Energy Efficiency and Job Creation

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Executive Summary: Numerous studies have examined the energy, economic, and environmental impacts of a national energy strategy that emphasizes greater energy efficiency. *America's Energy Choices*, for example, showed that vigorous adoption of cost-effective energy efficiency and renewable energy measures could reduce national energy intensity in 2030 by nearly 50%, dramatically reduce our nation's petroleum dependence, save consumers more than $2 trillion net over the next 40 years, and cut carbon dioxide emissions in 2030 by more then 70% relative to emissions in 1988.[1] However, *America's Energy Choices* and similar studies only consider direct economic impacts -- the cost of energy efficiency measures and the value of the energy savings.

The purpose of this study is to build on *America's Energy Choices* by analyzing the indirect economic benefits of a high efficiency energy strategy -- the impacts on employment and income that could result from shifting economic activity away from the energy supply sectors of our economy and from reducing the cost of energy services. We compare a High Efficiency scenario for all end-use sectors of the economy to a Reference, business-as-usual scenario.[2]

We also examine the employment and income impacts that result solely from improving the fuel economy of automobiles and light trucks.

The analysis is conducted using an input-output economic model. Dividing the economy into 25 sectors, the input-output model estimates the overall employment and income effects from changes in spending patterns in particular sectors.[3] The changes consist of investments in energy efficiency measures and reductions in energy consumption and thus energy bills. The model accounts for direct (i.e., on-site) effects, indirect (i.e., supplier) effects, and induced (i.e., respending) effects from investments and expenditures at all levels.

The High Efficiency scenario assumes extensive efficiency improvements in all sectors of the economy--more efficient vehicles, improved appliances, better insulated buildings, more efficient lighting, manufacturing improvements, and the like. All of the efficiency measures are cost effective on a life-cycle basis considering only direct energy costs (i.e., without quantifying and taking into account externalities). The additional investment in energy efficiency measures in the High Efficiency scenario averages about $46 billion per year during 1992-2010. These investments result in about 20% less energy consumption in 2010 compared to the Reference scenario, with absolute energy consumption rising slightly during 1992-2000, but then declining slightly during 2001-2010. Energy use per unit of GDP falls 2.4% per year on average during 1990-2010 in the High Efficiency scenario. This rate nearly matches the decline in energy intensity in the United States during 1973-86. We also estimate a 24% reduction in carbon dioxide (CO2) emissions, 14% reduction in nitrogen oxides (NOx) emissions and 5% reduction in sulfur dioxide (SO2) emissions in 2010 in the High Efficiency scenario relative to the Reference scenario.

Based on our input-output analysis, the High Efficiency scenario leads to more jobs, higher personal income, and marginally higher GDP throughout the twenty-year period (see Table S-1). We estimate that about 293,000 new jobs could be created by 1995, 471,000 new jobs by 2000, and nearly 1.1 million jobs by 2010 on a net basis. The addition of 1.1 million jobs in 2010 represents approximately a 0.7% increase in the projected employment level that year (see Figure S-1). Likewise, the rise in personal income during the twenty-year period in the high efficiency case reaches 0.5% by 2010, while the increase in GDP is less than 0.1%.

The positive employment and income results are due primarily to the relatively low labor intensity of the energy sectors (coal, oil and gas extraction, fuel refining, and electric and gas utilities) compared to the economy as a whole. Conserving energy reduces the energy bills paid by consumers and businesses, thereby enabling greater purchase of non-energy goods, equipment, and services. The result is a shift of economic activity away from energy supply industries and towards sectors of the economy which employ more workers per dollar received. Regarding the different effects, less than 10% of the net jobs created are associated with direct investment in efficiency measures while more than 90% are associated with energy bill savings and respending of those savings.

Most sectors of the economy gain jobs and generate additional income while a few sectors lose jobs and generate less income in response to widespread energy efficiency improvements (see Table S-2). Our analysis shows the largest absolute increase in jobs is in the construction, retail trade, and services industries. These sectors install energy efficiency measures and gain new business orders from the respending of energy bill savings.

As expected, the energy supply industries employ fewer workers in the High Efficiency scenario as compared to the Reference scenario. The oil and gas extraction industries and gas utilities lose the most workers in percentage terms. It is important to recognize that the projected job losses in Table S-2 are based on comparison with the Reference scenario. Considering the projected change in the actual employment levels between 1990 and 2010, a total of about 200,000 jobs

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could be lost in the five energy sectors by 2010 in the High Efficiency scenario. These potential job losses are due primarily to expected productivity improvements, not to changes in absolute energy use during 1990-2010. In addition, individual companies may be able to reduce any adverse jobs impacts by diversifying into the energy efficiency field (e.g., if utilities hire workers to implement energy efficiency programs).

Efficiency improvements solely in automobiles and light trucks also yield favorable jobs and income results. In the Vehicle Efficiency scenario, we assume that the average rated fuel economy of new cars increases from 28 miles per gallon in 1990 to 40 miles per gallon in 2000 and then to 50 miles per gallon by 2010, with equivalent percentage improvements in the fuel economy of light trucks. Compared to the Reference scenario, the Vehicle Efficiency scenario produces 72,000 and 244,000 more jobs in the overall economy by 2000 and 2010, respectively. About 20% of the net increase in jobs is within the motor vehicle industry itself. Furthermore, we find that there is a net gain in jobs in the nation as a whole even if there is either a moderate increase in the fraction of vehicles that are imported or a slight drop in vehicle sales at the same time that fuel economy increases. Conversely, a decrease in import share or an increase in vehicle exports would yield even more new jobs than indicated above.

The results of this study are consistent with other input-output studies that examine how energy efficiency improvements affect employment levels. These other studies, which consider more limited efficiency investments and/or geographic coverage, indicate that specific energy efficiency measures or programs create more jobs at the regional or state level as compared to energy supply projects.

In conclusion, this study adds a new dimension to the national debate over energy priorities. Energy efficiency improvements lead to more jobs and higher personal income at the national level, in addition to saving consumers money, reducing energy imports, and cutting pollutant emissions associated with energy supply. In terms of energy policy objectives, it is unnecessary to choose either economic benefits and jobs on the one hand or environmental protection on the other. We can create more jobs **and** better protect the environment by adopting policies that enhance energy efficiency. Given the economic, energy, and environmental challenges that our nation faces, can we afford not to act?
55 pp., 1992, $8.00/ED922

Table S-1. Summary of Input-Output Analysis

	1990	1995	2000	2005	2010
Reference Scenario					
GDP (Billion 1990$)	$5,514	$6,205.6	$6,993.0	$7,889.7	$8,911.1
Jobs (Thousands)	122,600	129,273	136,494	144,273	152,650
Income (Billion 1990$)	$3,290	$3,712.4	$4,192.9	$4,741.0	$5,366.3
Energy (Quads)	85.02	90.49	95.61	101.20	106.10
Btu/GDP (1990$)	15,419	14,582	13,672	12,827	11,906
High Efficiency Scenario					
GDP (Billion 1990$)	$5,514	$6,206.6	$6,993.8	$7,891.2	$8,914.8
Jobs (Thousands)	122,600	129,566	136,965	145,049	153,737
Income (Billion 1990$)	$3,290	$3,719.0	$4,203.6	$4,761.2	$5,394.8
Energy (Quads)	85.02	87.14	88.07	87.06	85.35
Btu/GDP (1990$)	15,419	14,040	12,593	11,033	9,574
Net Efficiency Gains					
GDP (Billion 1990$)	n/a	1.0	0.8	1.5	3.7
Jobs (Thousands)	n/a	293.0	471.0	776.0	1,087.0
Income (Billion 1990$)	n/a	6.6	10.7	20.2	28.5
Energy (Quads)	n/a	-3.4	-7.5	-14.1	-20.8
Btu/GDP (1990$)	n/a	-542.0	-1,079.0	-1,794.	-2,332.0

Table S-2. Differences in Employment Levels in 2010, High Efficiency vs. Reference Scenario

Sector	Net Job Changes	Percent Change
Subtotal Gains	1,503,088	n/a
Construction	342,101	4.4%
Retail Trade	197,491	1.1%
Services	152,264	0.3%
Agriculture	118,569	3.6%
Restaurants	105,259	1.3%
Health Services	91,651	0.8%
Finance, Insurance, Real Estate	77,931	0.8%
Non-Durable Goods	73,589	0.8%
Other Manufacturing	72,824	1.1%
Motor Vehicles	53,587	6.2%
Wholesale Trade	44,644	0.5%
Hotels and Lodging	34,404	1.4%
Food Processing	27,270	1.8%
Stone, Glass, Clay	26,403	4.1%
Primary Metals	23,417	2.3%
Transportation/Communications	22,873	0.4%
Chemicals	22,018	1.8%
Pulp and Paper	10,958	1.5%
Miscellaneous Mining	3,943	2.1%
Water/Sewer Utilities	892	0.4%
Subtotal Losses	(416,309)	n/a
Refining	(8,095)	(5.4%)
Coal Mining	(20,300)	(11.9%)
Gas Utilities	(71,090)	(31.0%)
Oil and Gas Extraction	(139,080)	(30.4%)
Electric Utilities	(177,744)	(21.6%)
Net Employment Gain	1,086,779	n/a

An Abrupt Climate Change Scenario and Its Implications for United States National Security

October 2003

By Peter Schwartz and Doug Randall

Imagining the Unthinkable

The purpose of this report is to imagine the unthinkable – to push the boundaries of current research on climate change so we may better understand the potential implications on United States national security.

We have interviewed leading climate change scientists, conducted additional research, and reviewed several iterations of the scenario with these experts. The scientists support this project, but caution that the scenario depicted is extreme in two fundamental ways. First, they suggest the occurrences we outline would most likely happen in a few regions, rather than on globally. Second, they say the magnitude of the event may be considerably smaller.

We have created a climate change scenario that although not the most likely, is plausible, and would challenge United States national security in ways that should be considered immediately.

Executive Summary

There is substantial evidence to indicate that significant global warming will occur during the 21st century. Because changes have been gradual so far, and are projected to be similarly gradual in the future, the effects of global warming have the potential to be manageable for most nations. Recent research, however, suggests that there is a possibility that this gradual global warming could lead to a relatively abrupt slowing of the ocean's thermohaline conveyor, which could lead to harsher winter weather conditions, sharply reduced soil moisture, and more intense winds in certain regions that currently provide a significant fraction of the world's food production. With inadequate preparation, the result could be a significant drop in the human carrying capacity of the Earth's environment.

The research suggests that once temperature rises above some threshold, adverse weather conditions could develop relatively abruptly, with persistent changes in the atmospheric circulation causing drops in some regions of 5-10 degrees Fahrenheit in a single decade. Paleoclimatic evidence suggests that altered climatic patterns could last for as much as a century, as they did when the ocean conveyor collapsed 8,200 years ago, or, at the extreme, could last as long as 1,000 years as they did during the Younger Dryas, which began about 12,700 years ago.

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In this report, as an alternative to the scenarios of gradual climatic warming that are so common, we outline an abrupt climate change scenario patterned after the 100-year event that occurred about 8,200 years ago. This abrupt change scenario is characterized by the following conditions:

- Annual average temperatures drop by up to 5 degrees Fahrenheit over Asia and North America and 6 degrees Fahrenheit in northern Europe
- Annual average temperatures increase by up to 4 degrees Fahrenheit in key areas throughout Australia, South America, and southern Africa.
- Drought persists for most of the decade in critical agricultural regions and in the water resource regions for major population centers in Europe and eastern North America.
- Winter storms and winds intensify, amplifying the impacts of the changes. Western Europe and the North Pacific experience enhanced winds.

The report explores how such an abrupt climate change scenario could potentially de-stabilize the geo-political environment, leading to skirmishes, battles, and even war due to resource constraints such as:

1) Food shortages due to decreases in net global agricultural production
2) Decreased availability and quality of fresh water in key regions due to shifted precipitation patters, causing more frequent floods and droughts
3) Disrupted access to energy supplies due to extensive sea ice and storminess

As global and local carrying capacities are reduced, tensions could mount around the world, leading to two fundamental strategies: defensive and offensive. Nations with the resources to do so may build virtual fortresses around their countries, preserving resources for themselves. Less fortunate nations especially those with ancient enmities with their neighbors, may initiate in struggles for access to food, clean water, or energy. Unlikely alliances could be formed as defense priorities shift and the goal is resources for survival rather than religion, ideology, or national honor.

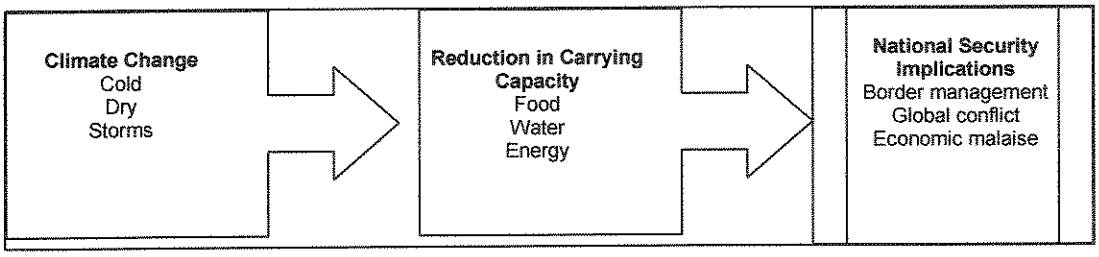
This scenario poses new challenges for the United States, and suggests several steps to be taken:

- Improve predictive climate models to allow investigation of a wider range of scenarios and to anticipate how and where changes could occur
- Assemble comprehensive predictive models of the potential impacts of abrupt climate change to improve projections of how climate could influence food, water, and energy
- Create vulnerability metrics to anticipate which countries are most vulnerable to climate change and therefore, could contribute materially to an increasingly disorderly and potentially violent world.

- Identify no-regrets strategies such as enhancing capabilities for water management
- Rehearse adaptive responses
- Explore local implications
- Explore geo-engineering options that control the climate.

There are some indications today that global warming has reached the threshold where the thermohaline circulation could start to be significantly impacted. These indications include observations documenting that the North Atlantic is increasingly being freshened by melting glaciers, increased precipitation, and fresh water runoff making it substantially less salty over the past 40 years.

This report suggests that, because of the potentially dire consequences, the risk of abrupt climate change, although uncertain and quite possibly small, should be elevated beyond a scientific debate to a U.S. national security concern.



An Abrupt Climate Change Scenario and Its Implications for United States National Security

October 2003

Introduction

When most people think about climate change, they imagine gradual increases in temperature and only marginal changes in other climatic conditions, continuing indefinitely or even leveling off at some time in the future. The conventional wisdom is that modern civilization will either adapt to whatever weather conditions we face and that the pace of climate change will not overwhelm the adaptive capacity of society, or that our efforts such as those embodied in the Kyoto protocol will be sufficient to mitigate the impacts. The IPCC documents the threat of gradual climate change and its impact to food supplies and other resources of importance to humans will not be so severe as to create security threats. Optimists assert that the benefits from technological innovation will be able to outpace the negative effects of climate change.

Climatically, the gradual change view of the future assumes that agriculture will continue to thrive and growing seasons will lengthen. Northern Europe, Russia, and North America will prosper agriculturally while southern Europe, Africa, and Central and South America will suffer from increased dryness, heat, water shortages, and reduced production. Overall, global food production under many typical climate scenarios increases. This view of climate change may be a dangerous act of self-deception, as increasingly we are facing weather related disasters -- more hurricanes, monsoons, floods, and dry-spells – in regions around the world.

Weather-related events have an enormous impact on society, as they influence food supply, conditions in cities and communities, as well as access to clean water and energy. For example, a recent report by the Climate Action Network of Australia projects that climate change is likely to reduce rainfall in the rangelands, which could lead to a 15 per cent drop in grass productivity. This, in turn, could lead to reductions in the average weight of cattle by 12 per cent, significantly reducing beef supply. Under such conditions, dairy cows are projected to produce 30% less milk, and new pests are likely to spread in fruit-growing areas. Additionally, such conditions are projected to lead to 10% less water for drinking. Based on model projections of coming change conditions such as these could occur in several food producing regions around the world at the same time within the next 15-30years, challenging the notion that society's ability to adapt will make climate change manageable.

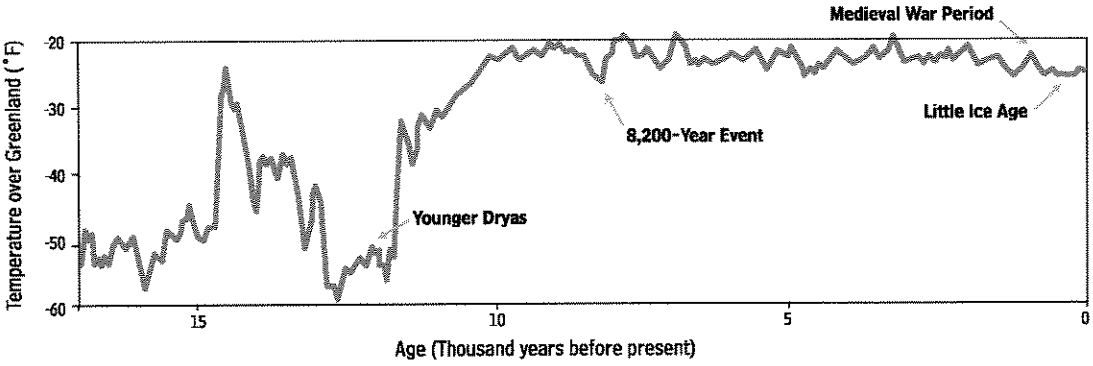
With over 400 million people living in drier, subtropical, often over-populated and economically poor regions today, climate change and its follow-on effects pose a severe risk to political, economic, and social stability. In less prosperous regions, where countries lack the resources and capabilities required to adapt quickly to more severe conditions, the problem is very likely to be exacerbated. For some countries, climate change could become such a challenge that mass emigration results as the desperate peoples seek better lives in regions such as the United States that have the resources to adaptation.

Because the prevailing scenarios of gradual global warming could cause effects like the ones described above, an increasing number of business leaders, economists, policy makers, and politicians are concerned about the projections for further change and are working to limit human influences on the climate. But, these efforts may not be sufficient or be implemented soon enough.

Rather than decades or even centuries of gradual warming, recent evidence suggests the possibility that a more dire climate scenario may actually be unfolding. This is why GBN is working with OSD to develop a plausible scenario for abrupt climate change that can be used to explore implications for food supply, health and disease, commerce and trade, and their consequences for national security.

While future weather patterns and the specific details of abrupt climate change cannot be predicted accurately or with great assurance, the actual history of climate change provides some useful guides. Our goal is merely to portray a plausible scenario, similar to one which has already occurred in human experieince, for which there is reasonable evidence so that we may further explore potential implications for United States national security.

Creating the Scenario: Reviewing History



The above graphic, derived from sampling of an ice core in Greenland, shows a historical tendency for particular regions to experience periods of abrupt cooling within periods of general warming.[1]

The Cooling Event 8,200 Years Ago

The climate change scenario outlined in this report is modeled on a century-long climate event that records from an ice core in Greenland indicate occurred 8,200 years ago. Immediately following an extended period of warming, much like the phase we appear to be in today, there was a sudden cooling . Average annual temperatures in Greenland dropped by roughly 5 degrees Fahrenheit, and temperature decreases nearly this large are likely to have occurred throughout the North Atlantic region. During the 8,200 event severe winters in Europe and some other areas caused glaciers to advance, rivers to freeze, and agricultural lands to be less productive. Scientific evidence suggests that this event was associated with, and perhaps caused by, a collapse of the ocean's conveyor following a period of gradual warming.

Longer ice core and oceanic records suggest that there may have been as many as eight rapid cooling episodes in the past 730,000 years, and sharp reductions in the ocean conveyer--a phenomenon that may well be on the horizon – are a likely suspect in causing such shifts in climate.

The Younger Dryas

About 12,700 years ago, also associated with an apparent collapse of the thermohaline circulation, there was a cooling of at least 27 degrees Fahrenheit in Greenland, and substantial change throughout the North Atlantic region as well, this time lasting 1,300 years. The remarkable feature of the Younger Dryas event was that it happened in a series of decadal drops of around 5 degrees, and then the cold, dry weather persisted for over 1,000 years. While this event had an enormous effect on the ocean and land surrounding Europe (causing icebergs to be found as far south as the coast of Portugal), its impact would be more severe today – in our densely populated society. It is the more recent periods of cooling that appear to be intimately connected with changes to civilization, unrest, inhabitability of once desirable land, and even the demise of certain populations.

The Little Ice Age

Beginning in the 14th century, the North Atlantic region experienced a cooling that lasted until the mid-19th century. This cooling may have been caused by a significant slowing of the ocean conveyor, although it is more generally thought that reduced solar output and/or volcanic eruptions may have prompted the oceanic changes. This period, often referred to as the Little Ice Age, which lasted from 1300 to 1850, brought severe winters, sudden climatic shifts, and profound agricultural, economic, and political impacts to Europe.

[1] R.B. Alley, from The Two Mile Time Machine, 2000.

The period was marked by persistent crop failures, famine, disease, and population migration, perhaps most dramatically felt by the Norse, also known as the Vikings, who inhabited Iceland and later Greenland. Ice formations along the coast of Greenland prevented merchants from getting their boats to Greenland and fisherman from getting fish for entire winters. As a result, farmers were forced to slaughter their poorly fed livestock -- because of a lack of food both for the animals and themselves -- but without fish, vegetables, and grains, there was not enough food to feed the population.

Famine, caused in part by the more severe climatic conditions, is reported to have caused tens of thousands of deaths between 1315 and 1319 alone. The general cooling also apparently drove the Vikings out of Greenland -- and some say was a contributing cause for that society's demise.

While climate crises like the Little Ice Age aren't solely responsible for the death of civilizations, it's undeniable that they have a large impact on society. It has been less than 175 years since 1 million people died due to the Irish Potato famine, which also was induced in part by climate change.

A Climate Change Scenario For the Future

The past examples of abrupt climate change suggest that it is prudent to consider an abrupt climate change scenario for the future as plausible, especially because some recent scientific findings suggest that we could be on the cusp of such an event. The future scenario that we have constructed is based on the 8,200 years before present event, which was much warmer and far briefer than the Younger Dryas, but more severe than the Little Ice Age. This scenario makes plausible assumptions about which parts of the globe are likely to be colder, drier, and windier. Although intensified research could help to refine the assumptions, there is no way to confirm the assumptions on the basis of present models.

Rather than predicting how climate change will happen, our intent is to dramatize the impact climate change could have on society if we are unprepared for it. Where we describe concrete weather conditions and implications, our aim is to further the strategic conversation rather than to accurately forecast what is likely to happen with a high degree of certainty. Even the most sophisticated models cannot predict the details of how the climate change will unfold, which regions will be impacted in which ways, and how governments and society might respond. However, there appears to be general agreement in the scientific community that an extreme case like the one depicted below is not implausible. Many scientists would regard this scenario as extreme both in how soon it develops, how large, rapid and ubiquitous the climate changes are. But history tells us that sometimes the extreme cases do

occur, there is evidence that it might be and it is DOD's job to consider such scenarios.

Keep in mind that the duration of this event could be decades, centuries, or millennia and it could begin this year or many years in the future. In the climate change disruption scenario proposed here, we consider a period of gradual warming leading to 2010 and then outline the following ten years, when like in the 8,200 event, an abrupt change toward cooling in the pattern of weather conditions change is assumed to occur.

Warming Up to 2010

Following the most rapid century of warming experienced by modern civilization, the first ten years of the 21st century see an acceleration of atmospheric warming, as average temperatures worldwide rise by .5 degrees Fahrenheit per decade and by as much as 2 degrees Fahrenheit per decade in the harder hit regions. Such temperature changes would vary both by region and by season over the globe, with these finer scale variations being larger or smaller than the average change. What would be very clear is that the planet is continuing the warming trend of the late 20th century.

Most of North America, Europe, and parts of South America experience 30% more days with peak temperatures over 90 degrees Fahrenheit than they did a century ago, with far fewer days below freezing. In addition to the warming, there are erratic weather patterns: more floods, particularly in mountainous regions, and prolonged droughts in grain-producing and coastal-agricultural areas. In general, the climate shift is an economic nuisance, generally affecting local areas as storms, droughts, and hot spells impact agriculture and other climate-dependent activities. (More French doctors remain on duty in August, for example.) The weather pattern, though, is not yet severe enough or widespread enough to threaten the interconnected global society or United States national security.

Warming Feedback Loops

As temperatures rise throughout the 20th century and into the early 2000s potent positive feedback loops kick-in, accelerating the warming from .2 degrees Fahrenheit, to .4 and eventually .5 degrees Fahrenheit per year in some locations. As the surface warms, the hydrologic cycle (evaporation, precipitation, and runoff) accelerates causing temperatures to rise even higher. Water vapor, the most powerful natural greenhouse gas, traps additional heat and brings average surface air temperatures up. As evaporation increases, higher surface air temperatures cause drying in forests and grasslands, where animals graze and farmers grow grain. As trees die and burn, forests absorb less carbon dioxide, again leading to higher surface air temperatures as well as fierce and uncontrollable forest fires Further, warmer temperatures melt snow cover in mountains, open fields, high-latitude tundra areas, and permafrost throughout forests in cold-weather areas. With the ground absorbing more and reflecting less of the sun's rays, temperatures increase even higher.

By 2005 the climatic impact of the shift is felt more intensely in certain regions around the world. More severe storms and typhoons bring about higher storm surges and floods in low-lying islands such as Tarawa and Tuvalu (near New Zealand). In 2007, a particularly severe storm causes the ocean to break through levees in the Netherlands making a few key coastal cities such as The Hague unlivable. Failures of the delta island levees in the Sacramento River region in the Central Valley of California creates an inland sea and disrupts the aqueduct system transporting water from northern to southern California because salt water can no longer be kept out of the area during the dry season. Melting along the Himalayan glaciers accelerates, causing some Tibetan people to relocate. Floating ice in the northern polar seas, which had already lost 40% of its mass from 1970 to 2003, is mostly gone during summer by 2010. As glacial ice melts, sea levels rise and as wintertime sea extent decreases, ocean waves increase in intensity, damaging coastal cities. Additionally millions of people are put at risk of flooding around the globe (roughly 4 times 2003 levels), and fisheries are disrupted as water temperature changes cause fish to migrate to new locations and habitats, increasing tensions over fishing rights.

Each of these local disasters caused by severe weather impacts surrounding areas whose natural, human, and economic resources are tapped to aid in recovery. The positive feedback loops and acceleration of the warming pattern begin to trigger responses that weren't previously imagined, as natural disasters and stormy weather occur in both developed and lesser-developed nations. Their impacts are greatest in less-resilient developing nations, which do not have the capacity built into their social, economic, and agricultural systems to absorb change.

As melting of the Greenland ice sheet exceeds the annual snowfall, and there is increasing freshwater runoff from high latitude precipitation, the freshening of waters in the North Atlantic Ocean and the seas between Greenland and Europe increases. The lower densities of these freshened waters in turn pave the way for a sharp slowing of the thermohaline circulation system.

The Period from 2010 to 2020

Thermohaline Circulation Collapse

After roughly 60 years of slow freshening, the thermohaline collapse begins in 2010, disrupting the temperate climate of Europe, which is made possible by the warm flows of the Gulf Stream (the North Atlantic arm of the global thermohaline conveyor). Ocean circulation patterns change, bringing less warm water north and causing an immediate shift in the weather in Northern Europe and eastern North America. The North Atlantic Ocean continues to be affected by fresh water coming from melting glaciers, Greenland's ice sheet, and perhaps most importantly increased rainfall and runoff. Decades of high-latitude warming cause increased precipitation

and bring additional fresh water to the salty, dense water in the North, which is normally affected mainly by warmer and saltier water from the Gulf Stream. That massive current of warm water no longer reaches far into the North Atlantic. The immediate climatic effect is cooler temperatures in Europe and throughout much of the Northern Hemisphere and a dramatic drop in rainfall in many key agricultural and populated areas. However, the effects of the collapse will be felt in fits and starts, as the traditional weather patterns re-emerge only to be disrupted again—for a full decade.

The dramatic slowing of the thermohaline circulation is anticipated by some ocean researchers, but the United States is not sufficiently prepared for its effects, timing, or intensity. Computer models of the climate and ocean systems, though improved, were unable to produce sufficiently consistent and accurate information for policymakers. As weather patterns shift in the years following the collapse, it is not clear what type of weather future years will bring. While some forecasters believe the cooling and dryness is about to end, others predict a new ice age or a global drought, leaving policy makers and the public highly uncertain about the future climate and what to do, if anything. Is this merely a "blip" of little importance or a fundamental change in the Earth's climate, requiring an urgent massive human response?

Cooler, Drier, Windier Conditions for Continental Areas of the Northern Hemisphere

The Weather Report: 2010-2020

- Drought persists for the entire decade in critical agricultural regions and in the areas around major population centers in Europe and eastern North America.
- Average annual temperatures drop by up to 5 degrees Fahrenheit over Asia and North America and up to 6 degrees Fahrenheit in Europe.
- Temperatures increase by up to 4 degrees Fahrenheit in key areas throughout Australia, South America, and southern Africa.
- Winter storms and winds intensify, amplifying the impact of the changes. Western Europe and the North Pacific face enhanced westerly winds.

Each of the years from 2010-2020 sees average temperature drops throughout Northern Europe, leading to as much as a 6 degree Fahrenheit drop in ten years. Average annual rainfall in this region decreases by nearly 30%; and winds are up to 15% stronger on average. The climatic conditions are more severe in the continental interior regions of northern Asia and North America.

The effects of the drought are more devastating than the unpleasantness of temperature decreases in the agricultural and populated areas. With the persistent reduction of precipitation in these areas, lakes dry-up, river flow decreases, and fresh water supply is squeezed, overwhelming available conservation options and depleting fresh water reserves. The Mega-droughts begin in key regions in Southern China and Northern Europe around 2010 and last throughout the full decade. At the same time, areas that were relatively dry over the past few decades receive persistent years of torrential rainfall, flooding rivers, and regions that traditionally relied on dryland agriculture.

In the North Atlantic region and across northern Asia, cooling is most pronounced in the heart of winter -- December, January, and February -- although its effects linger through the seasons, the cooling becomes increasingly intense and less predictable. As snow accumulates in mountain regions, the cooling spreads to summertime. In addition to cooling and summertime dryness, wind pattern velocity strengthens as the atmospheric circulation becomes more zonal.

While weather patterns are disrupted during the onset of the climatic change around the globe, the effects are far more pronounced in Northern Europe for the first five years after the thermohaline circulation collapse. By the second half of this decade, the chill and harsher conditions spread deeper into Southern Europe, North America, and beyond. Northern Europe cools as a pattern of colder weather lengthens the time that sea ice is present over the northern North Atlantic Ocean, creating a further cooling influence and extending the period of wintertime surface air temperatures. Winds pick up as the atmosphere tries to deal with the stronger pole-to-equator temperature gradient. Cold air blowing across the European continent causes especially harsh conditions for agriculture. The combination of wind and dryness causes widespread dust storms and soil loss.

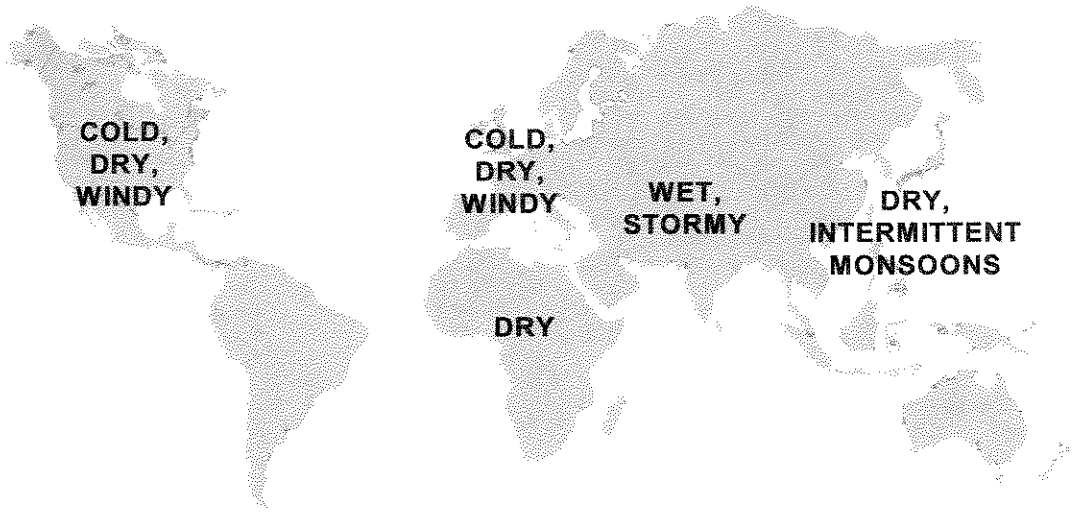
Signs of incremental warming appear in the southern most areas along the Atlantic Ocean, but the dryness doesn't let up. By the end of the decade, Europe's climate is more like Siberia's.

An Alternative Scenario for the Southern Hemisphere

There is considerable uncertainty about the climate dynamics of the Southern Hemisphere, mainly due to less paleoclimatic data being available than for the Northern Hemisphere. Weather patterns in key regions in the Southern Hemisphere could mimic those of the Northern Hemisphere, becoming colder, drier, and more severe as heat flows from the tropics to the Northern Hemisphere, trying to thermodynamically balance the climatic system. Alternatively, the cooling of the Northern Hemisphere may lead to increased warmth, precipitation, and storms in the south, as the heat normally transported away from equatorial regions by the ocean currents becomes trapped and as greenhouse gas warming continues to

accelerate. Either way, it is not implausible that abrupt climate change will bring extreme weather conditions to many of the world's key population and growing regions at the same time – stressing global food, water, and energy supply.

The Regions: 2010 to 2020



The above graphic shows a simplified view of the weather patterns portrayed in this scenario.

Europe. Hit hardest by the climatic change, average annual temperatures drop by 6 degrees Fahrenheit in under a decade, with more dramatic shifts along the Northwest coast. The climate in northwestern Europe is colder, drier, and windier, making it more like Siberia. Southern Europe experiences less of a change but still suffers from sharp intermittent cooling and rapid temperature shifts. Reduced precipitation causes soil loss to become a problem throughout Europe, contributing to food supply shortages. Europe struggles to stem emigration out of Scandinavian and northern European nations in search of warmth as well as immigration from hard-hit countries in Africa and elsewhere.

United States. Colder, windier, and drier weather makes growing seasons shorter and less productive throughout the northeastern United States, and longer and drier in the southwest. Desert areas face increasing windstorms, while agricultural areas suffer from soil loss due to higher wind speeds and reduced soil moisture. The change toward a drier climate is especially pronounced in the southern states.

Coastal areas that were at risk during the warming period remain at risk, as rising ocean levels continues along the shores. The United States turns inward, committing its resources to feeding its own population, shoring-up its borders, and managing the increasing global tension.

China. China, with its high need for food supply given its vast population, is hit hard by a decreased reliability of the monsoon rains. Occasional monsoons during the summer season are welcomed for their precipitation, but have devastating effects as they flood generally denuded land. Longer, colder winters and hotter summers caused by decreased evaporative cooling because of reduced precipitation stress already tight energy and water supplies. Widespread famine causes chaos and internal struggles as a cold and hungry China peers jealously across the Russian and western borders at energy resources.

Bangladesh. Persistent typhoons and a higher sea level create storm surges that cause significant coastal erosion, making much of Bangladesh nearly uninhabitable. Further, the rising sea level contaminates fresh water supplies inland, creating a drinking water and humanitarian crisis. Massive emigration occurs, causing tension in China and India, which are struggling to manage the crisis inside their own boundaries.

East Africa. Kenya, Tanzania, and Mozambique face slightly warmer weather, but are challenged by persistent drought. Accustomed to dry conditions, these countries were the least influenced by the changing weather conditions, but their food supply is challenged as major grain producing regions suffer.

Australia. A major food exporter, Australia struggles to supply food around the globe, as its agriculture is not severely impacted by more subtle changes in its climate. But the large uncertainties about Southern Hemisphere climate change make this benign conclusion suspect.

Impact on Natural Resources

The changing weather patterns and ocean temperatures affect agriculture, fish and wildlife, water and energy. Crop yields, affected by temperature and water stress as well as length of growing season fall by 10-25% and are less predictable as key regions shift from a warming to a cooling trend. As some agricultural pests die due to temperature changes, other species spread more readily due to the dryness and windiness – requiring alternative pesticides or treatment regiments. Commercial fishermen that typically have rights to fish in specific areas will be ill equipped for the massive migration of their prey.

With only five or six key grain-growing regions in the world (US, Australia, Argentina, Russia, China, and India), there is insufficient surplus in global food supplies to offset severe weather conditions in a few regions at the same time – let alone four or five. The world's economic interdependence make the United States increasingly vulnerable to the economic disruption created by local weather shifts in key agricultural and high population areas around the world. Catastrophic shortages of water and energy supply – both which are stressed around the globe today – cannot be quickly overcome.

Impact on National Security

Human civilization began with the stabilization and warming of the Earth's climate. A colder unstable climate meant that humans could neither develop agriculture or permanent settlements. With the end of the Younger Dryas and the warming and stabilization that followed, humans could learn the rhythms of agriculture and settle in places whose climate was reliably productive. Modern civilization has never experienced weather conditions as persistently disruptive as the ones outlined in this scenario. As a result, the implications for national security outlined in this report are only hypothetical. The actual impacts would vary greatly depending on the nuances of the weather conditions, the adaptability of humanity, and decisions by policymakers.

Violence and disruption stemming from the stresses created by abrupt changes in the climate pose a different type of threat to national security than we are accustomed to today. Military confrontation may be triggered by a desperate need for natural resources such as energy, food and water rather than by conflicts over ideology, religion, or national honor. The shifting motivation for confrontation would alter which countries are most vulnerable and the existing warning signs for security threats.

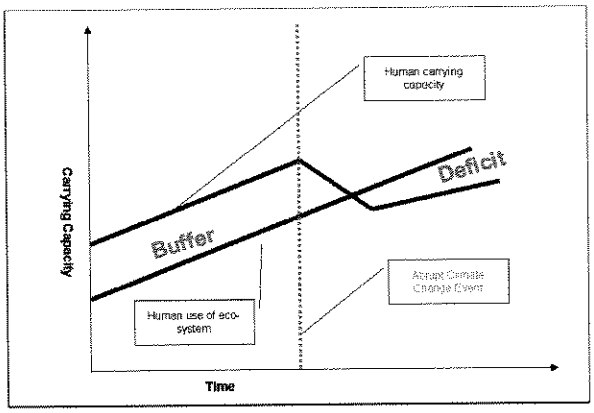
There is a long-standing academic debate over the extent to which resource constraints and environmental challenges lead to inter-state conflict. While some believe they alone can lead nations to attack one another, others argue that their primary effect is to act as a trigger of conflict among countries that face pre-existing social, economic, and political tension. Regardless, it seems undeniable that severe environmental problems are likely to escalate the degree of global conflict.

Co-founder and President of the Pacific Institute for Studies in Development, Environment, and Security, Peter Gleick outlines the three most fundamental challenges abrupt climate change poses for national security:

1. Food shortages due to decreases in agricultural production
2. Decreased availability and quality of fresh water due to flooding and droughts
3. Disrupted access to strategic minerals due to ice and storms

In the event of abrupt climate change, it's likely that food, water, and energy resource constraints will first be managed through economic, political, and diplomatic means such as treaties and trade embargoes. Over time though, conflicts over land and water use are likely to become more severe – and more violent. As states become increasingly desperate, the pressure for action will grow.

Decreasing Carrying Capacity



The graphic shows how abrupt climate change may cause human carrying capacity to fall below usage of the eco-system, suggesting insufficient resources leading to a contraction of the population through war, disease, and famine.

Today, carrying capacity, which is the ability for the Earth and its natural ecosystems including social, economic, and cultural systems to support the finite number of people on the planet, is being challenged around the world. According to the International Energy Agency, global demand for oil will grow by 66% in the next 30 years, but it's unclear where the supply will come from. Clean water is similarly constrained in many areas around the world. With 815 million people receiving insufficient sustenance worldwide, some would say that as a globe, we're living well above our carrying capacity, meaning there are not sufficient natural resources to sustain our behavior.

Many point to technological innovation and adaptive behavior as a means for managing the global ecosystem. Indeed it has been technological progress that has increased carrying capacity over time. Over centuries we have learned how to produce more food, energy and access more water. But will the potential of new technologies be sufficient when a crisis like the one outlined in this scenario hits?

Abrupt climate change is likely to stretch carrying capacity well beyond its already precarious limits. And there's a natural tendency or need for carrying capacity to become realigned. As abrupt climate change lowers the world's carrying capacity aggressive wars are likely to be fought over food, water, and energy. Deaths from war as well as starvation and disease will decrease population size, which overtime, will re-balance with carrying capacity.

When you look at carrying capacity on a regional or state level it is apparent that those nations with a high carrying capacity, such as the United States and Western Europe, are likely to adapt most effectively to abrupt changes in climate, because, relative to their population size, they have more resources to call on. This may give rise to a more severe have, have-not mentality, causing resentment toward those nations with a higher carrying capacity. It may lead to finger-pointing and blame, as the wealthier nations tend to use more energy and emit more greenhouse gasses such as CO2 into the atmosphere. Less important than the scientifically proven relationship between CO2 emissions and climate change is the perception that impacted nations have – and the actions they take.

The Link Between Carrying Capacity and Warfare

Steven LeBlanc, Harvard archaeologist and author of a new book called Carrying Capacity, describes the relationship between carrying capacity and warfare. Drawing on abundant archaeological and ethnological data, LeBlanc argues that historically humans conducted organized warfare for a variety of reasons, including warfare over resources and the environment. Humans fight when they outstrip the carrying capacity of their natural environment. Every time there is a choice between starving and raiding, humans raid. From hunter/gatherers through agricultural tribes, chiefdoms, and early complex societies, 25% of a population's adult males die when war breaks out.

Peace occurs when carrying capacity goes up, as with the invention of agriculture, newly effective bureaucracy, remote trade and technological breakthroughs. Also a large scale die-back such as from plague can make for peaceful times---Europe after its major plagues, North American natives after European diseases decimated their populations (that's the difference between the Jamestown colony failure and Plymouth Rock success). But such peaceful periods are short-lived because population quickly rises to once again push against carrying capacity, and warfare resumes. Indeed, over the millennia most societies define themselves according to their ability to conduct war, and warrior culture becomes deeply ingrained. The most combative societies are the ones that survive.

However in the last three centuries, LeBlanc points out, advanced states have steadily lowered the body count even though individual wars and genocides have grown larger in scale. Instead of slaughtering all their enemies in the traditional way, for example, states merely kill enough to get a victory and then put the survivors to work in their newly expanded economy. States also use their own bureaucracies, advanced technology, and international rules of behavior to raise carrying capacity and bear a more careful relationship to it.

All of that progressive behavior could collapse if carrying capacities everywhere were suddenly lowered drastically by abrupt climate change. Humanity would revert to its norm of constant battles for diminishing resources, which the battles

themselves would further reduce even beyond the climatic effects. Once again warfare would define human life.

Conflict Scenario Due to Climate Change

	Europe	Asia	United States
2010-2020	2012: Severe drought and cold push Scandinavian populations southward, push back from EU 2015: Conflict within the EU over food and water supply leads to skirmishes and strained diplomatic relations 2018: Russia joins EU, providing energy resources 2020: Migration from northern countries such as Holland and Germany toward Spain and Italy	2010: Border skirmishes and conflict in Bangladesh, India, and China, as mass migration occurs toward Burma 2012: Regional instability leads Japan to develop force projection capability 2015: Strategic agreement between Japan and Russia for Siberia and Sakhalin energy resources 2018: China intervenes in Kazakhstan to protect pipelines regularly disrupted by rebels and criminals.	2010: Disagreements with Canada and Mexico over water increase tension 2012: Flood of refugees to southeast U.S. and Mexico from Caribbean islands 2015: European migration to United States (mostly wealthy) 2016: Conflict with European countries over fishing rights 2018: Securing North America, U.S. forms integrated security alliance with Canada and Mexico 2020: Department of Defense manages borders and refugees from Caribbean and Europe.
2020-2030	2020: Increasing: skirmishes over water and immigration 2022: Skirmish between France and Germany over commercial access to Rhine 2025: EU nears collapse 2027: Increasing migration to Mediterranean countries such as Algeria, Morocco, Egypt, and Israel 2030: Nearly 10% of European population	2020: Persistent conflict in South East Asia; Burma, Laos, Vietnam, India, China 2025: Internal conditions in China deteriorate dramatically leading to civil war and border wars. 2030: Tension growing between China and Japan over Russian energy *	2020: Oil prices increase as security of supply is threatened by conflicts in Persian Gulf and Caspian 2025: Internal struggle in Saudi Arabia brings Chinese and U.S. naval forces to Gulf ,in direct confrontation

	moves to a different country		

The chart above outlines some potential military implications of climate change

The two most likely reactions to a sudden drop in carrying capacity due to climate change are defensive and offensive.

The United States and Australia are likely to build defensive fortresses around their countries because they have the resources and reserves to achieve self-sufficiency. With diverse growing climates, wealth, technology, and abundant resources, the United States could likely survive shortened growing cycles and harsh weather conditions without catastrophic losses. Borders will be strengthened around the country to hold back unwanted starving immigrants from the Caribbean islands (an especially severe problem), Mexico, and South America. Energy supply will be shored up through expensive (economically, politically, and morally) alternatives such as nuclear, renewables, hydrogen, and Middle Eastern contracts. Pesky skirmishes over fishing rights, agricultural support, and disaster relief will be commonplace. Tension between the U.S. and Mexico rise as the U.S. reneges on the 1944 treaty that guarantees water flow from the Colorado River. Relief workers will be commissioned to respond to flooding along the southern part of the east coast and much drier conditions inland. Yet, even in this continuous state of emergency the U.S. will be positioned well compared to others. The intractable problem facing the nation will be calming the mounting military tension around the world.

As famine, disease, and weather-related disasters strike due to the abrupt climate change, many countries' needs will exceed their carrying capacity. This will create a sense of desperation, which is likely to lead to offensive aggression in order to reclaim balance. Imagine eastern European countries, struggling to feed their populations with a falling supply of food, water, and energy, eyeing Russia, whose population is already in decline, for access to its grain, minerals, and energy supply. Or, picture Japan, suffering from flooding along its coastal cities and contamination of its fresh water supply, eying Russia's Sakhalin Island oil and gas reserves as an energy source to power desalination plants and energy-intensive agricultural processes. Envision Pakistan, India, and China – all armed with nuclear weapons – skirmishing at their borders over refugees, access to shared rivers, and arable land. Spanish and Portuguese fishermen might fight over fishing rights – leading to conflicts at sea. And, countries including the United States would be likely to better secure their borders. With over 200 river basins touching multiple nations, we can expect conflict over access to water for drinking, irrigation, and transportation. The Danube touches twelve nations, the Nile runs though nine, and the Amazon runs through seven.

In this scenario, we can expect alliances of convenience. The United States and Canada may become one, simplifying border controls. Or, Canada might keep its hydropower—causing energy problems in the US. North and South Korea may align to create one technically savvy and nuclear-armed entity. Europe may act as a unified block – curbing immigration problems between European nations – and allowing for protection against aggressors. Russia, with its abundant minerals, oil, and natural gas may join Europe.

In this world of warring states, nuclear arms proliferation is inevitable. As cooling drives up demand, existing hydrocarbon supplies are stretched thin. With a scarcity of energy supply – and a growing need for access -- nuclear energy will become a critical source of power, and this will accelerate nuclear proliferation as countries develop enrichment and reprocessing capabilities to ensure their national security. China, India, Pakistan, Japan, South Korea, Great Britain, France, and Germany will all have nuclear weapons capability, as will Israel, Iran, Egypt, and North Korea.

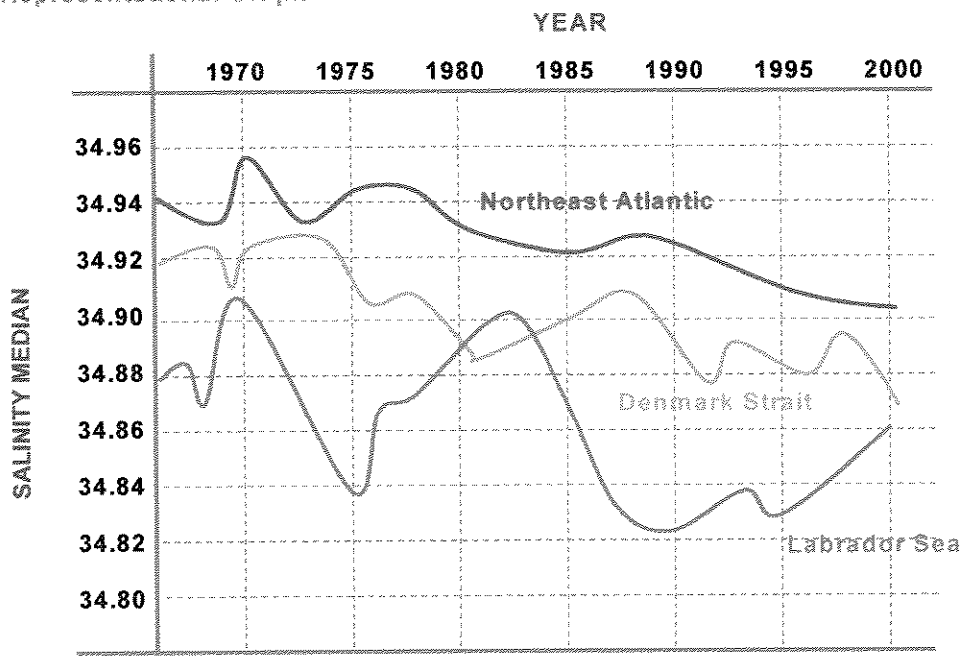
Managing the military and political tension, occasional skirmishes, and threat of war will be a challenge. Countries such as Japan, that have a great deal of social cohesion (meaning the government is able to effectively engage its population in changing behavior) are most likely to fair well. Countries whose diversity already produces conflict, such as India, South Africa and Indonesia, will have trouble maintaining order. Adaptability and access to resources will be key. Perhaps the most frustrating challenge abrupt climate change will pose is that we'll never know how far we are into the climate change scenario and how many more years – 10, 100, 1000 --- remain before some kind of return to warmer conditions as the thermohaline circulation starts up again. When carrying capacity drops suddenly, civilization is faced with new challenges that today seem unimaginable.

Could This Really Happen?

Ocean, land, and atmosphere scientists at some of the world's most prestigious organizations have uncovered new evidence over the past decade suggesting that the plausibility of severe and rapid climate change is higher than most of the scientific community and perhaps all of the political community is prepared for. If it occurs, this phenomenon will disrupt current gradual global warming trends, adding to climate complexity and lack of predictability. And paleoclimatic evidence suggests that such an abrupt climate change could begin in the near future.

The Woods Hole Oceanographic Institute reports that seas surrounding the North Atlantic have become less salty in the past 40 years, which in turn freshens the deep ocean in the North Atlantic. This trend could pave the way for ocean conveyor collapse or slowing and abrupt climate change.

Representational Graph



The above graphic shows early evidence that a thermohaline circulation collapse may be imminent, as the North Atlantic is increasingly being freshened by surrounding seas that have become less salty over the past 40 years.2

Decreasing overflow from the Nordic seas into the Atlantic Ocean through the Faroe Bank channel since 1950

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The overflow of cold, dense water from the Nordic seas, across the Greenland–Scotland ridge[1] and into the Atlantic Ocean is the main source for the deep water of the North Atlantic Ocean[2]. This flow also helps drive the inflow of warm, saline surface water into the Nordic seas[3]. The Faroe Bank channel is the deepest path across the ridge, and the deep flow through this channel accounts

Rapid freshening of the deep North Atlantic Ocean over the past four decades

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The overflow and descent of cold, dense water from the sills of the Denmark Strait and the Faroe–Shetland channel into the North Atlantic Ocean is the principal means of ventilating the deep oceans, and is therefore a key element of the global thermohaline

[2] Adapted from I Yashayaev, Bedford Institute of Oceanography as seen in Abrupt Climate Change, Inevitable Surprises, National Research Council.

The above two headlines appeared in Nature Magazine in 2001 and 2002, respectively. They suggest that the North Atlantic salinity level may lower, increasing the likelihood of a thermohaline circulation collapse.

With at least eight abrupt climate change events documented in the geological record, it seems that the questions to ask are: *When will this happen? What will the impacts be? And, how can we best prepare for it?* Rather than: *Will this really happen?*

Are we prepared for history to repeat itself again?

There is a debate in newspapers around the globe today on the impact of human activity on climate change. Because economic prosperity is correlated with energy use and greenhouse gas emissions, it is often argued that economic progress leads to climate change. Competing evidence suggests that climate change can occur, regardless of human activity as seen in climate events that happened prior to modern society.

It's important to understand human impacts on the environment – both what's done to accelerate and decelerate (or perhaps even reverse) the tendency toward climate change. Alternative fuels, greenhouse gas emission controls, and conservation efforts are worthwhile endeavors. In addition, we should prepare for the inevitable effects of abrupt climate change – which will likely come regardless of human activity.

Here are some preliminary recommendations to prepare the United States for abrupt climate change:

1) Improve predictive climate models. Further research should be conducted so more confidence can be placed in predictions about climate change. There needs to be a deeper understanding of the relationship between ocean patterns and climate change. This research should focus on historical, current, and predictive forces, and aim to further our understanding of abrupt climate change, how it may happen, and how we'll know it's occurring.

2) Assemble comprehensive predictive models of climate change impacts. Substantial research should be done on the potential ecological, economic, social, and political impact of abrupt climate change. Sophisticated models and scenarios should be developed to anticipate possible local conditions. A system should be created to identify how climate change may impact the global distribution of social, economic, and political power. These analyses can be used to mitigate potential sources of conflict before they happen.

3) Create vulnerability metrics. Metrics should be created to understand a country's vulnerability to the impacts of climate change. Metrics may include climatic impact on existing agricultural, water, and mineral resources; technical capability; social cohesion and adaptability.

4) Identify no-regrets strategies. No-regrets strategies should be identified and implemented to ensure reliable access to food supply and water, and to ensure national security.

5) Rehearse adaptive responses. Adaptive response teams should be established to address and prepare for inevitable climate driven events such as massive migration, disease and epidemics, and food and water supply shortages.

6) Explore local implications. The first-order effects of climate change are local. While we can anticipate changes in pest prevalence and severity and changes in agricultural productivity, one has to look at very specific locations and conditions to know which pests are of concern, which crops and regions are vulnerable, and how severe impacts will be. Such studies should be undertaken, particularly in strategically important food producing regions.

7) Explore geo-engineering options that control the climate. Today, it is easier to warm than to cool the climate, so it might be possible to add various gases, such as hydrofluorocarbons, to the atmosphere to offset the affects of cooling. Such actions, of course, would be studied carefully, as they have the potential to exacerbate conflicts among nations.

Conclusion

It is quite plausible that within a decade the evidence of an imminent abrupt climate shift may become clear and reliable. It is also possible that our models will better enable us to predict the consequences. In that event the United States will need to take urgent action to prevent and mitigate some of the most significant impacts. Diplomatic action will be needed to minimize the likelihood of conflict in the most impacted areas, especially in the Caribbean and Asia. However, large population movements in this scenario are inevitable. Learning how to manage those populations, border tensions that arise and the resulting refugees will be critical. New forms of security agreements dealing specifically with energy, food and water will also be needed. In short, while the US itself will be relatively better off and with more adaptive capacity, it will find itself in a world where Europe will be struggling internally, large number so refugees washing up on its shores and Asia in serious crisis over food and water. Disruption and conflict will be endemic features of life.

energy

NEWS ... INTERPRETATION ... ANALYSIS

Know Thy Costs

To remain competitive, planners must adopt sophisticated finance valuation tools.

For nearly a century, utility planners have used engineering-economics based models to estimate the cost of electricity produced by different generating technologies. In 1978, EPRI formalized these models and they are widely known under the name of EPRI-TAG or Revenue Requirements Models (RRM). While these procedures are almost universally used to estimate the kWh cost of electricity for planned resource alternatives, it is not generally understood that, as commonly applied, these approaches are rule-of-thumb proxies which yield only rough approximations of true cost.

This may have been reasonably useful in a simpler time, when the capacity choice may have been limited to a coal versus an oil-fired steam plant, both of which had similar financial risk characteristics. Today's environment, however, is far more complex and includes a variety of resource options - from purchased power, to capital-intensive renewables - which differ considerably in terms of their financial risk, flexibility attributes and the strategic options they create for management. In order to remain competitive in this environment, firms will have to adopt more sophisticated finance-oriented valuation tools.

Surprisingly, IRP and similar processes have not engendered investigations and debates about appropriate procedures for valuing resource alternatives. While these processes raise all sorts of planning issues, every-. one seems quite content to leave the" seemingly arcane procedures for estimating levelized electricity (busbar) costs to the green-visor types with little meaningful outside review.

This means that some of the firm's most important decisions are made on the basis of black-box output that few truly understand.

Correct resource valuation (i.e., investment analysis) is important in a monopoly setting. Partially competitive environments make resource valuation even more crucial, yet it seems widely believed that the prospect of a restructured industry eliminates the need for discussion of how renewables and conventional technologies should be valued. The assumption is that the market will take care of it. But competition does not imply that we will get brilliant, or even just plain "correct", analyses of the cost of electricity from various renewable and conventional sources.

History (and the literature) is replete with examples, mostly from manufacturing, which support this contention. For example, myopic capital budgeting contributed in part to the near collapse of the American steel industry in the 1970's: accounting-based analyses suggested that continued use of existing technology was the least-cost alternative. And, this is not an isolated. Indeed, traditional, accounting-based benefit- cost analyses almost always suggest that the incumbent technology is a better bet and that the innovation is too costly! Flawed engineering-based analyses also kept American manufacturers from making timely investments in innovative process technologies such as computer-aided design and computer-integrated-manufacturing.

This led to a loss of world preeminence for these manufacturers who then spent the next two decades re-gaining a leadership position. Given the dismal record engineering-based cost models have in identifying promising innovations in manufacturing, it is unreasonable to expect that they will help us understand the costs and benefits of renewable technologies or of distributed generation and other radical innovations to the electricity production process.

Now some will argue that the last thing we need is public debate about appropriate resource valuation models since under competition utilities will simply purchase from low-cost providers thus making IRP cost-analyses irrelevant. But these purchase decisions will require sophisticated valuation procedures - fuel and power contracts require valuation of uncertain future cost streams which is far more complex than, say, evaluating contracts for the firm's cleaning-supplies.

Utilities will need to understand that risk and other financial properties vary widely with the underlying generation

LOL-EX-10

technology and that this affects future costs and profitability; in a competitive market kilowatt- hours are not all equal. Finally, as utilities prepare for competition managers are increasingly concerned about creating value with each investment they make. Yet the investment analysis procedures used by their planners were conceived around the time of the Model-T Ford. It is not possible to make efficient investments in today's complex environment using outdated rule-of-thumb approaches that were "close enough" in a regulated monopoly environment; firms that rely on such models will make good investments and purchases only by accident.

Traditional Cost Models

EPRI-TAG, the RRM and similar models which rely on busbar costs generally favor expense-intensive over capital-intensive technologies. This section presents a number of reasons why engineering cost approaches do not correctly reflect the relative value *of* resource alternatives.

Engineering Approaches Ignore Financial Risk. Engineering models do not account for financial risk. Loosely defined, financial risk is the variability *of* annual costs. Under an engineering approach, a *risky* annual cost stream has the same present value as an equivalent but *safe* cost stream. This violates fundamental finance theory. Dollar for dollar, a risky cost stream, such as future outlays for fuel, has a *higher* present value since it is less desirable than a safe cost stream.

This intuition - that a risky cost stream is less desirable - seems to be widely understood. For example; home buyers overwhelmingly choose fixed rate mortgages even though adjustable rate mortgages carry initially lower interest rates. These borrowers obviously conclude that the projected fixed-rate stream *of* payments has a lower present value - it is more desirable. Similarly, investors *of* all types and all risk-aversions purchase riskless U.S. Treasury obligations even though they yield much less for a given. $1,000 investment than do riskier instruments such as low-grade bonds. Engineering cost approaches that ignore risk will always indicate that riskier, lower cost alternatives such as gas-fired turbines are the most economic, a result that is logically equivalent to arguing that junk bonds are a better investment than U.S. Treasury bills because they promise a higher annual payment stream for each $1,000 invested and are hence "cheaper."

Engineering Approaches Compare Resource Alternatives Exclusively on the *Basis of their Busbar Cost.* The busbar costs exclude overhead and indirect costs such as fuel purchasing, engineering staff time, or Clean Air Act compliance costs. Ignoring these costs in the resource evaluation probably worked reasonably well when. technology alternatives were fairly homogeneous - i.e., when the alternatives consisted *of* technologically- equivalent fossil-fired options which required (or "consumed") more or less the same types and amount of over- head resources.

Today's technology choices, however, are considerably more heterogeneous, consisting of a variety of technological and institutional alternatives with vastly different cost characteristics. The overhead requirements for this diverse range or resource options vary considerably. For example: some passive, renewable alternatives, such as remote PV sites, operate reliably and require little support from the corporate infra-structure thus consuming very little over- head or indirect costs as compared to traditional central station technologies.

Busbar cost comparisons thus tend to overstate the cost of renewable options relative to traditional fossil alternatives. This is consistent with experience in manufacturing, which taught us that new process technologies often produce what Paul Milgrom and John Roberts, both of Stanford University, call *complementary benefits* - benefits which yield important cost reductions in *overhead and indirect* costs, not in the direct costs. To the extent that such complementarities are, or will eventually be created by renewables, the exclusive reliance on the busbar cost measure becomes all the more problematic. Traditional FERC-based *cost* accounting procedures are insufficient to properly reflect indirect costs for decision making purposes. New, Activity-Based- Costing (ABC) procedures must be employed in order to fully understand the total costs of operating particular technologies.

Engineering Cost Approaches Estimate "Stand-Alone" Costs for Re- source Options When They *Should Evaluate Their Impact on the Cost and Risk* of *the Generating Portfolio.* Financial portfolios are widely used by investors to manage risk and to maximize performance under a variety of unpredictable economic outcomes. Similarly, it is important to conceive of electricity generation not in terms of the cost of a particular technology today, but in terms of its *portfolio cost.* At any given time some alternatives in the portfolio may have high costs while others have lower costs, yet over time, the astute combination of alternatives serves to minimize overall generation cost relative to the risk. By contrast, traditional engineering cost approaches focuses on finding the *least cost* alternative- a questionable procedure that is roughly analogous to trying to identify yesterday's best performing stock and investing in it exclusively.

Financial investors understand that the future is unpredictable; therefore, rather than emphasizing fortune telling, investors focus on building robust portfolios that are expected to maximize return for the given level of risk. Portfolio theory principles suggest that the important measure for valuing alternative resource options is *how a particular option affects the generating costs of the portfolio of resource options relative to how it affects the risk of that portfolio.* Finding the "least- cost" technology is probably no longer relevant, assuming it is even possible in this dynamic environment. Rather, it makes more sense to focus on developing efficient (i.e., optimal) generating portfolios which may consist of various technological as well as financial and contractual options. It may turn out that renewables play only a relatively minor role in such portfolios - perhaps *10%* or less for the foreseeable future.

Engineering Cost Approaches Ignore Valuable Managerial and Strategic Options That Renewables and Other New Technologies Often Create. The RRM and similar approaches assume that the benefits and costs of alternative technologies can be properly modeled purely on the basis of their direct cash flows. Experience in manufacturing, however, suggests that *new* technologies often create valuable managerial or strategic options which can be "exercised" at a later time. While such options in- crease a project's value, they yield no immediate accounting-cost benefit. For example, renewables and other modular technologies (e.g., small gas- fired generation) can create valuable *flexibility options* since managers can install capacity slowly, over time, to match load increases. This helps capacity expansion decisions become more routine -like the installation. of additional telephone central office capacity - and hence less costly. Recent work on the value of flexibility suggests that when valued in a traditional manner, inflexible projects are equivalent to flexible ones only if their present value is considerably greater.

Some modular technologies provide *strategic* and *capability* options for managers by creating opportunities to serve new customers, or to provide different services or levels of quality and reliability. Additional work will be required to better understand how to conceive of these options so we might begin to measure their value. The strategic/capability option idea was conceived in manufacturing, where Robert Kaplan of Harvard University observed an interesting result: manufacturers that adopted numerically controlled process technology in the 1970's were able to more readily adopt computer-integrated-manufacturing (CIM) a decade or so later be- cause of the special *capabilities* the initial investment yielded. Numerically controlled production machines required workers to learn how to resolve product shapes and the required machine movements into a series of numerically-coded instructions. This training and experience created a capability in the work force which helped the firm adopt CIM.

Strategic/capability options are hard to value because it is hard to see the future. In the case of the paper- tape technology, hindsight clearly implies that no matter what the initial cash-flow-based benefit-cost analyses may have indicated, the original adoption of numerically-con- trolled equipment was ultimately' cost-effective, not necessarily because of direct cost savings, but because of the capabilities and the strategic options it created. Similarly, the benefits of new energy technologies cannot be fully understood without conceptualizing the possible strategic options they create.

Engineering Cost Approaches Ignore the Cost-of-Quality in Generating and Delivering Electricity. In manufacturing, the *Cost-of-Quality* is a fairly well understood concept which implies the elimination of wasteful activities such as assembly-line set-ups, the maintenance of parts inventories or the re-manufacture of defective products. As yet, there is no generally accepted definition of the cost-of-quality in electricity production and delivery, although it undoubtedly implies the reduction or elimination of inherently wasteful activity including traditional reserve requirements and transactions such as meter-reading and the ordering, movement and storage of materials. Of course, attaining such results re- quires that we substantially re-conceptualize the entire generation/delivery process just as manufacturing was largely re-conceived in the late 1970's from *mass-production* to *flexible-manufacturing.* Renewables and other ,modular technologies may enable the process to be re-conceptualized in this fashion.

If manufacturers were able to eliminate inventories and other wasteful activity in the process of assembling autos and airplanes with literally millions of parts, then utilities can learn to reconceptualize their 19th century electricity production/ delivery process to eliminate reserves and other similar wasteful activities. But, the traditional cost accounting used by utilities does not identify these wasteful activities. This was also true in manufacturing until two de- cades ago; for example, there was no manufacturing cost category for "producing defective parts." Similarly, the costs of maintaining idle or spinning generation reserves are not explicitly recorded by utility accountants today so that managers have little incentive to focus on these activities so as to reduce cost. Instead, utility managers focus on line-item accounting costs such as fuel or maintenance - a process that is similar to the earlier focus of production managers, who equated cost reduction with such strategies as substituting lower-cost materials, a strategy that would generally be rejected in to day's

competitive global manufacturing.

Finally, quality manufacturing implies the production of goods that deliver value through intelligent de. sign which meets customer needs and expectations. Peter Drucker observes that flexible manufacturing has been able to reduce the energy, material and labor content of manufactured products because the information content has risen. The idea can apply to electricity production/distribution as well: the focus needs to shift from one of busbar cost minimization to one of delivering fewer, "smarter" kilowatt-hours, each of which has a greater value to customers.

While all of the above issues affect the valuation of new energy technologies, a detailed discussion of them is beyond our scope. The rest of this article focuses on one of the key limitations of traditional engineering cost models - their failure to correctly reflect financial risk.

Resource Valuation Risk and Discount Rates. **Valuation is one of the key differences between the engineering and the finance approaches to estimating a project's kWh costs. The finance approach attempts to estimate how knowledgeable investors would discount a particular cost stream, given that increased systematic risk commands a higher required return or discount rate. Appropriate discount rates can be estimated by comparing a particular cost stream to a similar stream which has a known risk.**

For example, consider a projected stream of fixed maintenance outlays for a newly installed gas turbine. Fixed maintenance will be undertaken as long as the firm has sufficient income to do so. In other words, by installing a gas turbine, the firm obligates itself to a stream of yearly maintenance outlays. This is not much different from the firm's obligation to make its bond interest payments. Indeed fixed or contractual obligations are "debt- equivalents" in the words of Richard Brealey and Stewart Myers, which must be discounted at the firm's cost of debt.

In contrast to the finance approach, utility planners tend to discount all costs using the firm's weighted average cost of capital (WACC), which is the logical equivalent of estimating a project's labor. costs on the basis of the wage rate of Hong Kong tailors. The WACC is the discount rate for the firm's net cash flows - its profits and is not correct for valuing project cost streams. When we estimate the present value for a particular project cost stream, say the expected cost of fuel or maintenance, we are attempting to estimate the price at which a contract for the future delivery of that fuel or maintenance would trade in the marketplace, an exercise that has nothing to do with a particular firm's cost of capital. The following example illustrates.

The owner of a gas turbine wants to "sell" its annual fuel purchase obligation rather than assume the risk itself. I-t seeks an investor who, in re- turn for a single up front payment, will supply a fixed amount of fuel each year for the next thirty years. The owner could take "bids" for this con- tract and, given perfect information, bidders would discount the expected fuel outlays at the appropriate risk- adjusted discount rate. The owner's WACC would not even enter the analysis. Indeed, it has nothing to do with the bidder's risk. If it did, bids for future fuel delivery would vary on the basis of each owner's (i.e., utility's) WACC which makes little sense. Indeed, as far as I am aware, firms that offer long term fixed rate gas contracts do not charge low-WACC utilities more even though a WACC based present value analysis says that this is what they should do!

Proper resource valuation, using appropriate market-based discount rates invariably indicates that renewables are considerably more cost-effective than engineering-based models would suggest. In some locations, such as Hawaii,. where generous tax credits are offered, photovoltaics, at under five cents per kilowatt-hour, are clearly the low-cost alternative. (By comparison, the levelized cost for conventional (combustion turbine) power in the Northeast is $O.O51/kWh.)

Two Components *of Risk Total financial risk, which can be thought of as the year-to-year fluctuations in a cost* stream, is the sum of: i) random or *unsystematic (diversifiable)* risk and ii) *systematic* risk which is correlated to changes in economic conditions. Both components must be reflected in a cost analysis using the following valuation rule: *expected* (after- tax) cash flows are discounted at the (after-tax) *market-based* discount rate. The discount rate reflects *systematic* risk only; random risk must be reflected through the proper estimation of *expected* cash flow which is the probability-weighted average of all cash flow possibilities. While this is a basic idea in finance, it creates considerable confusion. For example, a recent NREL report concluded that capturing uncertainty in the cash flows is superior to discount rate adjustments, which it found "question- able." *(A Manual for the Economic Evaluation of Energy Efficiency,* Analytic Studies Division, 1993). The report's conclusion obviously flies in the face of standard finance theory.

Engineers and planners tend to conceive of risk in terms of specific failures or undesirable outcomes, e.g.: the risk that a technology or component will fail prematurely or that a fuel price forecast may be wrong. Planners express such risks through "scenarios," an exercise which can help gauge random risk but completely ignores the important systematic component. An illustration can help distinguish the two ideas.

Projected Fuel Prices

Natural gas price forecasts vary considerably. The random risk of correctly estimating a future gas price escalation rate can be considered a *planning* risk. However, even if one particular forecast were known to be correct, it can only be correct *on average.* as Figure 1 illustrates. It assumes two gas escalation forecasts, 2% and 4% per annum, with each outcome equally likely. If the gas-price escalation rate is driven only by random factors, (which is not likely) then the expected escalation rate is: .5 x 2% + .5 x 4%=3%.

This escalation forecast, no matter how "accurate," still represents an expected value - an average. Actual daily and monthly gas prices will vary around this expected value in a systematic manner with changes in economic conditions. The market-based discount rate compensates only for this systematic variation around the expected value. The discount rate does not compensate for the fact that the expected value is in itself uncertain.

Why does the discount rate not reflect random risk? Because capital markets do not compensate investors for undertaking diversifiable risk. For example, the shares of oil drilling firms are relatively low-risk (and yield relatively low rates of return) even though oil drilling is a risky business to an individual firm. But investors can easily diversify the random risk of how many *"dry holes/* a given firm might hit which leaves them with the remaining non-diversifiable systematic risk: i.e., the value of the oil produced varies systematically with economic conditions. The discount rate reflects only this risk.

Technology Risk

Emerging technologies such as photovoltaics are said to pose a so- called technology risk: e.g., arrays may degrade or may not survive the *30* years promised by manufacturers. It is frequently, and erroneously assumed that this technology risk requires a discount rate adjustment. But array-failures are random, and an *expected* array life - the probability-weighted mean *of* all the lives examined - can be estimated by studying past performance. The "technology risk" *of* PV; therefore, is handled by adjusting the expected cash flow so that it reflects a module's *expected* life. No discount rate adjustment is made since array life is a random risk. This does not mean PV has no risk; it simply means that the technology has no systematic risk.

These arguments may seem less than satisfactory to some, who might reason that there exists a finite probability *of* premature array failure which poses a significant uncertainty. that should be captured in the discount rate. But this risk is diversifiable; it is Virtually eliminated in a large installation, *of* say, hundreds *of* arrays. Now, some relatively constant percentage *of* arrays will fail every year, which is not a risk issue, but involves establishing reserve requirements - a cash flow issue - to cover replacements. This is identical to the risk surrounding component failure for any other technology including gas turbines and nuclear plants.

Conclusion

Proper resource valuation is crucial to firms hoping to prosper under restructuring. Traditional, engineering-based energy valuation tools focus on direct cash flows and ignore financial risk, overhead costs, embedded options and quality issues surrounding the generation of power in a newly emerging competitive environment. These tools failed miserably when American manufacturers tried to use them in an effort to understand and become part of the "new manufacturing" twenty years ago. It is important for energy managers and public policy makers to understand the potentially misleading indications that such tools can give and to pro actively support additional research which will lead to more robust valuation models.

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Efficiency Vermont
your resource for energy savings

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Vermont Takes Top Honor from Harvard's Kennedy School
Efficiency Vermont wins prestigious "Oscar" of Government Awards

May 8, 2003, Washington, DC – It's been called the Oscar of government awards. The Innovations in American Government Award is granted to just five recipients each year, by Harvard University's Kennedy School of Government. Today, Efficiency Vermont received the award, for its pioneering approach to energy efficiency services. Selected from a nationwide field of 1,200 nominees, Efficiency Vermont received recognition for its impact on Vermont's environment, economy and on energy policies as the nation's first statewide energy efficiency utility.

"By creating an independent entity whose sole mission is energy efficiency, Vermont has empowered its citizens to secure their energy future," said Patricia McGinnis, President and CEO of the Council for Excellence in Government, which administers the award in partnership with Harvard. "And this small state is leading the way to a brighter future for those far beyond its borders. Already other states and countries – Maine, Indiana, Brazil – are looking to Efficiency Vermont as a model for cost-effective energy savings."

The award brings with it $100,000 to fund efforts to encourage replication of the winning initiatives. Efficiency Vermont plans to use the funds to inform and advise other states in their efforts to develop cost-effective energy efficiency services.

"Today, Vermont received recognition as a national leader for its innovative approach to meeting its energy needs," said Vermont Governor Jim Douglas. "We are proud that the nation can look to Vermont for solutions to America's energy challenges.
I congratulate the Vermont Legislature and Public Service Board for their vision, the staff at Efficiency Vermont for their hard work and dedication, and, most importantly, I congratulate all Vermonters, because - as a state - we all benefit from energy efficiency."

Winners were selected by a national committee that included David Gergen, Director of the Center for Public Leadership at Harvard University and editor-at-large at *U.S. News and World Report;* former Maryland Lieutenant Governor Kathleen Kennedy Townsend and former San Diego Mayor Susan Golding.

"Vermont is in distinguished company," said Michael Dworkin, Chair of the Vermont Public Service Board, who accepted the award with Efficiency Vermont Managing Director Blair Hamilton. "Efficiency Vermont has rightfully earned a place among a group of organizations that truly are making the world a better place. By helping Vermonters use energy more efficiently, Efficiency Vermont will save Vermont homes and businesses millions of dollars and eliminate hundreds of thousands of tons of green-house gas emissions – all at half the cost of generating and distributing new power."

Operating since 2000, Efficiency Vermont provides technical guidance and financial incentives to businesses and households statewide.

- more -

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About Efficiency Vermont

Efficiency Vermont is the nation's first statewide energy efficiency utility. It provides technical advice, financial assistance, and design guidance to help make Vermont homes and businesses more energy efficient.

Efficiency Vermont was created in 1999 when the Vermont Public Service Board ordered the creation of one, statewide efficiency utility. Previously, Vermont's 22 energy utilities were independently responsible for efficiency services. Efficiency Vermont is operated by Vermont Energy Investment Corporation (VEIC), an independent, non-profit organization under contract to the Vermont Public Service Board. VEIC is a Vermont-based organization founded in 1986. Efficiency Vermont began operating in 2000.

For more information about Efficiency Vermont, call toll-free 1-888-921-5990 or visit www.efficiencyvermont.com.

About the Innovations Award

For 16 years the Innovations in American Government Award has recognized quality and responsiveness at all levels of government and has fostered the replication of innovative approaches to the challenges facing government.

The award – a program of the Institute for Government Innovation at Harvard University's John F. Kennedy School of Government – is administered in partnership with the Council for Excellence in Government. The program was founded by the Ford Foundation to identify and promote excellence and creativity in the public sector.

The Institute for Government Innovation at Harvard University's John F. Kennedy School of Government, established through an endowment from the Ford Foundation, fosters excellence in governments throughout the world. It serves as a global hub for public-sector innovators through networks, conferences and research.

The Council for Excellence in Government is a national, nonprofit, nonpartisan organization whose mission is to improve the government performance by strengthening results-oriented management and creative leadership in the public sector, and to build understanding by focusing public discussion on government's role and responsibilities.

For more information on the Innovations in American Government program and this year's finalists, please visit www.excelgov.org.

ConsciousChoice

April 2002

Green Technology Center to Open

Collaborations Build Environmental "Brightfield" on Chicago's Industrial West Side

by Bobbye Middendorf

Drawing on the ideas, visions, and inspirations of all stakeholders in a big project allows for the whole to become truly greater than the sum of its parts. Such all-encompassing collaboration has been instrumental in the process of developing the Chicago Center for Green Technology, the city's new energy efficient and environmentally friendly showcase. And it has worked. The project is almost finished; the tenants are moving in; and its grand opening is scheduled for May.

The Chicago Center for Green Technology is an integral part of the city's aggressive plan to generate 20 percent of its electrical power from alternative sources within five years. It is the new home of Spire Solar Chicago, a company dedicated to manufacturing and marketing solar panels in the greater Chicago area. It will also house the non-profit GreenCorps, an innovative welfare-to-work life skill and landscaping training program launched eight years ago by the City of Chicago's Department of Environment (DOE).

Collaborating Built Opportunities from the Start

This site's clean-up and the building's renovation embody the collaborative process, engaging the expertise of federal and local government departments and agencies, associations, and public and private business and industry, as well as the local community.

Together, they set the stage for the return of manufacturing, offices, training facilities, and a surrounding public park landscape to this circa 1950s office building on a recovered brownfield. Brownfields are properties whose environmental conditions hinder their redevelopment. The U.S. Department of Energy's "Brightfields" plan envisions such properties as ideal locations for alternative energy farms, with solar panels arrayed on the surface.

According to David Reynolds, Deputy Commissioner at Chicago's DOE, collaborations between government agencies and departments were a hallmark of the early stages of this project, from committing to the cleanup to deciding to turn the parcel from brownfield to brightfield. The property had become a dumping ground, covered with debris from road building and housing teardowns, never processed for reuse. When the mountains of rubble continued to build, the former owner was taken to court. After the city became receiver of the site, it took on the task of removing the debris.

Working with the planning and budgeting departments, the city's DOE was able to identify funds to reprocess the materials and use the cleanup operation as a way to give back to the local community. In the beginning, they processed the housing teardown piles, recycling all materials they could and hauling out the rest. Leaders at the DOE encouraged other city departments to reuse the wealth of materials, such as gravel, that had been dumped

at the site. Local businesses were treated as resources to be preserved, as well. Reynolds notes that "every truck driver was part of a minority-owned trucking company. As the project progressed, the city was able to help local companies build capacity."

Creating a Dream Team

As it busied itself clearing the site, the City began talking to members of the American Institute of Architects Chicago Committee on the Environment, which shared the vision of green design. It partnered with ComEd, which committed to generating more energy from alternative sources. And it began looking for a tenant. Then the Federal Department of Energy introduced Spire to Chicago's Department of Environment. The city's alternative energy plan clicked into place.

Says Reynolds, "We used the purchasing power of the city and ComEd to guarantee cash flow for the start-up, giving Spire Solar Chicago a chance to build up its marketing muscle locally. The city agreed to purchase $2 million of the initial production, while ComEd agreed to purchase $6 million of the company's initial production."
In most projects, the architects are the only partners who talk with everyone involved. But Carol McLaughlin, Project Architect at Farr Associates, the architecture firm leading the project, "gathered the client, tenants, owners, building managers, architects and all the engineering partners — including civil, electrical, and mechanical engineers — the landscape architects, everyone." The firm held an Integrated Design Workshop, in which all parties could brainstorm ways to create one of the most energy efficient, environmentally friendly public buildings in the country.

Aiming for Platinum

In 1999, the Green Building Council published their LEED ("Leadership in Energy and Environmental Design") Green Building Rating System, which "evaluates environmental performance from a 'whole building' perspective over the building's life cycle." So the Chicago Center for Green Technology aimed to achieve the highest, or Platinum, LEED Rating. In fact, the LEED rating system document was used as the working checklist when the parties came together at the day-long Integrated Design Workshop.

LEED ratings start from the basics, and offer additional points for exceeding standard requirements related to planning for sustainable sites, energy efficiency, conserving materials and resources, enhancing indoor air quality, and safeguarding water. Farr Associates architect Ron Dean went through the LEED ratings list on the building point by point. Among the many innovations are a light (highly reflective) parking lot surface glued together with resin byproducts of the paper industry, and tree islands to provide shade in the parking lot. A pond collects and cleans storm water runoff from building, parking lots, and sidewalks, leeching out toxins before water enters the sewer system.

The building also boasts 20-30 percent recycled materials, innovative heating and cooling systems, solar panels used as southern window awnings to block the sun, automatic fluorescent light dimmers that adjust with the natural light, elevators that run on vegetable oil, parking and showers for bike commuters, and of course solar panels arrayed on the roof. Extensive computer energy modeling indicates the building is scheduled to be 40 percent more energy efficient than other similar buildings. The site's greenhouse is framed with non-arsenic-treated lumber. At least 50 percent of the building materials were manufactured within 300 miles of Chicago. Using off-the-shelf technology in innovative ways means that the learning curves for installing parts of the system are really more like a process of modification than radical new techniques. Still, there were local challenges to getting innovations like geo-wells approved on the project. These 200-foot deep wells carry plastic pipe filled with propylene glycol, a nontoxic, environmentally safe anti-freeze. As it circulates through the tubes, it helps the heating and cooling system use the steady-state deep ground temperature to draw away the building's summer heat or pre-warm the building in the winter.

McLaughlin emphasizes the importance of generating ideas that embodied multi-use. For an example she points to the section of green roof and says, "It helps with insulation. It helps to lessen the summer 'heat island' effect, and it helps slow storm water runoff." According to Ron Dean, the roof will be planted with sedum and other drought-tolerant ground cover.

"It is a place where citizens can learn about innovative ways to harness alternative energy, understand the huge opportunities for recycled and reused materials, and experience a world class model of energy efficient, environmentally friendly green design. Interpretive signs both inside and out will help visitors fully comprehend the environmental principles put to work." — Jessica Rio, spokesperson for the Department of Environment.

Making the Whole System Work

When I checked in with Mark Burger, sales manager for Spire Solar Chicago, the company had just recently moved into its new home. "I've never been in so comfortable a space before. Most buildings can't handle rapid temperature fluctuations. As we're talking, the temperature is dropping and the wind is blasting. You don't see the blinds swaying from drafts around the windows, and this building seems to be handling the plunging temperatures well. It maintains its temperate environment without blasts of heat or cold from the [heating and cooling system]."

According to Jessica Rio, spokesperson for the Department of Environment, this building will become a new Chicago destination. "It is a place where citizens can learn about innovative ways to harness alternative energy, understand the huge opportunities for recycled and reused materials, and experience a world class model of energy efficient, environmentally friendly green design. Interpretive signs both inside and out will help visitors fully comprehend the environmental principles put to work." Docents as well as permanent signage will serve to enlighten visitors. Training, meeting, and community programming rooms will be available for public use, as they are at North Park Nature Center. With GreenCorps landscapers in training, visitors will be able to see city lot gardening in action as well as view the pond, greenhouse, and arrays of solar panels capturing nonpolluting energy.

The building's focus on public education will encourage citizens to learn what's possible and enable them to speak up with authority. Burger observes that incorporating solar panels is a capital-intensive investment. Getting involved with large scale residential, commercial, and industrial rehabs and new construction early in the process, and working with architects, engineers, and developers who are also the source for repeat business, generates a higher likelihood of success. "It's critical that consumers start to speak up, demanding innovative, energy efficient technologies be used on new construction and rehabs where they have a voice. People have to start making their demands for clean, alternative energy known to landlords, developers, architects, and others," concludes Burger. "Then they'll have to start to pay attention!"

The Principal Players and the Project Team, Chicago Center for Green Technology

Farr Associates, Lead Architects
Sieben Energy Associates, Lighting Design
Prisco Serena Sturm Architects, Energy Modeling
OWP&P Architects, Indoor Air Quality
Michael Roy Iverson, Architect, Specifications for Demolition and Construction, Waste Management, 708-383-1189
IBC Engineering Services, Mechanical and Plumbing, 262-549-1190
Spectrum Engineering, Electrical
Site Design Group, Landscape Architecture, 312-855-0186

Terra Engineering, Civil Engineering, 312-467-0123
T.G.R.W.A., Structural Engineering
Spire Solar Chicago, PV array
City of Chicago Department of Environment
DOE's Greencorps Chicago crews performed installation with assistance from WRD Environmental
Plant Selection:
GreenCorps Chicago
Bob Porter, restoration ecologist for the Department of Environment's North Park Village Nature Center, 312 744-5472
Public Building Commission, acting Owner/Developer
Contracting with: Cotter Consulting, Construction Management

www.consciouschoice.com/2002/cc1504/greentechnologyctr1504.html

ConsciousChoice

April 2002

Chicago will be America's Greenest City

by Jim Slama

Have you heard? America's third largest city has set its sights on a new image. Hog butcher to the world is out. Solar power, energy efficiency, habitat restoration, and twenty-first century windmills are in. It's an exciting time to be an environmentalist in Chicago.

The effort is being led by Mayor Daley. In the early years of his administration, he began an ambitious program to plant thousands of trees each year in neighborhoods across Chicago. Now more than 250,000 of these living air conditioners have been planted to provide oxygen and cooling throughout the summer. And inspired by world class cities like Paris and Rome, the mayor has also embarked on an ambitious beautification program in which grafitti is blasted, flowers are planted, and litter is cleaned up from streets and neighborhoods throughout the city.

In recent years, the Mayor teamed up with Commissioner of the Department of the Environment, Bill Abolt, a nine-year veteran of the administration. During his tenure, Abolt has led an impressive effort to make the city a global leader in renewable energy production and manufacturing. If you're in Chicago, you don't have to travel far to see some of his successful endeavors. Solar panels on the Field Museum, Art Institute, and Nature Museum come to mind. So does the rooftop garden on top of city hall. Next month the Chicago Center for Green Technology opens as a showcase green building that houses some cutting-edge environmental companies. And soon after that, internationally known green consultant Bill McDonough will introduce his view on what it will take to make Chicago America's greenest city.

Abolt's hard work and effectiveness recently were rewarded with a promotion. He is now Chicago's Chief Management Officer, the number three job in city government, behind the Mayor and his Chief of Staff. This new position should give Abolt even more authority and resources to support the city's green vision.

Jim Slama: Chicago has an intention to be the greenest city in America. Tell us about that goal and how it developed.

Bill Abolt: The vast array of environmental projects we have created are making the city more prosperous, more beautiful, and more healthy. People are paying attention to this because very few other major cities have defined themselves as green. You expect progressive policies in places like Seattle and Portland. When a big, diverse city like Chicago takes these steps it's pretty significant. The bottom line is that Mayor Daley is committed and serious about our environmental initiatives and sees them as a key part of the city's competitive strategy in the future.

What's driving the mayor?

The mayor appreciates that cities are an environmentally friendly way to live. Dense urban areas served by good public transit are far preferable to far flung suburbs contributing to sprawl, traffic congestion, and the related air pollution. Mayor Daley also understands the importance of sustainability and the responsibility that he has to be a steward of the city and its resources. There is a tremendous opportunity to reconnect city dwellers with nature and with natural areas. With the right kind of programs we can beautify streets and neighborhoods, improve our air quality, and make the city more livable and attractive — the kind of place [where] you want to work and raise a family.

What kind of projects are you working on?

The city has a tremendous commitment to a variety of green programs. Chicago is already the leading big city for bicycling in North America. Our beautification program has placed planters loaded with beautiful plants and flowers throughout the city. Development of the museum campus park and reconstruction of the entire Lake Michigan shoreline are also important programs. Beyond that the city has the largest and most aggressive brownfields redevelopment program in the United States.

What's a brownfield?

A brownfield is a piece of property that is under-utilized and has some kind of environmental contamination. Examples are an old gas station with a leaky oil tank or a former factory with contaminated grounds. You have to clean that contamination before you can redevelop the property. So the mayor was on the leading edge back in the early 1990s in turning brownfield sites around.

What is the cornerstone of your vision to make Chicago America's greenest city?

The mayor has laid out an energy plan for Chicago that is strategically linked with this goal. The plan aims to meet most of our future electrical needs through a few simple strategies. The first is to transform the city of Chicago into one of the smartest energy managers out there by making most of our facilities energy efficient. The next strategy will use clean-burning small-scale power plants placed in city facilities to generate power at peak times. Those can be managed from one location and dispatched as needed without the additional cost of a new power plant. We were able to create what amounts to a six-and-a-half megawatt power plant in six weeks just by installing the technology. In a similar vein, we are working with a hospital association to convert the diesel generators used in over forty city hospitals to cleaner burning natural gas.

The third element of the plan is to promote renewable energy. Last year Mayor Daley committed to make the largest purchase of renewable power in the United States. So we signed a contract with Com Ed to develop 20 percent of the city's electrical needs from renewable sources coming from the Chicago area. Some of it will come from burning methane that comes off landfills. The majority will come from new wind, solar, biomass, and small scale hydro-electric generation. The biggest challenge is getting the wind online, but already Com Ed has agreed to have fifty megawatts under construction this year with a commitment to sell us this wind power by the beginning of 2003.

Tell us more about your energy efficiency programs.

Mayor Daley has committed over a hundred million dollars to rehab buildings across the city to be more energy efficient. It's going into everything from private developments to individual residences to city facilities. We will be retro-fitting over 15 million square feet of city facilities and building new facilities like public libraries and fire stations — all using state of the art energy efficiency technology. The rooftop garden on top of city hall is another example of our work in energy efficiency, with an estimated impact of about $4,000 a year in reduced energy costs. We are also putting in more efficient light bulbs in 145,000 traffic lights across the city, which will save taxpayers about $4.5 million in electric bills.

On a micro scale, last year when citizens were having problems with their gas bills we gave out vouchers in cooperation with Home Depot to weatherize homes. We are also constructing five new state of the art energy efficient homes and restoring four historic bungalows as a model for environmentally responsible residences.

How are you encouraging solar power?

This is a really exciting part of our green policy. We created incentives to lure Spire, a new solar manufacturing company to the city. They are the anchor tenant of our Chicago Center for Green Technology. The company will create about 100 good jobs. Using Spire technology we already put solar panels on top of the Field Museum, the Mexican Fine Arts Museum and the Art Institute. These are some of the biggest solar installations in the Midwest.

How did the Chicago Center for Green Technology come about?

The site has quite a history. It used to be an old demolition debris facility that we shut down when it got out of compliance. The company went into bankruptcy to protect themselves from having to pay the clean-up costs. So the city had to go to bankruptcy court and ultimately become the receiver of a seventeen-acre parcel on the west side of the city of Chicago. When we received title to it, the site had 600,000 cubic yards of construction debris piled up on top of it. So we applied some environmentally sound principles and recycled much of the debris, which cut our disposal costs in half. The concrete was crushed and used in everything from the construction of parking lots to roads and sewer projects.

Once the site was cleaned up it consisted of an abandoned building and twelve acres of vacant property. Our goal was to then find a green company to redevelop it in an environmentally friendly sort of way. At that point, we had reached a settlement agreement with Commonwealth Edison to create a $100 million green development fund which gave us the money to redevelop the site. In addition, the U.S. Department of Energy came to us and said that people are going to want to buy green power but there is no green power in Illinois. They recommended that we make a significant purchase commitment to lure a solar manufacturing company to Chicago. We did and that is how we landed Spire.

What other types of businesses do you want to attract to the Center?

We want Chicago to be the nation's premier manufacturing center for green technology. In addition to Spire, we hope to land companies with other solar products such as thermal solar and integrated solar. I also think we can attract manufacturers who are involved in wind energy production. The Center also houses Greencorps Chicago, a community gardening program that also teaches job skills.

Is the city doing any other innovative economic development plans that tie in with the environment?

The Mayor has worked with Governor Ryan to create a $34 million program to revive the Lake Calumet area

with a combination of environmental restoration and green business development. The centerpiece of the project is an initiative to restore and enhance the environmentally sensitive land in the region which has the largest collection of wetlands in the midwest. Ultimately we expect the Calumet Open Space Reserve to consist of over 3,000 acres of wetlands, streams, marshes, and lakes. This is great opportunity to enhance the wildlife in the region, because the area is home to so many unique species, including the yellow headed blackbird and black crowned night heron, both of which are on the Illinois endangered species list.

The plan for the area includes the development of a renewable energy center. We hope to build the country's largest solar generating station as well as a facility to convert landfill gas (methane) to energy. In addition, we will create an environmental center to showcase the rich habitat and history of the area as well as to teach people about sustainable industrial and economic development.

Keep up the good work, Bill.

http://www.consciouschoice.com/2002/cc1504/aboltinterview1504.html

FORTUNE

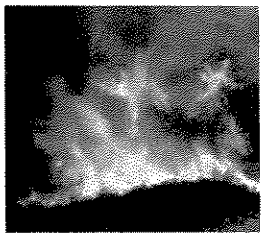
FORTUNE - Technology

CLIMATE COLLAPSE

The Pentagon's Weather Nightmare

The climate could change radically, and fast. That would be the mother of all national security issues.

By David Stipp



Global warming may be bad news for future generations, but let's face it, most of us spend as little time worrying about it as we did about al Qaeda before 9/11. Like the terrorists, though, the seemingly remote climate risk may hit home sooner and harder than we ever imagined. In fact, the prospect has become so real that the Pentagon's strategic planners are grappling with it.

The threat that has riveted their attention is this: Global warming, rather than causing gradual, centuries-spanning change, may be pushing the climate to a tipping point. Growing evidence suggests the ocean-atmosphere system that controls the world's climate can lurch from one state to another in less than a decade—like a canoe that's gradually tilted until suddenly it flips over. Scientists don't know how close the system is to a critical threshold. But abrupt climate change may well occur in the not-too-distant future. If it does, the need to rapidly adapt may overwhelm many societies—thereby upsetting the geopolitical balance of power.

Though triggered by warming, such change would probably cause cooling in the Northern Hemisphere, leading to longer, harsher winters in much of the U.S. and Europe. Worse, it would cause massive droughts, turning farmland to dust bowls and forests to ashes. Picture last fall's California wildfires as a regular thing. Or imagine similar disasters destabilizing nuclear powers such as Pakistan or Russia—it's easy to see why the Pentagon has become interested in abrupt climate change.

Climate researchers began getting seriously concerned about it a decade ago, after studying temperature indicators embedded in ancient layers of Arctic ice. The data show that a number of dramatic shifts in average temperature took place in the past with shocking speed-in some cases, just a few years.

The case for angst was buttressed by a theory regarded as the most likely explanation for the abrupt changes. The eastern U.S. and northern Europe, it seems, are warmed by a huge Atlantic Ocean current that flows north from the tropics-that's why Britain, at Labrador's latitude, is relatively temperate. Pumping out warm, moist air, this "great conveyor" current gets cooler and denser as it moves north. That causes the current to sink in the North Atlantic, where it heads south again in the ocean depths. The sinking process draws more water from the south, keeping the roughly circular current on the go.

But when the climate warms, according to the theory, fresh water from melting Arctic glaciers flows into the North Atlantic, lowering the current's salinity-and its density and tendency to sink. A warmer climate also increases rainfall and runoff into the current, further lowering its saltiness. As a result, the conveyor loses its

LoL-EX-13

main motive force and can rapidly collapse, turning off the huge heat pump and altering the climate over much of the Northern Hemisphere.

Scientists aren't sure what caused the warming that triggered such collapses in the remote past. (Clearly it wasn't humans and their factories.) But the data from Arctic ice and other sources suggest the atmospheric changes that preceded earlier collapses were dismayingly similar to today's global warming. As the Ice Age began drawing to a close about 13,000 years ago, for example, temperatures in Greenland rose to levels near those of recent decades. Then they abruptly plunged as the conveyor apparently shut down, ushering in the "Younger Dryas" period, a 1,300-year reversion to ice-age conditions. (A dryas is an Arctic flower that flourished in Europe at the time.)

Though Mother Nature caused past abrupt climate changes, the one that may be shaping up today probably has more to do with us. In 2001 an international panel of climate experts concluded that there is increasingly strong evidence that most of the global warming observed over the past 50 years is attributable to human activities-mainly the burning of fossil fuels such as oil and coal, which release heat-trapping carbon dioxide. Indicators of the warming include shrinking Arctic ice, melting alpine glaciers, and markedly earlier springs at northerly latitudes. A few years ago such changes seemed signs of possible trouble for our kids or grandkids. Today they seem portents of a cataclysm that may not conveniently wait until we're history.

Accordingly, the spotlight in climate research is shifting from gradual to rapid change. In 2002 the National Academy of Sciences issued a report concluding that human activities could trigger abrupt change. Last year the World Economic Forum in Davos, Switzerland, included a session at which Robert Gagosian, director of the Woods Hole Oceanographic Institution in Massachusetts, urged policymakers to consider the implications of possible abrupt climate change within two decades.

Such jeremiads are beginning to reverberate more widely. Billionaire Gary Comer, founder of Lands' End, has adopted abrupt climate change as a philanthropic cause. Hollywood has also discovered the issue-next summer 20th Century Fox is expected to release The Day After Tomorrow, a big-budget disaster movie starring Dennis Quaid as a scientist trying to save the world from an ice age precipitated by global warming.

Fox's flick will doubtless be apocalyptically edifying. But what would abrupt climate change really be like ? Scientists generally refuse to say much about that, citing a data deficit. But recently, renowned Department of Defense planner Andrew Marshall sponsored a groundbreaking effort to come to grips with the question. A Pentagon legend, Marshall, 82, is known as the Defense Department's "Yoda"-a balding, bespectacled sage whose pronouncements on looming risks have long had an outsized influence on defense policy. Since 1973 he has headed a secretive think tank whose role is to envision future threats to national security. The Department of Defense's push on ballistic-missile defense is known as his brainchild. Three years ago Defense Secretary Donald Rumsfeld picked him to lead a sweeping review on military "transformation," the shift toward nimble forces and smart weapons.

When scientists' work on abrupt climate change popped onto his radar screen, Marshall tapped another eminent visionary, Peter Schwartz, to write a report on the national-security implications of the threat. Schwartz formerly headed planning at Royal Dutch/Shell Group and has since consulted with organizations ranging from the CIA to DreamWorks-he helped create futuristic scenarios for Steven Spielberg's film Minority Report. Schwartz and co-author Doug Randall at the Monitor Group's Global Business Network, a scenario-planning think tank in Emeryville, Calif., contacted top climate experts and pushed them to talk about what-ifs that they usually shy away from-at least in public.

The result is an unclassified report, completed late last year, that the Pentagon has agreed to share with FORTUNE. It doesn't pretend to be a forecast. Rather, it sketches a dramatic but plausible scenario to help planners think about coping strategies. Here is an abridged version :

A total shutdown of the ocean conveyor might lead to a big chill like the Younger Dryas, when icebergs appeared as far south as the coast of Portugal. Or the conveyor might only temporarily slow down, potentially causing an era like the "Little Ice Age," a time of hard winters, violent storms, and droughts between 1300 and 1850. That period's weather extremes caused horrific famines, but it was mild compared with the Younger Dryas.

For planning purposes, it makes sense to focus on a midrange case of abrupt change. A century of cold, dry, windy weather across the Northern Hemisphere that suddenly came on 8,200 years ago fits the bill-its severity fell between that of the Younger Dryas and the Little Ice Age. The event is thought to have been triggered by a conveyor collapse after a time of rising temperatures not unlike today's global warming. Suppose it recurred, beginning in 2010. Here are some of the things that might happen by 2020 :

At first the changes are easily mistaken for normal weather variation-allowing skeptics to dismiss them as a "blip" of little importance and leaving policymakers and the public paralyzed with uncertainty. But by 2020 there is little doubt that something drastic is happening. The average temperature has fallen by up to five degrees Fahrenheit in some regions of North America and Asia and up to six degrees in parts of Europe. (By comparison, the average temperature over the North Atlantic during the last ice age was ten to 15 degrees lower than it is today.) Massive droughts have begun in key agricultural regions. The average annual rainfall has dropped by nearly 30% in northern Europe, and its climate has become more like Siberia's.

Violent storms are increasingly common as the conveyor becomes wobbly on its way to collapse. A particularly severe storm causes the ocean to break through levees in the Netherlands, making coastal cities such as the Hague unlivable. In California the delta island levees in the Sacramento River area are breached, disrupting the aqueduct system transporting water from north to south.

Megadroughts afflict the U.S., especially in the southern states, along with winds that are 15% stronger on average than they are now, causing widespread dust storms and soil loss. The U.S. is better positioned to cope than most nations, however, thanks to its diverse growing climates, wealth, technology, and abundant resources. That has a downside, though : It magnifies the haves-vs.-have-nots gap and fosters bellicose finger-pointing at America.

Turning inward, the U.S. effectively seeks to build a fortress around itself to preserve resources. Borders are strengthened to hold back starving immigrants from Mexico, South America, and the Caribbean islands-waves of boat people pose especially grim problems. Tension between the U.S. and Mexico rises as the U.S. reneges on a 1944 treaty that guarantees water flow from the Colorado River into Mexico. America is forced to meet its rising energy demand with options that are costly both economically and politically, including nuclear power and onerous Middle Eastern contracts. Yet it survives without catastrophic losses.

Europe, hardest hit by its temperature drop, struggles to deal with immigrants from Scandinavia seeking warmer climes to the south. Southern Europe is beleaguered by refugees from hard-hit countries in Africa and elsewhere. But Western Europe's wealth helps buffer it from catastrophe.

Australia's size and resources help it cope, as does its location-the conveyor shutdown mainly affects the Northern Hemisphere. Japan has fewer resources but is able to draw on its social cohesion to cope-its government is able to induce population-wide behavior changes to conserve resources.

China's huge population and food demand make it particularly vulnerable. It is hit by increasingly unpredictable monsoon rains, which cause devastating floods in drought-denuded areas. Other parts of Asia and East Africa are similarly stressed. Much of Bangladesh becomes nearly uninhabitable because of a rising sea level, which contaminates inland water supplies. Countries whose diversity already produces conflict, such as

India and Indonesia, are hard-pressed to maintain internal order while coping with the unfolding changes.

As the decade progresses, pressures to act become irresistible-history shows that whenever humans have faced a choice between starving or raiding, they raid. Imagine Eastern European countries, struggling to feed their populations, invading Russia-which is weakened by a population that is already in decline-for access to its minerals and energy supplies. Or picture Japan eyeing nearby Russian oil and gas reserves to power desalination plants and energy-intensive farming. Envision nuclear-armed Pakistan, India, and China skirmishing at their borders over refugees, access to shared rivers, and arable land. Or Spain and Portugal fighting over fishing rights-fisheries are disrupted around the world as water temperatures change, causing fish to migrate to new habitats.

Growing tensions engender novel alliances. Canada joins fortress America in a North American bloc. (Alternatively, Canada may seek to keep its abundant hydropower for itself, straining its ties with the energy-hungry U.S.) North and South Korea align to create a technically savvy, nuclear-armed entity. Europe forms a truly unified bloc to curb its immigration problems and protect against aggressors. Russia, threatened by impoverished neighbors in dire straits, may join the European bloc.

Nuclear arms proliferation is inevitable. Oil supplies are stretched thin as climate cooling drives up demand. Many countries seek to shore up their energy supplies with nuclear energy, accelerating nuclear proliferation. Japan, South Korea, and Germany develop nuclear-weapons capabilities, as do Iran, Egypt, and North Korea. Israel, China, India, and Pakistan also are poised to use the bomb.

The changes relentlessly hammer the world's "carrying capacity"-the natural resources, social organizations, and economic networks that support the population. Technological progress and market forces, which have long helped boost Earth's carrying capacity, can do little to offset the crisis-it is too widespread and unfolds too fast. As the planet's carrying capacity shrinks, an ancient pattern reemerges : the eruption of desperate, all-out wars over food, water, and energy supplies. As Harvard archeologist Steven LeBlanc has noted, wars over resources were the norm until about three centuries ago. When such conflicts broke out, 25% of a population's adult males usually died. As abrupt climate change hits home, warfare may again come to define human life.

Over the past decade, data have accumulated suggesting that the plausibility of abrupt climate change is higher than most of the scientific community, and perhaps all of the political community, are prepared to accept. In light of such findings, we should be asking when abrupt change will happen, what the impacts will be, and how we can prepare-not whether it will really happen. In fact, the climate record suggests that abrupt change is inevitable at some point, regardless of human activity. Among other things, we should :

• Speed research on the forces that can trigger abrupt climate change, how it unfolds, and how we'll know it's occurring.

• Sponsor studies on the scenarios that might play out, including ecological, social, economic, and political fallout on key food-producing regions.

• Identify "no regrets" strategies to ensure reliable access to food and water and to ensure our national security.

• Form teams to prepare responses to possible massive migration, and food and water shortages.

• Explore ways to offset abrupt cooling-today it appears easier to warm than to cool the climate via human activities, so there may be "geo-engineering" options available to prevent a catastrophic temperature drop.

In sum, the risk of abrupt climate change remains uncertain, and it is quite possibly small. But given its dire consequences, it should be elevated beyond a scientific debate. Action now matters, because we may be able to

reduce its likelihood of happening, and we can certainly be better prepared if it does. It is time to recognize it as a national security concern.

The Pentagon's reaction to this sobering report isn't known-in keeping with his reputation for reticence, Andy Marshall declined to be interviewed. But the fact that he's concerned may signal a sea change in the debate about global warming. At least some federal thought leaders may be starting to perceive climate change less as a political annoyance and more as an issue demanding action.

If so, the case for acting now to address climate change, long a hard sell in Washington, may be gaining influential support, if only behind the scenes. Policymakers may even be emboldened to take steps such as tightening fuel-economy standards for new passenger vehicles, a measure that would simultaneously lower emissions of greenhouse gases, reduce America's perilous reliance on OPEC oil, cut its trade deficit, and put money in consumers' pockets. Oh, yes-and give the Pentagon's fretful Yoda a little less to worry about.

www.fortune.com/fortune/technology/articles/0,15114,582584,00.html

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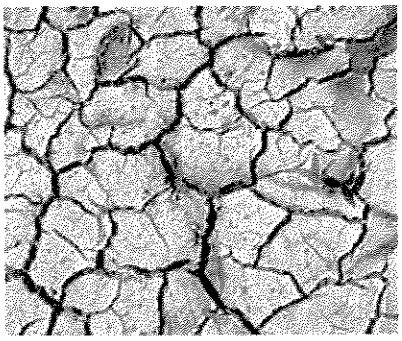
CLIMATE IMPACTS

A WORST-CASE VIEW OF GLOBAL CHANGE

Defense Department report warns of "abrupt" global warming impact

JEFF JOHNSON

A pentagon report made public last week lays out the worst-case impact from an abrupt change in climate, driven by global warming. It was prepared by two futurists under a Defense Department contract to gauge the national security impact of climate change.



PHOTODISC

HIGH AND DRY Prolonged drought and high temperatures will transform the world's croplands.

The report warns of average temperature drops of 5 °F in Asia, North America, and Northern Europe and average temperature increases of 4 °F in Australia, South America, and Southern Africa, as well as droughts, severe winter storms, and intense winds.

The report considers a scenario of a fast change in climate, rather than a more gradual one in which technological innovation could help stave off disaster. That fast scenario could develop in as short as a decade, the authors say. The scenario springs from recent research indicating that global warming could lead to a quick slowing of the ocean's thermohaline conveyor, which would upset global weather patterns.

The authors caution that the scenario would most likely occur in only a few regions and the magnitude may be

LOL-EX-14

smaller than they describe. However, they add that it is plausible and would challenge U.S. national security and therefore should be considered immediately.

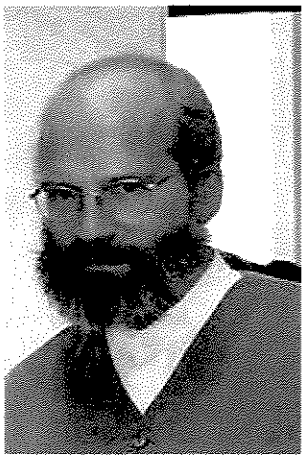
Wealthy countries may be better positioned than most to avoid the worst of the scenario, the report says. The U.S. is likely to survive a harsh climate and shorter growing season because of its diverse agriculture and climate, wealth, technology, and abundant resources, but it would put much effort into building "defensive fortresses" to hold back the "unwanted starving immigrants."

The report warns that, under its scenario, large movements of refugees are inevitable and U.S. diplomatic action will be particularly needed in affected areas, such as Asia and the Caribbean. It predicts border tensions and the need for new forms of international security agreements for energy, food, and water.

Although the U.S. might be relatively better off, the Pentagon report says, it would find itself in a world where Europe will be struggling and Asia will face a crisis over food and water. "Disruptions and conflict will be endemic features of life."

http://pubs.acs.org/cen/topstory/8209/8209notw9.html

HENRY CURTIS
LIFE OF THE LAND



Henry Curtis is Executive Director of Life of the Land (LOL), Hawai`i's own environmental and community action group advocating for the people and the `aina since 1970. Henry has been LOL's Executive Director since 1995 concentrating on energy, environmental and social justice issues.

Henry has distinguished himself through his extensive research into and understanding of energy issues. He has become the community's voice on energy issues and has successfully brought that perspective to the Legislature and countless other venues where the community has not traditionally been heard. He is committed to Hawai`i's energy self-sufficiency and well being.

Henry is powered by the values of aloha `aina and malama `aina and is constantly motivated by his aloha for the community.

Henry has a B.A. in Economics from Queens College, City University of New York (CUNY). The program specialized in economic and mathematical theory. He completed the course work towards a masters degree in economics, specializing in macroeconomics and resource economics.

He has served on a military Technical Review Committee (TRC) and on several Restoration Advisory Boards (RAB) monitoring and advising the military on cleanup issues for the army, navy and air force. He served as Community Co-Chair of the Hickam Air Force Base RAB from 1996-2005. As Executive Director of LOL he has been involved with several non-military toxic campaigns including securing money for soil testing, monitoring a superfund site, and reviewing environmental documents focusing on brownfields and toxics.

Henry represented LOL in the Board of Land and Natural Resources (BLNR) contested case hearing regarding the proposal to put a high-voltage transmission line Wa`ahila Ridge.

Henry has represented LOL's interests at HEI's annual shareholder meetings.

Henry has represented LOL before the Public Utilities Commission in dockets on Distributed Generation, Investigation of Restructuring, Energy Efficiency, and Integrated Resource Planning.

LOL-EX-19