter in a thirty-year period. This chapter will not repeat those assessments. The agreed assumptions for this chapter's discussion of catastrophic change are that aggregate global temperature increases by 5.6 degrees C by the end of the century, accompanied by a dramatic rise in global sea levels – two meters in the same time period.

Three factors should lead a prudent individual to consider such catastrophic change plausible: first, the possibility that some "positive feedback loops" could radically accelerate climate change well beyond what the climate models currently predict; second, the prospect of accelerated emissions of CO2 in the near future due to substantial economic growth, particularly in developing countries such as China; and third, the interactive effects between these two phenomena and our increasingly integrated and fragile just-in-time -- but certainly not just-in-case -- globalized economy.

Positive Feedback Loops and Tipping Points

The climate models agreed upon by the Intergovernmental Panel on Climate Change (IPCC) deal with some but my no means all of the warming effects of emissions that can occur as a result of positive feedback loops. This is not because climatologists don't regard such issues as important, but rather because, as scientists, they are given to producing testable hypotheses. There are typically not enough data to satisfy that requirement for a number of the positive feedback issues. Modeling non-linear phenomena of this sort is extremely difficult. But a number of climatologists have nevertheless assessed the data and offered opinions about the importance of these positive feedback effects and the likelihood that they could have substantial impact on climate change even in this century. NASA's James Hansen puts it succinctly: "I'm a modeler, too, but I rate data higher than models."[3]

Despite the deceptively benign name, positive feedback can relatively quickly accelerate climate change to thresholds, or tipping points, at which it becomes impossible to reverse destructive trends even with future reductions of greenhouse gas emissions. Several possible such positive feedback loops are conceivable in this century, including the risk that fresh water from melting Greenland glaciers would slow the meridional overturning (conveyor) in the Atlantic, which could weaken and ultimately even undermine the operation of the Gulf Stream's warming of Europe. But the existence of tipping points at

which there might be irreversible thawing of the, principally, Siberian tundra and the melting and breakup of the Western Antarctic ice cap have such stunning implications they deserve particular attention.

There are stretches of tundra in the Arctic, in Western Siberia (in an area about the size of France and Germany together), and in a smaller area in Alaska, in which approximately 500 billion tons of carbon are trapped in frozen peat bogs -- about one-third of all the carbon in the world's soils.[4] If the permafrost were to thaw, much of this would be quickly converted to methane. Current methane emissions are probably still below 50 million tons annually, but methane is more than twenty times more potent than CO2 in affecting climate so even this would be the warming equivalent of over a billion tons of carbon dioxide. Today, overall carbon emissions from fossil fuels are about 8 billion tons (29 billion tons of CO2), or just over a ton of carbon per person on average.[5] If the thawing of the tundra should add enough warming gases to the atmosphere then the tundra thaw could reach a tipping point and accelerate rapidly: the release of methane could further speed up the thaw and hence further methane release. We don't know the exact point at which thawing tundra would begin this vicious feedback, but there are some initial indications that a substantial tundra thaw is already underway.[6] The key point is that because of methane's potency its release could provide a substantial short-term kick to climate change – the equivalent of billions of tons of CO2. Release over a few decades could raise worldwide temperatures by 5-6 degrees C or more [7], to the approximate level of temperature increase posited for this scenario.

Another potential major positive feedback potentially leading to a tipping point is the prospect of ice sheets melting in Greenland and, dramatically, in Western Antarctica. The Western Antarctic ice sheet is of particular concern because historical evidence suggests it could conceivably melt and affect sea levels quite quickly. Some 14,500 years ago the rise in sea level (just under half an inch a year, about 4-5 times today's rate) went from rapid to amok – increasing by about a further factor of five. Sea levels rose by 20 meters within 400 years. Such a rapid rise would require some phenomenon other than steady ice-sheet melting. [8] Glaciologists believe the most likely source was collapse of major segments of the huge West Antarctic ice sheet, which rests in some places on bedrock as much as 2 km below sea level[9] and thus is less stable than the Greenland sheet (itself at risk from some positive feedback loops) or Eastern Antarctica.

Such a scenario is conceivable for the future, with West Antarctic ice being lubricated by melting where it is grounded, then beginning to float, and then causing the coastal ice shelves to shatter.[10] Regarding the possibility of such a tipping point being reached in our time, NASA's James Hansen points out that,

even short of catastrophic accelerated change we can expect temperatures to rise in this century to a level as high as they were 3 million years ago, before the ice ages. Sea levels then were about 25 meters higher than today, Hansen points out – give or take around 10 meters.[11]

It is difficult to persuade government decision-makers to take account of such tipping points that are reached by exponential change. This may be because most people have what Ray Kurzweil calls an "intuitive linear" view of phenomena rather than an "historical exponential" view. In The Singularity Is Near Kurzweil suggests that most of us have great difficulty grasping exponential change. He compares us to an individual who has a small lake on his property and who regularly cleans out lily pad growth every few days. Then, with the pads covering only 1 percent of the lake, the property owner decides to go on vacation, but when he returns a few weeks later he is surprised to find the lake covered with lily pads and the fish dead.[12] The property owner forgot that the lily pads didn't know that they were not supposed to expand exponentially just because the human mind tends to think linearly. So too with climatological tipping points. We have to learn to think about phenomena the way they in fact occur – nature is not always going to behave in a linear fashion because our minds tend to think that way. The world's physical phenomena are not a lesser included case of homo sapiens' intuitive linear thinking.

Economic Growth

To take only one example of the impact of vigorous economic development on CO2 emissions, China is building approximately one large coal-fired power plant per week for the foreseeable future. Rapidly growing developing countries will account for an overwhelming 85 percent of energy demand growth between today and 2020. China alone represents a third of total growth.[13]

Robert Zubrin suggests a simple thought experiment to illustrate the power of economic growth to affect climate change – a process that could help push us to a climatic tipping point sooner rather than later. The world today has achieved an average GDP per capita comparable to US GDP per capita at the beginning of the twentieth century (about $5,000 in today's dollars). [14] In the twentieth century, world population quadrupled and world economic growth averaged 3.6 percent.[15] Even if we assume slower population growth, say a doubling of world population in the twenty-first century, and also a lower growth rate of 2.4 per cent -- the latter producing a five fold increase in GDP per capita -- unless fuel use per unit of GDP changes substantially we would see a tenfold increase in carbon dioxide emissions by century's end. This prospect leads even a climate change skeptic such as Zubrin to imagine an extraordinary scenario in which presumably all known and some unknown feedback loops becoming activated

and thus our "only tak[ing] a few decades to reach Eocene carbon dioxide atmospheric concentrations of 2000 ppm…"[16] and certain catastrophe.

The OECD and the rest of the developed world has its work cut out for it even if member nations act quickly to reduce greenhouse gas emissions. Unless developed countries can, perhaps cooperatively with China and other developing countries, develop affordable, effective, and clean ways to produce energy they will hear from the developing world that greenhouse gas emissions are rich countries' problem, not theirs. China and other developing nations may insist that their prosperity should not be hostage to greenhouse gas reductions, the need for which has been created largely by the past two centuries of OECD-nation emissions. But especially if development-driven CO2 emissions move the world toward a climatic tipping point, we may not have the time to debate this issue for long.

Interactive Effects: Climate Change, Sea Level Rise, and the Existing Infrastructure

As the 2007 IPCC report (Working Group I's Contribution to the 4th Assessment) points out, the prospect of climate change and sea level rise coming to a tipping point is particularly troubling because, once a tipping point has been passed, it will become apparent that sea level will continue to rise, quite probably for centuries. Beyond the immediate damage such a sea level rise would wreak, this is the importance of two-meter increases in sea level by the end of the century. Such a rise would be unlikely to occur without substantial and irreversible glacial melting having begun.

Thus James Hansen's view is that sea level rise is "*the* big global issue" that will transcend all others in the coming century.[17] Even if the East Antarctic ice sheet is not destabilized, the steady melting of the Greenland sheet together with the perhaps sudden melting of the West Antarctic sheet would hold the prospect for some twelve meters of sea level rise. [18] The melting of the East Antarctic shelf would add approximately another 25 meters, marking in Antarctic research scholar Peter Barrett's words "the end of civilization as we know it."[19] Even without a melting of the East Antarctic shelf civilization would not see the rising sea levels just as a terrible episode, but rather as endless horror. Realistically, there world be no end to rising seas and chaotic climate changes for the next several generations.

Most people need some sense of hope in order to struggle, especially against great difficulties. Being past a tipping point of climate change and looking at inevitable sea level rises measured in meters per century for centuries to come would, for a great many, destroy hope itself. Moreover, humanity would have to face the coastal inundation and related destruction that a two-meter rise by the

end of this century would entail while dealing with substantial disruption of agriculture and food supplies, and resulting economic deprivation, due to changing availability of water – more in some regions, less in others.

Among the regions in the developed world facing the likely prospect of inundation by the end of the century would be: major portions of cities and wide regions of the U.S. coast from South Texas to West Florida and from East Florida to New York; extensive areas bordering the Chesapeake Bay and most of South Florida and eastern North Carolina; the lower Hudson Valley; huge shares of the coasts of San Francisco Bay; much of Sydney and all of Darwin, Australia; a large share of Japanese ports; Venice and a major share of coastal Tuscany; Montpelier; the majority of the Netherlands; much of Dublin; a major share of Copenhagen; and the Thames and the eastern and southern coasts of England. [20] Storm surge would affect people much farther inland and on more elevated coastlines. (See discussion above in chapter by Jay Gulledge.)

Even without considering storm surge, sea level rise in the range of two meters in this century could have a "potentially catastrophic" effect on a number of developing countries. According to a February 2007 World Bank Policy Research Working Paper, these include particularly Egypt, Vietnam, and the Bahamas and a number of other island nations. Some of the latter, in the Pacific and elsewhere, could be completely inundated. Sea level rise could also have "very large" effects on a number of other states, including China. Considering all factors – land area, urban area, population, etc. -- the most affected countries, in addition to the above, would be Guyana, Surinam, and Mauritania. Substantial impacts would also occur in Gambia, Liberia, Senegal, Guinea, Thailand, Burma, Indonesia, Taiwan, Bangladesh, and Sri Lanka.

A 2006 report by the British Tyndall Centre for the Stern Review on the Economics of Climate Change stresses that even if the climate is stabilized, ice sheet melting already underway has created a "commitment to sea-level rise" for many centuries; the question is its extent. The Tyndall Centre does point out that the impact can be mitigated by seacoast protection, even with rises on the order of two meters in this century, but substantial measures are needed. There is a serious question whether seacoast populations around the world will approach such prospects with the same discipline as, for example, the Dutch have done historically, especially if the prospect of substantially greater sea level rise seems likely for century after century.

The above rise in sea levels, together with changed climate, agricultural disruptions and famines, spread of disease, water scarcity, and severe storm damage will not occur in a world that is otherwise sustainable and resilient. In the Philippines, for example, sea level rise would add to a problem already

created by excessive ground water extraction, which is lowering the land from between several centimeters to more than a tenth of a meter *annually.*[21] Thus two meters of sea level rise by the end of the century may well be additive to the substantial lowering of land levels in some areas by such extraction. And the concentration of population in the low-lying areas listed above of course exacerbates the effect of sea level rise.

Glacial melting cannot be ignored in the midst of these other phenomena. Some hundred million people in South America and one to two billion in Asia rely on glacial runoff for all or part of their fresh water supply. As these glaciers melt, quite possibly within a few decades, they will add substantially to the need to emigrate in search of water and arable land. In a world that also sees a two-meter sea level rise, with continued flooding ahead, it will take extraordinary effort for the United States, or indeed any country, to look far beyond its own salvation. If Americans have difficulty reaching a reasonable compromise on immigration legislation today, consider what such a debate would be like if we were struggling to resettle millions of our own citizens -- driven by high water from the Gulf of Mexico, South Florida, and much of the East Coast reaching up nearly to New England – even as we witness the northward migration of large populations north from Latin America and the Caribbean. Such migration will likely be one of the Western Hemisphere's early social consequences of climate change and sea level rise of these orders of magnitude. Issues deriving from inundation of a large amount of our own territory together with migration toward our borders by millions of our hungry and thirsty Southern neighbors are likely to dominate U.S. security and humanitarian concerns. Globally as well, populations will migrate from increasingly hot and dry climates to more temperate ones.

In the 1990s many decisions about the use of U.S. military forces were dominated by humanitarian considerations: Somalia, Bosnia, Kosovo. Where we did not act in response to such concerns, such as in Rwanda, many are regretful. But in a world in which there has been a two meter rise in sea level with more in prospect, and millions of people are migrating out of coastal areas and ports all over the world, it will be extremely difficult, perhaps impossible, for the United States to replicate the kind of professional and generous assistance provided to Indonesia following the 2004 tsunami. Even overseas deployments in response to clear military needs may prove very difficult. Nuclear-powered aircraft carriers and submarines might be able to deploy, but aviation fuel or fuel for destroyers and other non-nuclear ships could be unobtainable.

Overseas air bases would doubtless also be tangled in climatic chaos and aircraft fuel availability overseas would be highly uncertain. Further, the Navy is likely to be principally involved in finding ways to base, operate, overhaul, and

construct ships, as many ports and harbors south of New York on the East Coast and in foreign countries become unusable or usable only with massive expenditures for protection from the rise in sea levels. Civilians will likely be fleeing many coastal regions around the world, including in the United States. The US military's worldwide reach could be reduced substantially by logistics and missions near our shores.

One likely result of climate change -- especially if Northern Europe sees much colder weather as a result of a halting of the North Atlantic meridional overturning circulation and the weakening of the Gulf Stream – is Russia's substantially increased leverage over its neighbors. Cold Europeans are going to need even more Russian oil and gas, and quite likely Russian agricultural exports too as their own growing season shrinks.

On the other hand, based on current demographic trends and life expectancy (the average Russian male life expectancy is below that of Bangladesh), there will be fewer than 100 million Russians by 2050, nearly a third of whom will be Muslim. Even a cold Europe may experience substantially increased levels of immigration from south of the Mediterranean, both from sub-Saharan Africa and from the Arab world. Many of Europe's Muslim minorities, including Russia's, are not well-assimilated today, and the stress of major climate change and sea level rise may well foster social disruption and radicalization. Russia may not be a stable supplier of anything.

Northern Eurasian stability could also be substantially affected by China's needing to resettle many tens, even hundreds, of millions from its flooding southern coasts and coastal cities. China has never recognized many of the Czarist appropriations of Chinese territory, and Siberia may be more agriculturally productive after a 5-6 degree C rise in temperatures – adding another attractive feature to a region rich in oil, gas, and minerals . A small Russian population might have substantial difficulty preventing China from asserting control over much of Siberia and the Russian Far East.

Energy Infrastructure

Other interactions between climate change and the existing infrastructure could create major failures in the systems that support modern civilization. All other systems – from operating telecommunications to distributing food, pumping water, and more -- depend on energy. Yet energy systems themselves are vulnerable. Hydroelectric generation may be substantially affected by reduced glacial runoff or by upstream nations commandeering rivers in some parts of the world. Nuclear power plant cooling may be limited by reduced water availability. Increased numbers and intensity of storms could interfere with

long-distance electricity transmission, already heavily stressed in the United States and elsewhere.

Sea level rise and chaotic weather patterns may interfere with oil production in a number of locations, particularly from sea-based platforms and in parts of the Middle East, and with the operation of large oil tankers. Many U.S. oil refineries are in the Gulf Coast region and thus more vulnerable to disruption by storms than if they were located elsewhere. Hurricane Katrina came very close to shutting down the Colonial Pipeline, the major link from the Gulf Coast to the Eastern seaboard.

Malevolent Risks: Terrorism and Rogue States

Malignant risks may be bad enough, but our society, our way of life, and our liberty face serious challenges in addition to the infrastructure fragility exacerbated by climate change. The most salient is attack by terrorist groups or an enemy state, or a combination thereof. In addition, conflicts of different kinds would interrupt supply in major oil-exporting states. Finally, both our transportation infrastructure and our electricity grid are alarmingly vulnerable to a variety of malevolent threats.

Infrastructure Vulnerability: Oil

Our problems with oil derive in no small measure from the fact that over two-thirds of the world's proven reserves of conventional oil lie in the turbulent Persian Gulf region, as does much of oil's international infrastructure. Increasing U.S. dependence on this part of the world for our transportation needs will subject us to a wide range of perils.

In February 2006, in response to bin Laden's many calls in recent years for attacks on oil infrastructure, al Qaeda attacked Abcaiq, the world's largest oil production facility, in northeastern Saudi Arabia. Had it succeeded in destroying, for example, the sulfur-clearing towers there through which about two-thirds of Saudi crude passes -- say with a mortar attack -- it could have driven the price of oil to well over $100 a barrel for many months, perhaps even close to bin Laden's goal of $200 a barrel. Another major al Qaeda attack on oil infrastructure in the Gulf region was thwarted in April 2007.

Royal succession in Saudi Arabia could also bring major problems. King Abdullah is a sponsor of some reforms in the Saudi system and sometimes works toward cordial relations with us and other oil importers, but he is well into his eighties, as is Crown Prince Sultan. Prince Nayef, the Interior Minister, is one

possible successor to the throne. His views are famously close to those of the extremely reactionary Wahhabi religious movement in the Kingdom.

Iran's President Ahmadinejad is radical even by post-1979 Iranian standards. The efficacy of deterrence and containment in dealing with Iran's nuclear weapons development program is not clear when some of Iran's leaders talk of the desirability of Iran's becoming "a martyr nation" and shrug at the possibility of millions of deaths by saying "Allah will know his own."

In response to Iran's nuclear program, six Sunni Arab states, including Egypt and Saudi Arabia, announced in early 2007 that they too would have "peaceful" nuclear programs. But since a number of these states have very plentiful supplies of oil and gas it seems unlikely that all these programs will be limited to electricity generation. We may well be seeing the beginning stages of a Sunni-Shi'a nuclear arms race in the Gulf region.

The United States now borrows over $300 billion per year from creditors such as China and Saudi Arabia, writing national IOUs at a rate approaching a billion dollars a day to import oil. This contributes heavily to a weakening dollar and upward pressure on interest rates (our annual oil debt is well above our trade deficit with China). If borrowing to pay for oil is straining the world's wealthiest economy, it is far more debilitating for developing countries in, say, Africa that have no oil themselves. Debt is the central inhibitor of economic development. Importing expensive oil is helping bind hundreds of millions of the world's poor more firmly in poverty and desperation.

Some U.S. and international oil payments find their way to Saudi Arabia. The Saudis provide billions of dollars annually to their Wahhabi sect, which establishes religious schools and institutions throughout the world. Lawrence Wright in The Looming Tower states that with a little over one percent of the world's Muslim population, the Saudis support via the Wahhabis "… 90 percent of the expenses of the entire faith, overriding other traditions of Islam."[22]

These Wahhabi teachings, as articulated in the fatwas of their imams (as set forth, for example, in Shmuel Bar's, Warrant for Terror: Fatwas of Radical Islam and the Duty of Jihad (2006), are murderous with respect to Shi'a, Jews, homosexuals, and apostates, and horribly repressive with respect to everyone else, especially women. They are essentially the same basic beliefs as those expressed by al Qaeda. Indeed the fundamental argument between the Wahhabis and al Qaeda is not about underlying beliefs. It is rather a struggle, a bit like that between the Stalinists and Trotskyites of the 20's and 30's, over which of them should be in charge. The hate-filled underlying views of both, however, point in the same overall direction. Many Wahhabi-funded madrassahs, world-wide, echo and

perpetrate this hatred and thus promote its consequences. Thus, as has often been said, this Long War in which we are engaged is the only war we have ever fought in which we are funding both sides.

Finally, as Tom Friedman of the New York Times puts it, "the price of oil and the path of freedom run in opposite directions". Work by Oxford Academic Paul Collier and other scholars has pointed out the link between commodities commanding huge amounts of economic rent, such as oil (or the gold and silver brought from the New World by Spain in the sixteenth century), and political autocracy. Such a commodity, unless acquired by a mature democracy such as Norway or Canada, tends to concentrate and enhance the power in the hands of a ruler. "There should be no taxation without representation" Princeton's Bernard Lewis often says, "but it should also be noted that there is no representation without taxation." If a country is so oil-rich that it doesn't need taxes, it does not need, and often does not have, any real legislative body to levy them – and thus no alternate source of power in the State. And as for enhanced power from oil wealth, note the behavior in recent years of Messrs. Ahmadinejad, Chavez, and Putin.

Put simply, there are substantial national security reasons to be concerned about oil's role as a strategic commodity.

Infrastructure Vulnerability: Electricity

Our electric grid is quite vulnerable to attack in a number of ways. I will deal here with only two, both potentially catastrophic: terrorist physical and cyber attack on key components, and electro-magnetic pulse attack utilizing a nuclear weapon.

Terrorist Attack

In 2001 the National Research Council (composed of the National Academies of Sciences and Engineering and the Institute of Medicine) convened a Committee on Science and Technology for Countering Terrorism. The Committee, on which I served, published in 2002 its Report titled Making the Nation Safer. One section dealt with the electricity grid and its vulnerabilities.

The Committee was candid:

> "The most insidious and economically harmful attack would be one that exploits the vulnerabilities of an integrated electric power grid. 'A chain is only as strong as its weakest link' applies here. Simultaneous attacks on a few critical components of the grid could result in a widespread and

> extended blackout. Conceivably, they could also cause the grid to collapse, with cascading failures in equipment far from the attacks, leading to an even larger long-term blackout."[23]

The Committee also stressed that some key components had few spares and that those "could take several years to procure." And it made a point of noting that those who operate the grid have historically focused on natural disasters, not on the far more demanding "security from malevolent attack." It emphasized that, whereas deregulation has encouraged efficiency, it has *not* encouraged "redundancy, reliability, and security," and that protection against cyberthreats "seriously lags the rapidly advancing cyberweapons available."[24]

The Committee made seventeen detailed recommendations to improve the grid's resilience against terrorist attack, including the development and acquisition of "modular, lightweight, universal" Extra-High-Voltage (EHV) transformers. EHV's today have few spares, and replacements would "require many months to manufacture and ship from foreign suppliers."[25] Finally, the Committee recommended technology to enable the "islanding" of the portions of the grid (making it possible for some segments to continue to operate even if the rest of the grid is taken down), based in part on "distributed generation" – generators "of more modest size in close proximity to load centers." [26]

Five years later, very little has been done to implement these recommendations.

It is important to recognize that, with one exception, military bases in the United States no longer have their own capacity to generate electricity. The military thus shares civilians' vulnerability to terrorist attack on the grid.

Electro-Magnetic Pulse (EMP) Attack

In 1962, both Soviet and American atmospheric nuclear tests detected a troubling phenomenon: three types of electro-magnetic pulses generated at high altitude by nuclear detonations could seriously damage or destroy electronic and electrical systems at ranges as much as 1000 miles from the blast.[27] (There is no reported direct effect on humans of these pulses; thus EMP effects are, in a sense, the opposite of those of the neutron bomb that was much discussed in the 1980's.) Both the USSR and the United States hardened some of their key military components against these EMP effects in subsequent years, but such hardening is still undertaken for only a very few military components. As a general proposition our civilian systems and the vast majority our military electronics systems are vulnerable to EMP attack.

For most of the Cold War we were concerned exclusively with the Soviet nuclear threat, then later with the Chinese threat as well. It was thought that both adversaries could be deterred by our own nuclear capability and thus there was little impetus behind the occasional efforts to spend the money to expand protection against EMP. The 2004 EMP Commission Report, however, provides a useful update.

The detonation of a single nuclear warhead between 40 and 400 kilometers above Earth[28] could cause "unprecedented cascading failures of our major infrastructures," primarily "through our electric power infrastructure" crippling "telecommunications … the financial system … means of getting food, water, and medical care to the citizenry … trade … and production of goods and services."[29] The Commission points out that "the slightest insult or upset to the system can cause functional collapse..." , since as a result of inadequate transmission lines our electric grid "operates at or very near local limits on its physical capacity." The Commission assesses that detonation of a single nuclear warhead could "encompass and degrade at least 70 percent of the Nation's electrical service, all in one instant."[30] It also notes that, as a result of fire safety and environmental concerns, locally stored fuel for emergency power supplies, such as diesel for generators, is often limited to about 72 hours' worth.[31] Meanwhile, food available in supermarkets generally supplies about one to three days of requirements for customers and regional food warehouses usually carry enough for a multi-county area to last about one month.[32]

The Commission points out that "[w]hat is different now is that some potential sources of EMP threats are difficult to deter." It discusses North Korea and Iran as well as terrorist groups. Both nations have ballistic missiles; if either state had a nuclear warhead for even a short-range missile such as a SCUD, launching an effective EMP attack from a small ship would not be a major technical feat. Deception to mask the source and sponsor of such an attack is easily imaginable – for example a fishing boat launch platform sunk immediately after launch. But even if the source of the attack were known one must contend with the Commission's point about the possible inefficacy of deterrence. President Ahmadinejad and other Iranian leaders, for example, have welcomed the prospect of Iran's becoming a "martyr nation," although it cannot be said that this notion is generally affirmed in Iranian ruling circles. The Commission points out that in the aftermath of the Cold War both China and Russia have considered employing EMP as a sole means of attacking the United States, and senior Russian officials have spoken openly to US officials about the possibility as recently as the late 1990s.[33]

Toward a Partnership to Deal With Both Malignant and Malevolent Risks: Tree Huggers and Hawks

The malignant and malevolent risks set out above seem to stem from very different causes -- and different kinds of people, with different backgrounds, tend to address them separately. This cultural separation – analogous in some ways to C.P. Snow's famous description some decades ago of the intellectual world's division into the two cultures of literature and science – hinders cooperative action. For the issues at hand, let's call this a division between the tree hugger culture and the hawk culture.

Both the malignant and malevolent problems described above are extraordinarily grave, and much too urgent to await a lengthy debate between the two cultures about how intensely we should believe that each risk will become manifest. This is especially true because, as suggested below, the steps needed to contend successfully against both types of problems appear to have a great deal in common, at least in the important field of energy.

A hawk who is steeped in the history of the Muslim Brotherhood but has no time for the history of glaciers need not be required to pledge his belief that climate change will hit a certain degree by a certain date. Scientific theories, Karl Popper taught us, must always be held tentatively; they are productive precisely to the degree that they offer an invitation to be *dis*proven. Even as society used Newton's theories for centuries, the path of human progress was to give others a chance to create theories that would replace his. Eventually Einstein's did.

Nevertheless, we should argue to our hawk that as a matter of judgment, not certainty, there is sufficient evidence of developing climate change that he or she should take the issue seriously. Further, if we consider together plausible climatic tipping points and the increased emissions from world economic development, there is a risk that such change could become cataclysmic. Thus the only responsible course of action is to begin now to deal with the problem as sensibly and affordably as we can.

We should say something similar to a tree hugger who is quite attentive to possible change in the North Atlantic conveyor, but who believes that to deal with terrorism now and for the foreseeable future we need only enforce the criminal law -- and that a rogue state or terrorist EMP attack on the United States must be someone's idea of a film plot for the PG-13 market. The tree hugger's blind spot is precisely where the hawk's eyes are trained (and vice versa). But our tree hugger needs to remember that fanatic enemies with access to destructive technology have already wreaked mass death on modern societies.

The tree hugger needs to keep an open mind, remember the Nazis, and recognize that evil exists, and happens.

As a thought experiment we might try inviting a tree hugger, someone strongly committed to reducing the risk of climate change, to address a major malignant issue by producing a short list of policies that could soon lead to substantial reductions of emissions. We will ask the tree hugger to focus on the ways in which we generate electricity, fuel transportation, power industry, and operate buildings, leaving such topics as preventing deforestation and promoting proper agricultural practices until later. We want him to focus on energy because we are going to submit his list to someone else for comment -- a hawk who is heavily focused on energy security -- to see if there is anything on which they can agree.

For our tree hugger we decide to summon the shade of John Muir, and for our hawk the shade of George S. Patton. They eye one another warily, but agree to undertake our project.

After sitting and pondering thoughtfully for a time under some redwoods, Muir submits a list of nine proposals for Patton's consideration:

l. Begin with improving the energy efficiency of buildings. Muir notes that Wal-Mart is finding that with such simple steps as painting its store roofs white and adding skylights, the company is getting 20 percent improvement in energy efficiency today and expects 25-30 percent improvements by 2009. And Muir has seen a recent McKinsey & Company report that says that merely by using existing technologies (where there is an internal rate of return of 10 percent or more) we can reduce world energy demand by 125-145 QBTUs by 2020, 20-24 percent of end-use demand. The vast majority of this, the report says, would be in buildings of all sorts, including industrial facilities, and would contribute up to half the greenhouse gas emission abatement needed to cap the long-term concentration of greenhouse gases in the atmosphere at 450-550 ppm.[34] Muir knows that the Rocky Mountain Institute's thorough work shows even more opportunity for energy savings from reduced energy use in buildings.

"I'm completely with you on this one", says Patton. "Less need for energy, less need to add generating capacity and transmission lines to the grid. Every day, the grid reminds me more and more of the Maginot Line, just sitting there vulnerable to being taken out by creative tactics – the less we need it the better. And I like the fact that this efficiency stuff makes money for the folks who implement it rather than costing something."

2. Radically increase the use of combined heat and power (CHP). His second item, Muir says, could be implemented relatively quickly and would let us get dual use from energy instead of wasting a lot of the heat our industry produces by just venting it into the atmosphere. Half of Denmark's electricity, for example, comes from CHP. Only about 8 percent of U.S. electricity comes from CHP, but the problem – like building efficiency – is not that we don't have the technology. Rather, Muir says, our commitment to wasting heat is determined by culture and regulations. Much of the reason CHP struggles in the United States is because of the opposition of state Public Utility Commissions (PUCs). Certain steps are needed to ensure safety, Muir concedes, but the Danes have figured this out and completely changed their system in just 20 years. To do what they've done we just need to change most states' PUC policies. CHP generally has the effect of generating electricity and heat closer to where they are used, in relatively small facilities, Muir notes.

"Go Danes!" says Patton. "You know, John," he continues, "I admit I was pretty skeptical when I agreed to do this with you, but I've gotta admit I'm learning some things and I like this one too. Just using energy we're already producing – makes all the sense in the world. And it looks like each of these two ideas of yours reduces the need for new centralized power generation plants as well as new long-distance transmission lines. Relying on smaller, more distributed, production should improve resilience against terrorist attack. Keep 'em coming."

3. Create strong long-term incentives for small-scale (single-building-based) distributed generation of electricity and heating/cooling. Forty out of fifty states, Muir says, now have "net metering" laws that in principle make it possible for those who have generating capacity -- say roof-top solar photovoltaic systems -- to sell some home-generated electric power back to the grid. But in practical terms, state laws and regulations leave a lot to be desired in making this work. The cost of home-generated power is about to decline sharply, says Muir. As thin-film and nano-solar come on the market at costs substantially below those of today's silicon cells, and as solar collectors are integrated into building materials such as shingles, these technologies can begin to have a substantial effect on the need for central power generation. Small-scale wind turbines, operating at lower wind speeds than the large wind turbines, are beginning to come into the single-building market as well. Distributed solar and wind technologies complement one another since generally the sun shines at a different time of day than the wind blows, and increased use of both can be facilitated by storing electricity in improving batteries. Shallow (heat pump) geothermal is showing promise for heating and cooling of individual buildings; together with distributed solar and wind it may be able to satisfy a very substantial share of individual building energy needs. Distributed generation

will be renewable and hence not carbon-emitting, Muir notes: a coal-fired power plant will not fit on a roof.

"John," says Patton, "anyone who has ever been in combat knows that you need flexibility and initiative at the small-unit level because the unexpected always happens, and if your small units are good you can adapt faster. I've always said "small had damned well better be beautiful." You have to be able to put maximum reliance on your platoon leaders and sergeants -- that's how I was able to relieve Bastogne so fast. You're making me see that the same logic applies to having an energy system that's resilient against terrorist and EMP attack. Damn, are you sure you don't have a military background?"

4. Follow California and decouple revenue from earnings for electric utilities to encourage conservation and grid modernization. This is a big one, says Muir. California, he notes, initiated this simple step some twenty years ago; there, and (very recently) in Idaho, utilities' earnings are based on their investment, not their sales of electricity. But in the other 48 states, utilities must sell more electricity in order to earn more for their shareholders. It doesn't matter if it's used wastefully – the incentive systems established by 48 PUCs don't deter waste. In California though, if a utility invests in making the grid "smarter", say to help consumers conserve electricity, it earns more for its shareholders. The effect of decoupling revenue from earnings is dramatic: over the last twenty years, electricity use per capita in California has stayed flat, while that of the rest of the country has increased 60 percent. Major double-digit improvements in energy efficiency are possible if other PUCs would just admit that what California and Idaho have done is problem-solving and that their own current policies are problem-creating.

"Sounds great," says Patton. "I know California screwed up on the Enron thing a while back – hell, everybody screws up sometime – even I did once. But the Californians sure have this decoupling right. Say, who writes those other 48 PUCs' fitness reports? Why don't their superior officers just relieve them of command and put somebody in charge who's willing to learn from what the California folks have done?"

5. Give steady and long-term encouragement to the deployment of renewable electricity generation for the grid from wind, solar, hydro and geothermal. Muir says many incentives such as tax credits for such deployment have been periodically interrupted, delaying, for example, production of wind turbines and slowing the introduction of these technologies.

"Well," says Patton, "if we have to add to the grid I suppose these are okay. The grid will be around for a long time, so we have to improve its resilience by

stockpiling transformers and defending better against cyber attacks in any case. But even if we improve its defenses and make it cleaner, increasing our reliance on a Maginot Line is not my favorite way to go. I liked your efficiency and CHP and rooftop ideas better, but I guess I can go along with these – I like the fact that at least some of them probably won't be too large and can be distributed to some extent. Also, power plants using sun, wind, hydro and geothermal aren't vulnerable to terrorist interruption of their fuel supplies."

6. Vigorously develop carbon capture and sequestration (CCS) for coal-fired power plants. Muir points out that this may well rely on already-developed Integrated Gasification Combined Cycle (IGCC) plants that facilitate CO2 capture. For sequestration, the gas may initially be utilized for tertiary recovery in existing oil and gas wells. Subsequently, deep saline aquifers show promise as a locus for long-term CO2 sequestration.

Again, Patton is only lukewarm. "Adding to the grid just gives the terrorists eyeing our transformers and the crazy guys with EMP attack plans a bigger target," he says. "But if we can't get all the power we need by implementing your ideas about reducing demand and increasing distributed generation, then I'm okay with this CCS stuff, but reluctantly."

7. Provide tax incentives for the purchase of plug-in hybrid gasoline-electric vehicles (PHEVs). Now for transportation, Muir says. GM has announced the production of the Chevrolet Volt PHEV in 2010; Toyota's Prius was designed originally with an all-electric mode for driving, so it is well on the way to being a plug-in once a battery more capable than that in the current Prius is supplied. There are several dozen hybrid vehicles, principally Priuses, that have been converted by their owners into PHEVs using currently available batteries; they seem to be getting up around 100 mpg once their initial 25-40 miles of all-electric driving is factored in (Muir tells Patton he can follow all this at www.calcars.org.) A PHEV that has been plugged into a standard 120-volt socket in a garage overnight and then driven the next day -- once it reaches the end of the electricity supplied in its overnight charge -- becomes an ordinary hybrid using both gasoline and electricity until it can be charged again.

The average US light vehicle is driven just over 30 miles a day, Muir adds. It is clear that, in addition to providing consumers the ability to drive for some tens of miles a day on inexpensive off-peak overnight electricity at a fraction of the cost of driving on gasoline, moving from a standard internal-combustion-engine vehicle to a PHEV reduces greenhouse gas emissions substantially. Studies four years ago estimated that the average reduction nationally would be in the range of 46 to 61 percent.[35] In states without substantial coal-fired generation (such as on the West Coast), the greenhouse gas reduction has been estimated at over 80

percent, although the reduction is small to negligible in states that have almost entirely coal-fired grids. Still, as electricity production is modified, say via renewables or CCS, and its CO2 emissions reduced, cleaning up the grid also cleans up PHEV emissions.

Finally, by keeping just a small number of PHEVs plugged into the grid after they are charged, they can be used in such Vehicle-to-Grid (V2G) connections to substitute for around $12 billion annually in "ancillary services," such as fossil fuel purchases to stabilize and regulate the grid's operations and "spinning" reserves to deal with power outages.[36] This can mean a lot less use of fossil fuel and also substantial payments back to plug-in hybrid owners – one FERC Commissioner even calls plug-ins "Cash-Back Hybrids." Grid modernization can help implement such major innovations.

"John, now you're talking again," says Patton. "Electricity (and plug-ins) can do to oil what electricity (and refrigeration) did to salt around the time I was born – destroy the damned stuff as a strategic commodity. Salt used to be a really big deal because it was the only way to preserve meat. People even fought wars over it. But now nobody gives a damn what country has salt mines. Since around the time I commanded the Third Army, maybe before, the number one strategic commodity has been oil. It sure was in the War. If old Tooey Spaatz, God bless him, hadn't persuaded FDR to let him hit Ploesti and Leuna and take out the Germans' fuel, they would have had enough for the Panzers to get to Antwerp and the Battle of the Bulge could have gone the other way."

Patton shook his head sadly: "You know, John, there are some jaspers at the Council on Foreign something-or-other in New York who say we're doing a 'disservice to the nation' by trying to get the country away from oil dependence. Do they think it's a 'service' to make it easier for some other country to have the leverage over us that we had over the Germans in the War? Those guys would probably also tell drunkards to make sure they have a glass or two of red wine every day for their health – not crazy in the abstract, but sure as hell not the message a guy in his cups needs to hear. But you're telling those Council guys to get with the program and help get us off oil fast – John, you're my man."

8. <u>Mandate a rapid transition to flexible fuel vehicles (FFVs).</u> Muir says this is simple, and would mean that both US-produced vehicles and imports could use at least gasoline, ethanol (particularly cellulosic), butanol, and methanol in any mixture. This would create a market for renewable fuels by removing a needless barrier, Muir points out. He adds that using such fuels can substantially reduce greenhouse gas emissions, especially when the feedstocks are biomass and waste. The cost is modest – around $100 per vehicle or less. Between 2002 and 2005, Brazil moved from 5 percent to 75 percent of their new vehicles' being

FFVs. Incentives such as tax credits should be provided promptly to encourage pumps for these fuels to be installed at stations.

"Hey, John," Patton booms. "I'm fine with markets and cap-and-trade and all that, but sometimes ya gotta just tell people to, damn it, *do* it. I got no problem with mandates – hell, if you gotta move fast and it's important, I absolutely *love* 'em. We did it for cars with seat belts and air bags because people's lives were at stake. Well, they're at stake because of oil dependence too. Getting away from that dependence is a matter of national security. Somebody just needs to show as much gumption as the Brazilians and issue a damned *order* about obvious stuff like this."

9. Provide incentives for the production of renewable fuels and specialty chemicals from cellulosic biomass; give special attention to the desirability of using waste products as a feedstock, particularly where methane is thereby reduced. Muir points out that we should be moving away from hydrocarbons and toward carbohydrates generally as feedstocks for liquid fuels, electricity generation, and chemical production. But he is especially worried about a number of wastes producing methane if left in their natural state because of the latter's potency as a greenhouse gas (more than 20 times that of CO2).

"Fine with me, John, " says Patton. "Let's clean stuff up while we get off oil – a threefer: helps thwart the terrorists, reduces that carbon you're so worried about, and things smell better. I'm gonna start calling you 'God's janitor'. Basically you're nine for nine. Pretty interesting – we keep getting to the same place as long as we don't have to agree with one another's reasons for going there. Who'd 'a thought it?"

"But there are three things you didn't mention," he adds: "nuclear power, hydrogen, and coal-to-liquid transportation fuels. I've seen a lot of guys lobbying lately on all three of those -- must be some money behind 'em. What do you think?"

Patton and Muir talk for a while and agree that nuclear power plants may be an acceptable last resort if we have to add generating capacity in the United States. Muir winces at the prospect, but in spite of the waste storage problem he's always been worried about, he's come reluctantly to support nuclear in some cases because of nuclear plants' lack of carbon emissions. Patton has a nagging problem with terrorist threats to power plants, but agrees that it would be very hard to cause a core meltdown. The two agree we should definitely oppose spreading nuclear energy around the world since with today's treaties and inspections it's impossible in practical terms to stop countries from using their nuclear "electricity" programs as a way to get into the nuclear weapons business.

The hydrogen discussion just takes a few seconds. Both see some uses for hydrogen, but when they start talking about driving the "hydrogen highway" in family cars with hydrogen fuel cells and hydrogen storage and pumps at all the neighborhood filling stations, they shake their heads, amazed at the huge cost – especially, they chuckle, since the only infrastructure fueling cost you need for plug-in hybrids is an extension cord for each car-driving household.

Coal-to-liquids (CTL) is their only area of disagreement. Muir hates the carbon it would produce; Patton likes the way it undermines oil. As they finish their discussion, Patton puts a hand on Muir's shoulder and says, "John, tell you what I'll do. Even though CTL plants would use American coal, which I like, some plants might need a big infrastructure that could be vulnerable to terrorists, which I don't like. I'm happy with your transportation ideas because they move us toward small local plants and distributed production of fuel, whether electricity or liquid -- nicely resilient. How about this: unless they figure out how to sequester enough of the carbon from CTL to satisfy you, I won't drop this option but I'll move it down to the bottom of my list -- but in exchange I'd like a little help from you on another matter: I think the Army needs at least 2-3 more armored divisions. What do you say?"

"George," laughs Muir, "You're a piece of work. I might be able to talk myself into rolling over for one or two of those things, but, if I do, for each one I support I'm going to need your backing for at least one new national park."

"John," says Patton, "I like your style. Say, can you hunt in those places?"

"George," gasps Muir, "you are absolutely imposs . . ."

Patton grins, "just pullin' your chain."

As they stroll off together into the evening haze, Patton adds, "Y' know, Johnny, this could be the start of a beautiful friendship."

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[3] Fred Pearce, With Speed and Violence (Beacon Press, 2007), p.58 (hereinafter "Pearce")
[4] Pearce, pp. 84-85 (quoting L. Smith)
[5] Ibid
[6] Pearce, pp. 77-85
[7] Pearce, p. 85 (citing L. Smith)
[8] Pearce, pp. 57-58
[9] Joseph Romm, Hell and High Water (HarperCollins, 2007), p. 86 (hereinafter, "Romm")
[10] Romm, p. 86; Pearce, p. 58
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[16] Zubrin, pp. 109-10
[17] Pearce, p. 59
[18] Romm, p. 86
[19] Romm, p. 87 (quoting P.Barrett)
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[28] EMP Commiss, p. 4
[29] EMP Commiss, p.1
[30] EMP Commiss, p. 18
[31] EMP Commiss, p. 17
[32] EMP Commiss, p. 40
[33] EMP Commiss, p. 2
[34] McKinsey, p. 12
[35] EPRI 2003, Argonne-led consensus of researchers, chart 11
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