SCENARIOS FOR 2035:
LONG-TERM TRENDS, CHALLENGES AND UNCERTAINTIES FACING NOAA

A Working Document for NOAA Planning: May 2009

Cover: Coastal dune

AN INVITATION TO CONTRIBUTE TO NOAA'S NEXT GENERATION STRATEGIC PLAN

In the fall of 2008, NOAA began preparations for a Next Generation Strategic Plan by convening a multi-disciplinary team of individuals from across the organization to begin thinking about the forces that will shape the world over the next 25 years. Through a series of workshops, this team identified approximately 200 major external forces and trends that could significantly affect NOAA's future through 2035. The team analyzed the degree of uncertainly and potential scope of impact of these forces, and used that analysis to develop three alternative yet equally plausible scenarios of the future. This document details these three scenarios.

Scenarios are a powerful and widely used tool for helping organizations understand, respond to, and sometimes influence the complex economic, governmental, social, and environmental forces shaping the future. We cannot predict the future, but we can identify key forces and imagine how they might combine to form plausible alternative futures. The scenarios NOAA has crafted are not the most likely alternatives for 2035—no one can even begin to outline the full range of potential outcomes over this time frame. Rather, they are plausible combinations of real-world forces that allow us to evaluate, test, and refine NOAA's long-term strategy.

With its complex and long-term mission responsibilities in mind, NOAA has developed these scenarios to stimulate thinking and catalyze discussion about how the world might evolve, what types of opportunities and challenges might emerge for NOAA and its partners and stakeholders, and how NOAA can best position itself for successfully executing its mission over the long term. We encourage readers to join in this discussion about our shared future.

NOAA's "Scenarios for 2035" provides a point of departure for thinking about the challenges and opportunities facing NOAA and its extended stakeholder community. While NOAA welcomes comments on any aspect of this document, we are most interested in obtaining readers' views on the long-term trends and forces they believe are most significant, the types of challenges and opportunities that may arise, and the potential responses that NOAA should consider. The views of NOAA's stakeholders and staff on these questions will help NOAA craft a robust long-term strategy, one that sets objectives for the next 5 years in the context of long-term goals that will enable NOAA to maximize its value to society and the world—from today through 2035.

To participate in developing NOAA's Next Generation Strategic Plan, please visit www.ppi.noaa.gov.

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NOAA needs to consider alternative external environments in which it might operate in the next 25 years so it can best position itself to fulfill its mission requirements and generate sustained benefits in the areas most highly valued by society. The world in 2035 will be shaped by a complex set of forces, only some of which NOAA will be able to influence. In addition, the future external dynamics and outcomes of many forces and drivers are highly uncertain over this long period of time; only a few are relatively predictable.

The scenarios conveyed in this document are derived from different combinations of outcomes at the extreme ends of three axes of uncertainty: the nature and mix of economic activity; governance and decision-making processes; and the interaction between society and the physical environment. The scenarios also include a range of forces that are fairly certain to occur and consequently appear nearly identically in each scenario, although their impacts may vary substantially.

MAJOR AREAS OF LONG-TERM UNCERTAINTY FOR NOAA

Three clusters of tightly linked, uncertain forces are likely to shape the composition of demand for NOAA's mission functions in the future, as well as NOAA's ability to respond. Because of their uncertainties, the dynamics and outcomes among these forces could range widely over the next 25 years.

Nature and mix of economic activity: The first axis of uncertainty centers on the nature and mix of economic activity in the United States and around the world. The important forces on this axis include the relative priority and nature of economic growth in the United States and other nations and regions; urbanization and migration trends; growth in energy demand in different segments of society; the availability of energy supply; and the drive by businesses, consumers, and governments to be "green." Potential outcomes on this axis range from a business-as-usual mix of socio-economic activities to a sustainable, smart-growth commitment and outcome.

In the business-as-usual extreme, for the U.S. population prosperity and well-being would largely be a function of personal financial wealth, with GDP growth representing the highest priority for policy makers. In business as usual, policy measures would be implemented to expand low-cost supplies wherever they may be even while there are growing requirements to limit emissions of CO^2. Efficiency measures would be undertaken to minimize the chances for disruption and to keep costs low. With GDP growth as the primary criterion, policy makers might do little to restrain economic development in coastal regions. With the business-as-usual dynamic, there could be large changes in the physical environment around the world, with urban sprawl becoming much worse and few profitable property and casualty insurance companies.

At the smart growth end of this axis, U.S. society would develop an intense quality of life focus and would support major drives in building a green infrastructure, implementing green-management practices in companies and changing personal and family activities to be more energy-efficient, non-carbon generating, and environmentally sustainable. State and local authorities in the United States would develop and successfully implement new policies for smart urban planning.

Governance and decision-making: The second axis of uncertainty centers on the governance and decision-making processes of governmental organizations at State, federal, and international levels. The important forces on this axis include the nature and mix of international laws and agreements, the U.S. federal budget process, the extent of information sharing across government organizations, the trend toward privatization of government functions, and the nature of energy policy in the United States. Potential outcomes on this axis range from relatively fragmented processes for governance and decision-making to highly collaborative processes.

In the fragmentation extreme, government bodies would compete and government allocation of resources to meet needs would be highly inefficient. At the international level, nations would typically act in their own interests, and the United States would often be at odds on international issues with other major powers or the developing countries. Bilateral agreements would be the primary means for creating international order, but these would generally be weak arrangements and often leave problems unresolved. In the United States, government agencies would compete strongly for their budgets. The private sector could assume some government functions over time, but the outcome would be largely unplanned. Information about the environ-

ment, while exploding in volume around the world, would remain hard to share because of the lack of interoperability standards and intellectual property concerns of all the parties—both government and private.

In the collaboration extreme for the governance and decision-making axis, efforts would occur at all levels of government (and in many businesses and NGOs) to learn and implement skills and models for achieving multi-party agreements on environment, economic, and social issues through collaboration. International laws and agreements on environmental issues would be developed and implemented on a collaborative basis. In this extreme, information sharing of all the data among the parties—particularly at the international level—would be facilitated by the development of interoperability standards and access technology. At the same time, new policy mechanisms would be implemented to align the public and private sectors on environmental issues and leverage the private sector's innovation capacities. The federal government budgeting process would be overhauled to better allocate resources to the highest priority needs and capabilities.

Interaction between society and the environment: The third axis of uncertainty involves the interaction between society and the physical environment. The important forces in this cluster include climate change developments, the outcomes for U.S. and global ocean resources, water quality for U.S. coastal areas, the U.S. public's attitudes and behavior on the environment, and food security in the world. Potential axis outcomes range from a dysfunctional interaction between society and the environment to a harmonious one.

In the dysfunctional extreme of this axis, economic and societal activities would be out of balance with what is happening with the environment. Many of the major indicators of environmental health would be getting worse. Problems would be developing everywhere—in water quality, agricultural practices, food security, fish stocks, and ocean and coastal ecosystems. But the overwhelming new change in the world would be the abrupt and highly disruptive climate change effects by 2035.

At the other end of the spectrum, in a harmonious interaction between society and the environment, nations would be generally sensitive to the changing natural environment and very responsive to future possibilities. For both business and society, the priority would be on developing and maintaining sustainable ecosystems with the recognition that the changes required would be all encompassing. Much progress would be made in addressing climate change drivers, improving water quality, and finding workable, sustainable water-management practices. Food security would not an issue for society or governments because of efforts to diversify sources and monitor and manage safety for the major centers of food supply.

MAJOR AREAS OF LONG-TERM CERTAINTY FOR NOAA

In addition to the high-impact, highly uncertain forces, there are some key external issues for which there is little to no doubt about their outcomes in the next 25 years; only the pacing and the intensity of their impacts will vary. Perhaps the most important one of these issues for NOAA, which will occur across all scenarios, will be the continuing advances in computing and availability of new high-performance hardware and software. Today's petaflop machines will be supplanted by exaflop and beyond capabilities by 2020. The new machines and software will require significant investment to install and operate.

Another key driver for NOAA that will be constant across the scenarios will be the ongoing occurrence of catastrophic events that will continue to be frequent, severe, and often surprising in their impacts. Natural (volcanic eruptions, earthquakes, tsunamis, and hurricanes) and manmade (terrorist attacks, fires, and infrastructure failures) events will continue to occur. New catastrophic events—defined by their economic and natural-system impacts—will occur more frequently in the Arctic region because of increased industrial and marine transport activity in the area.

The third major constant across the scenarios will be that water supply issues will worsen. According to the United Nations Secretary General, "Half the nations of the world will face freshwater stress or shortages by 2025." Similarly, the American Meteorological Society notes, "The provision of adequate fresh-water resources for humans and ecosystems will be one of the most critical and potentially contentious issues facing society and governments at all levels during the 21st century." By 2030, U.S. electricity demand is expected to grow by 50 percent, placing an additional burden on freshwater supplies. Water availability and utility will continue to be linked to population growth, development, and weather patterns. Water discharge into the oceans will continue to impact the health of lakes and coastal estuaries, and will play a role in algal blooms, declining oyster productivity, and similar hazards.

Finally, national population growth rates also will not vary across the scenarios. Population development is important because it influences a wide range of economic and environmental activities. Population will grow in the United States at about 1 percent per year, while the European Union and Japan will experience essentially no changes. China will grow at approximately 0.5 percent per year, while India will grow at 1.5 percent per year. The expected changes by key region are shown in the table below.

	POPULATION (MILLIONS) IN YEAR		
	2010	**2020**	**2030**
North America	344	380	415
European Union	497	507	515
India	1180	1380	1580
China	1350	1430	1510

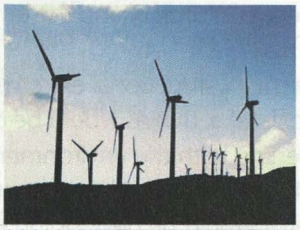
THREE PLAUSIBLE SCENARIOS OF THE FUTURE FOR NOAA

NOAA developed three scenarios to explore different potential combinations of forces, dynamics, and outcomes on each of the three axes of uncertainty. These three scenarios do not represent futures that NOAA thinks are particularly likely to happen: No one can predict what the world will look like in 2035, and there is no way to even define the full range of probable outcomes. Nor do the scenarios represent futures that NOAA wants to see unfold: That is the role of NOAA's vision statement, which will be a central component of the Next-Generation Strategic Plan. Rather, the scenarios represent divergent yet equally plausible combinations of forces and trends across each of the axes of uncertainty. By conveying the widest range of plausible outcomes, NOAA's "Scenarios for 2035" can challenge our understanding of how the world might evolve, catalyze a strategic conversation within and outside the organization, and help NOAA identify and evaluate possible strategic goals and objectives for the long-term as well as the next 5 years.

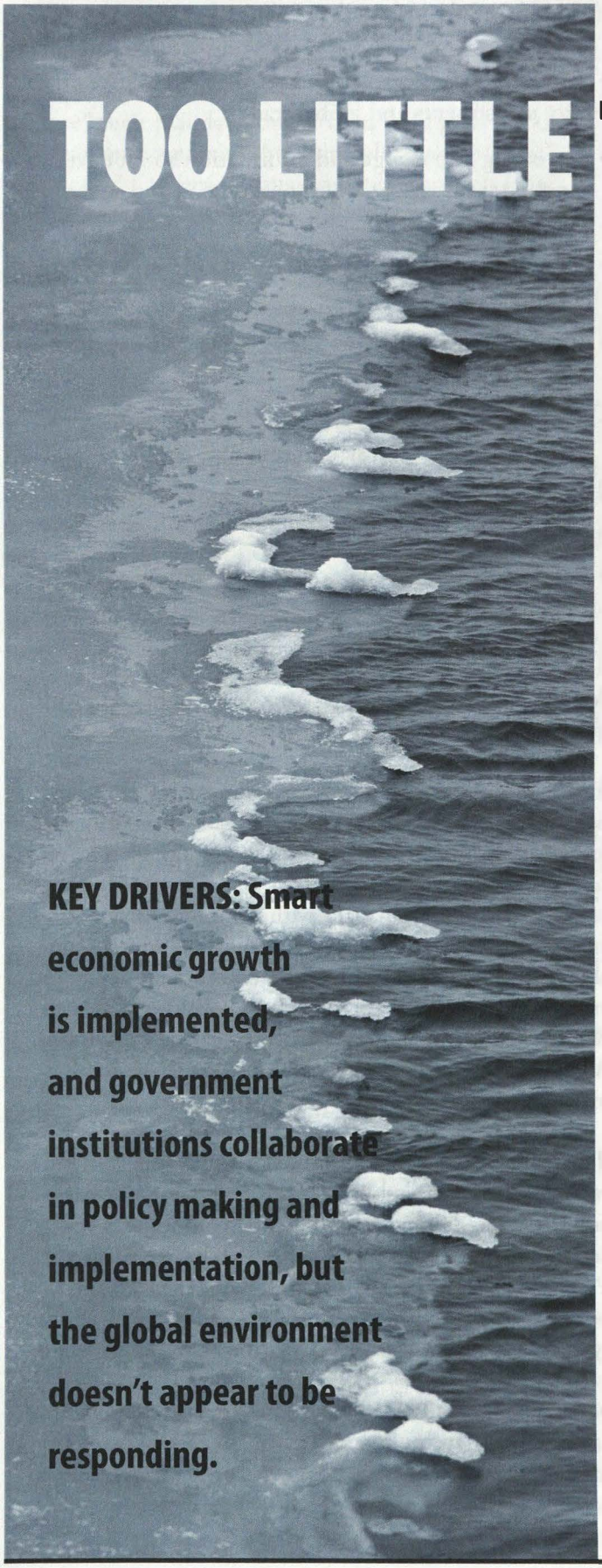
To this end, "Scenarios for 2035" presents two ways of looking at the world of 2035. The first is through the narrative text, which provides short stories of the forces, dynamics, and outcomes within each scenario. The second view of the future is provided in the table at the end of the document, which compares the major forces and trends across each of the scenarios. Readers are encouraged to review the three scenarios in this document with an open mind, using them as a point of departure for thinking about the challenges and opportunities facing NOAA and its extended stakeholder community.

Summary of Scenarios for 2035

Too Little, Too Late?	Despite smart economic growth based on alternative energy and sustainable production, and despite collaboration on environmental policy at all levels of government, it may be too late to stop abrupt climate change and its social, economic, and environmental impacts.
Green Chaos	Environmental policy at all levels of government is fragmented and disorganized, but a growing market for alternative energy and other sustainable products leads to smart economic growth and an increasingly harmonious relationship between humans and nature supported by the forces of supply and demand.
Carbon Junkies	Environmental policy at all levels of government is collaborative, particularly in developing advanced environmental science and technology, but business-as-usual practices in industry and the public's focus on traditional metrics of economic success lead, ultimately, to extensive environmental degradation.



TOO LITTLE TOO LATE?



KEY DRIVERS: Smart economic growth is implemented, and government institutions collaborate in policy making and implementation, but the global environment doesn't appear to be responding.

IN TOO LITTLE TOO LATE?, we initially see the U.S. economy enjoying spectacular expansion as advances in computing and alternative energy technologies dramatically spur new projects around the world and facilitate a return to rapid economic development in developing countries. This early period is far removed from conditions of decline and mistrust. Instead of an economy dependent on a growing use of hydrocarbons, here the world enjoys strong economic growth fueled by alternative energy investments and global trade. Instead of ineffective government action on energy, water, and environmental issues, here we have international cooperation on mitigation spurred by growing knowledge and information about environmental threats and new observation and analysis capabilities. Instead of government institutions predominantly playing a role of asset and resource protection, here they are a lever to create new markets and facilitate the transition of society.

But, while new generations of hardware and software continue to stimulate the economy and the new energy model begins to succeed, demand for fossil fuels remains high and the environment appears too sick to respond. Turbulent and massive shifts in weather and the earth's ecosystem are occurring, and in 2020 the world's scientific community splits on whether an abrupt climate change threshold has been passed. Many experts believe a policy shift from mitigation to adaptation is needed, while many others believe the mitigation efforts should be sustained and increased. In retrospect, we can see that the first decade after the severe recession of 2008 to 2010 was, for both developed and developing economies, a period of accomplishment, economically and policy-wise, but also a period of using more resources, despite best intentions.

Arctic sea ice is shrinking.

Years 2009 to 2020

Despite the severe recession, the scenario "Too Little Too Late?" begins with global optimism that the world's energy, water, climate, and economic problems can be addressed. A new ethic takes hold to improve the processes for making world decisions, and in ways similar to the holistic re-engineering of business and efforts to reinvent government of the 1990s, substantial investments are made at all levels of government (international, federal, State, and local) to build collaborative capabilities and reach effective multiparty agreements on the major environment, economic, and social issues.

A global agreement on smart-growth policies occurs early in the scenario with the UNFCCC COP-15 in Copenhagen (2009) leading to "Super Kyoto" (signed by the United States, et al) and a set of new incentive-laden laws. The result is alternative energy development, sustainable manufacturing, and energy-efficiency investment on a grand scale, and a goal to reduce greenhouse gas (GHG) emissions. Soon after, the United States is party to several more newly negotiated agreements, including a revamped Law of the Sea Convention and the Convention of Biodiversity, and the Treaty of the Arctic for protecting the environment and implementing sustainable development practices.

A key element achieved in the international agreements is the commitment to information sharing of all the data, among nations, the public, and key stakeholders. In addition, national agencies and government research groups, under the auspices of the United Nations, develop an aggressive global climate science program. The new program, funded by the United States, the EU, the economic arm of the Shanghai Cooperation Organization (SCO), and OPEC, takes advantage of innovations in high-performance computing and rapidly advancing climate science, resulting in a new level of capability to predict the evolution of the earth's climate system. Advances in computer technology allow more complex climate models to be run, revealing new insights into the behavior of the climate system and stimulating new research avenues to increased understanding. By 2020, increased computer power is enabling large ensembles of climate model runs to be made whose spread in outcomes allows the confidence one can place in the model predictions to be more reliably quantified. The enhanced computer power is allowing climate predictions to be made at scales as small as the Chesapeake Bay which, like decadal predictions for the oceans, have usable skill with quantifiable uncertainties over portions of the globe.

HALLMARKS OF "TOO LITTLE TOO LATE?"

- Strong economic growth is fueled by alternative energy investments and global trade.
- A growing knowledge and information about environmental threats, and new observation and analysis capabilities.
- There is strong international cooperation on climate change.
- Government creates new markets and facilitates the transition of society.
- Demand for fossil fuels remains high and the environment appears too sick to respond.
- Turbulent and massive shifts in weather and the earth's ecosystems are occurring.
- Experts disagree over a policy shift from mitigation to adaptation.

In the United States, serious government reform is undertaken and, with strong public support, new priorities for the economy and environment are adopted. The result is several environmental laws and a new Department of the Environment in 2012 with comprehensive powers, information systems, and capabilities. New sustainable freshwater management processes are implemented, and the National Ocean Policy Act of 2013 is passed to protect, maintain, and restore ocean marine ecosystems. A new disaster relief system is adopted at the federal level with strong regional and local support.

The primary mechanism adopted by policy makers for reducing GHG emissions was cap-and-trade systems, and the United States passed its first comprehensive law in 2009 (known as United States Climate Action Partnership, USCAP) with widespread business support. Many environmentalists (and California) claim the system is too lenient for large emitters and the timetable is too long for reducing GHG emissions, but the legislation passes and quickly becomes the international standard for developing countries. No carbon taxes are imposed in the United States but a series of agreements is made with the auto industry to increase new-car fuel efficiencies by 2.5 percent per year.

A key part of the government reform that is implemented is the performance measurement and accountability principle that ultimately allows government agencies to "lose" their mandate (or be "fired") for poor performance. Consistent with that principle, many non-policy making and non-enforcement functions are privatized, during the course of the scenario, because the private sector is more innovative and efficient. Government agencies experience continual pressure to use outside resources for non-essential services and implement performance-improvement processes with real teeth.

While the recession in the United States is deep through 2010, the smart-growth measures taken in 2009 are adopted quickly in most parts of the country because of strong popular support. Federal government expenditures increase again as the economy improves after the recession, but at a rate no greater than the growth of the economy, and as a result, the deficit and national debt as a percent of GDP come down rapidly. The landscape of American industry is radically changed. The job-creation results are spectacular as costs fall in many traditional industries and demand for new services, materials, and systems for sustainable systems increases rapidly. U.S. GDP growth is less than 1 percent in 2009 and 0 percent in 2010, rising to 3 percent in 2011 to 2015. Thereafter, U.S. GDP growth continues in the 2.5 percent to 3.5 percent range until 2030.

Despite the major recessionary bump in the road, the developing countries of the world, particularly China, India, and Indonesia, adjust quickly to the new world economy based on information technology and sustainable development. Many new products and services are needed, and Brazil, China, and India all position themselves to meet the world's new demand. New technology developments go beyond energy improvement and clean water, and include biotechnology and transportation systems operating entirely off renewable energy, as does society as a whole. Highly distributed and sustainable energy sources become available by 2020, complete with new centralized infrastructure (fusion to biofuels) and with crude oil prices swinging wildly between US$60/b to US$200/b, the transport industries begin the transition away from conventional fossil fuels to biofuels and plug-in hybrids. Success in electrifying the transport industry is still some years away, but the rapid growth in the new generation of biofuels reinforces the social norms for non-governmental organizations (NGOs) and government-agency teams to collaborate with increasingly transparent decision processes.

"New technology developments go beyond energy improvement and clean water, and include biotechnology and transportation systems operating entirely off renewable energy, as does society as a whole."

Fossil energy remains the major source of energy worldwide, but because of high prices, the growing supply of renewable energy, and the emerging biofuels industry, global oil demand reaches only 102 million barrels per day in 2035 from 84 mb/d in 2005. Oil and gas developments in the Arctic were allowed to move forward under the Treaty of the Arctic, but the time scale is very slow.

Many argue that water shortages around the world, including in the United States and the Mid-West, are more urgent than climate change, and new water investments are executed, accompanied by sustainable-development pricing policies in both developed and developing countries to ensure sustainable water management practices are implemented. But, the water shortages continue and are exacerbated in many places by increased biofuels production.

Renewable energy sources—especially solar, wind, and geothermal—grow rapidly because of the renewable energy standard (RES) for utilities requiring them to get 20 percent of their power from clean, renewable energy sources by 2025 (up from 9 percent of U.S. electricity supply in 2006) and 25 percent by 2030. In fact, the total share of renewable energy used for electricity generation overall reaches nearly 35 percent by 2030 as technologies improve and costs drop. Offshore wind development also begins in earnest by 2015 and grows to provide about one-fifth of total wind capacity.

In the scenario "Too Little Too Late?," the coastal population of the United States continues to grow steadily through 2020, increasing another 10 percent, exposing a large segment of the U.S. population to severe weather and climate effects. Major hurricanes continue to strike the East Coast and Gulf Coast with regularity, but as smart growth policies take hold (the flow to coastal areas stops), a new urbanization trend in the United States is evident—a shift from the car-centric development of suburbia and the business park, to concentrated pedestrian and transit-centric, walkable, mixed-use communities.

Major efforts are undertaken to reduce the threats of pollution to coasts and oceans, and good strides are taken in many areas to address both point and nonpoint source pollution. While in 2001, 23 percent of estuarine areas were impaired, that number is only 20 percent in 2030. But many efforts to address the nonpoint source pollution (runoff from agricultural land and streets) are insufficient because of the sheer volume of new economic activity along the coasts and the difficulties in modifying agricultural practices.

Space weather prediction, which was in its infancy in 2009, rapidly develops after the solar maxima of 2012 spawns an unprecedented number of severe geomagnetic and radiation storms, disrupting satellite telecommunication, GPS-enabled navigation, and NextGen-coordinated air traffic management, and causing massive electrical power blackouts around the world. By 2024 when the next solar maxima occurred, the international solar wind forecast systems are capable of accurate predictions of the trajectories of solar storms and is able to provide lead times of 1 to 4 days for government agencies to protect assets from damage and ensure continuity of vital services.

Another change in the rapidly developing global economy is the explosion in increased maritime trade. By 2020, traffic along the coast of Alaska and the east coast of Canada among the provinces is 10 times the volume it was in 2008. But with the increased traffic, several major ship accidents occur in the Arctic area with significant impact on the natural environment.

The embrace of sustainability as a way of life leads to comprehensive new fisheries management practices, sensible crop rotation, and more efficient water use. New fisheries management practices have a dramatic effect on fish stocks, and by 2020 less than 10 percent of U.S. major fish stocks are overfished or close to overfished, down from 20 percent in 2008. Alaska still accounts for over half the fish caught in the United States, although there is considerable uncertainty about the effects of climate change on its fish stocks.

Years 2021 to 2035

Significant benefits of smart growth are achieved worldwide in less than 20 years, but it's still unknown whether they are forestalling an "abrupt" climate change. Some scientists are beginning to believe the policies were too late and were always too little to halt abrupt climate change. There are also many saying it's still too uncertain to know how resilient the world's natural systems

A Palm Springs wind farm.

will be to the changing conditions. Water shortages continue to get worse in the developing countries, and worldwide gigatonnes of carbon (GtC) per year emissions from CO_2 rise from 27 in 2008 to 37 in 2035.

What is not disputed is that climate change effects are everywhere. Greenland and West Antarctic ice sheets continue to lose mass and are clearly accelerating in movement. Drought conditions in the Southwestern United States are more frequent and severe, and spreading northward. Ocean acidification along the coasts is increasing at a rate much higher than was predicted. And ecosystem disruptions are having significant agricultural, water availability, social, and economic consequences, including several territorial conflicts in Africa, the Middle East, and Central Asia.

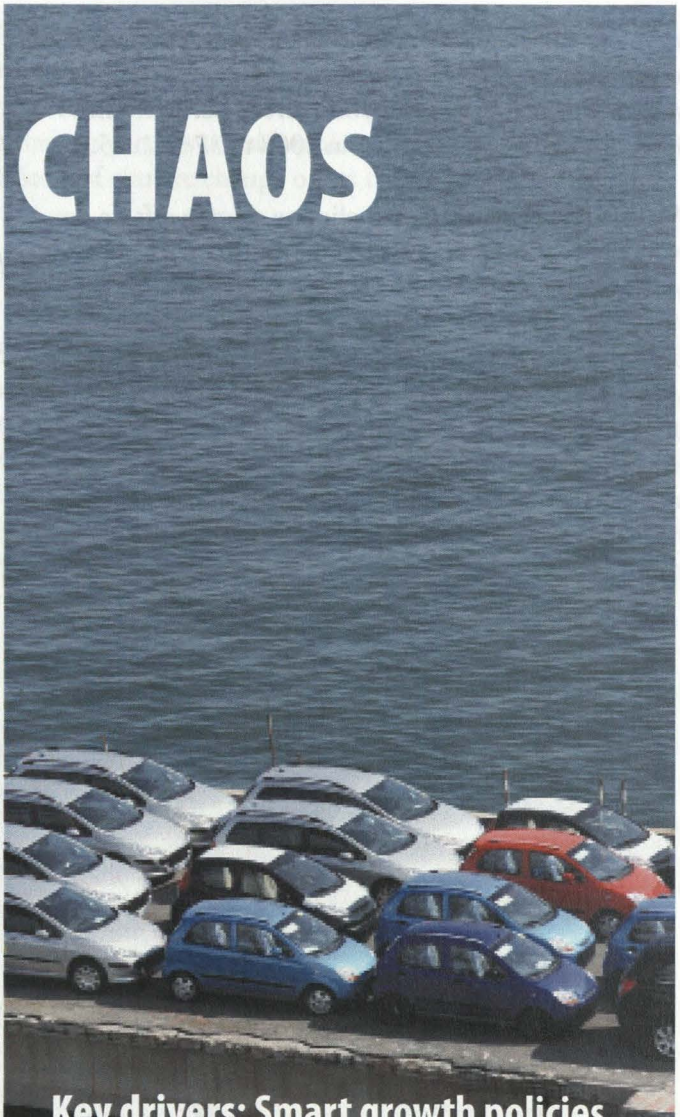
The changes in conditions in the United States are staggering and include the loss of summertime Arctic sea ice (the Arctic perennial ice is down to 1 million km^2 in 2035 from approximately 3.0 million km^2 in 2008); ocean acidification, leading to the loss of marine species; more severe solar impacts from weather; and sea level rise that contributes to increasing coastal impacts and inundation in the United States. But it is outside the United States where the economic impacts are greatest, and great portions of the populations in China, India, Bangladesh, and Eastern Africa are forced to migrate. In the latter half of the scenario, tensions between governments in the East and West begin to fray as it is becoming clear that an entirely new level of commitment will probably be needed to address the relationship between people and the planet.

GREEN CHAOS

THE HALLMARK OF THIS SCENARIO is the effectiveness of the markets when confronted with environmental uncertainties. Following the worldwide economic recession and widely recognized emerging resource shortages in energy, food, and water at the end of the first decade of the 21st century, it is the major multinationals, venture capital firms, and state-owned enterprises in developing countries that invest aggressively in green and sustainable development solutions. Those investments, some staggering carbon taxes in the United States, and an uneven patchwork of regional and local government policies quickly succeed, and new ways of doing things are implemented by business and the general public. While government policy makers continue to debate priorities, responsibilities, and budgets, local smart-growth practices and green markets flourish. Many of the feared economic consequences from externality pricing and heavily regulated resource use do not materialize.

Years 2009 to 2020

Countries vary in how they respond to all the diverse economic and environmental issues they face after the global recession, but the mood of the times favors customized solutions to problems, and new regulations vary among the different regions and trading blocks. The EU is the most stringent and remains an advocate of sustainable development initiatives. But no country in the world, including those in Europe, shows much global leadership as politicians focus largely on domestic problems. In addition, the growing clout of the state-based funds in Asia and the Middle East changes the dynamic for how contracts are awarded and products are traded worldwide; protectionism policies are implemented by many nations, despite the efforts of the United States



Sea car-parking: Queue of new cars waiting to be boarded onto a ferry boat.

Key drivers: Smart growth policies are adopted and successfully implemented, the interaction between the environment and society becomes harmonious, and government institutions act according to self-interests in a fragmented fashion.

HALLMARKS OF "GREEN CHAOS"

- Markets deal effectively with environmental uncertainties.
- Multinationals, venture capital firms, and state-owned enterprises in developing countries invest aggressively in green and sustainable development solutions.
- Carbon taxes in the United States, and an uneven patchwork of regional and local government policies exist.
- Government policy makers are overwhelmed by the environmental and economic uncertainties.
- Many of the feared economic consequences from externality pricing and heavily regulating resource usage were hype.

and EU, and trade tensions among nations are unresolved by any new international agreements. A rash attempt in 2009 at linking trade and emission reductions in both developed and developing countries fails.

At the beginning of the scenario, the U.S. government's efforts to stimulate the economy—while often dramatic—mostly fail. In 2011, 3 years after the recession began, companies in traditional industries are still going bankrupt, unemployment is still close to 9 percent, and consumer spending remains low. But history teaches important lessons: that innovation is often strong when companies and individuals are threatened, and that entrepreneurship is stimulated by commercial opportunity. Small investments of money in sustainable energy and green research and development (R&D), government programs to buy next-generation technology, tax incentives for supplying and buying green products and services, and most importantly, a significant carbon tax bear fruit from 2010 to 2020.

The public is generally out of sync with national governmental actions to preserve and protect ecosystems, water resources, biodiversity, habitat, and so on, and is generally dissatisfied with federal efforts to improve the national disaster mitigation and relief system. The public also resists strongly for several years any notion of a carbon tax. But an innovative policy solution is developed whereby some of the carbon tax revenue is returned to individuals by contributing to their retirement accounts and health insurance costs.

Throughout the scenario, the United States endeavors to become energy independent and reduce its heavy reliance on carbon fuels. In 2013 the U.S. Congress and Administration agree on a series of subsidies for the auto and utility industries to make way for carbon taxes on petroleum products and coal. The overnight effect is to double gasoline prices in the United States to (on average) $7 per gallon.

Also, after 3 years of strident debate, and after most States have implemented their own State requirements to encourage new equipment to be installed to reduce emissions, but with only weak public support, the U.S. Federal Government is able to implement an aggressive cap-and-trade system for GHG emissions in 2012. The U.S. system has goals for reducing CO_2-equivalent emissions to 30 percent below 2005 levels by 2020 and to 50 percent below 2005 levels by 2030. With the price of emissions starting out in the range of $30 to $40 per ton of CO_2-equivalent during the 2012 to 2020 time period and rising to $50 to $70 per ton of CO_2-equivalent during 2020 to 2030, the system provides the financial incentive for utility companies to begin capturing and sequestering CO_2 emissions from power plants on a large scale.

Overall economically, U.S. GDP growth is negative 2 percent for 2009, negative 1 percent in 2010, and 0 percent in 2011, before rising to a positive 2 percent in 2012 and 2.5 percent thereafter. U.S. GDP growth is never really strong, as the world is very competitive and many smart growth policies are expensive.

But it is green markets in developing countries that determine "where the action is." While there are bright spots in the United States and Europe (renewable energy sources continue to work, and demand for plug-in hybrids and electric cars is growing rapidly), by the year 2020 it is clear that the greatest growth in green products and services is coming from developing country markets in China, India, and other Asian countries.

Coal and oil use continues initially to drive the economic growth of China and India, and water shortages and food supply issues remain key challenges throughout. But powerful forces for increased economic sufficiency, sustainable water use, and energy independence take over. With the many advances in high-performance computing occurring in Asia, China undergoes a radical change in economic policy that is strongly supported by its population to seize the lead in high-performance

computing and build up its energy-efficient and green industries. The government's "new economy" focus also prompts policies encouraging investment by foreign parties and multinationals in green business areas. In fact, throughout Asia governments push their demands for green venture investments—and they have the market power to get them, using government purchasing power to stimulate next-generation green technology development (and using government tariffs to prevent foreign imports).

Economically, China's growth is higher than any other major country, averaging 7 percent per year. India's doesn't rise above 5 percent, and the African nations remain stagnant. Oil-producing nations experience rapid rises and declines.

In the United States, government budgets are increasing faster than the economy despite new green revenue sources, and too many government agencies are chasing too few dollars. In-fighting among agencies abounds, Congress can rarely pass budget legislation on time, and the federal budget deficit and national debt as a percent of GDP come down only slowly. New administrations continually attempt to reform the system but to little avail, and relations between the federal government and States remain tense. One outcome of the continuing government budget problems is that the private sector slowly assumes more government functions over time, but this outcome is largely unplanned and uncoordinated, generating mixed results.

Efforts undertaken to improve the effectiveness of federal agencies in administering environmental laws and policies, by reorganizing the executive departments and integrating them (including the EPA, DOT, and NOAA) into one department are disappointing and don't result in improvements in decision-making or service. U.S. ocean policy remains a hodgepodge of individual laws.

While energy and environmental policies remain fragmented, environment-oriented agencies receive more funds to enforce the laws. However, information about the environment, while exploding in volume around the world, remains hard to share because of the lack of interoperability standards and intellectual property concerns of all the parties—both government and private. Even in the United States, it remains very hard to integrate information quickly. In addition, there is weak cooperation between the government agencies, the business community, and NGOs on many issues.

In this generally confrontational world, the most powerful forces for change turn out to be market ones. It is the private sector's investments in green technology innovation, the public's response to those innovations, and the public sector's use of smart-growth market incentives that change the dynamic for how the economy grows, how energy is used, and how environmental effects are factored in.

One clear indication of these market forces is the trend of counter urbanization, with cities losing population to rural areas because of better living conditions in the suburbs and such factors as the fear of crime and poor urban environments. At the same time, the U.S. coastal population continues to grow steadily throughout the entire scenario period, increasing a total of 35 percent from 2008 to 2035, from 160 million to 190 million, but without the sprawl by better planning, creating no-development zones, and implementing creative property tax schemes.

A polar bear cub stands on its hind legs while its mother stays nearly. The two bears approached within 200 meters of the ship.

PHOTO: HIDDEN OCEAN 2005 EXPEDITION, NOAA OFFICE OF OCEAN EXPLORATION, KELLEY ELLIOTT, PHOTOGRAPHER.

Economic incentives are also used by States and federal agencies to change agricultural and fishing practices. While the impaired estuarine areas stay approximately the same from 2008 to 2035, California implements an aggressive nonpoint source pollution program focused on the agricultural industry that has some success.

Because of the lack of cooperation internationally and domestically, climate change research by academia and government agencies remains curiosity-driven despite widespread acceptance that humans affect the evolution of atmospheric composition, land use, and so on. The United Nations can't replicate the success of the Intergovernmental Panel on Climate Change (IPCC) in the early 2000s, while in the United States national agencies don't coordinate their research or data gathering very well.

"...we see a sophisticated green consumer worldwide and many new industries established, with Asian players usually controlling the biggest share."

Outcomes of this weak coordination are that the Global Earth Observation System of Systems (GEOSS) vision to develop integrated weather, climate, and Earth system monitoring, assessment, and data-assimilation prediction systems is not achieved, and models with all the components needed to accurately predict the evolution of the earth's climate system evolve slowly. Despite advances in computing power, the confidence levels associated with climate change predictions are not more reliably quantified.

Many significant advances in climate change science are actually produced in the private sector as multinationals and technology developers seek to develop new green products and services and take advantage of the growing information about the ocean and Arctic areas. New assessment models rapidly evolve as markets seek more effective means for evaluating environmental impact uncertainties.

Even after the solar maxima of 2012 spawns an unprecedented number of severe geomagnetic and radiation storms, disrupting satellite telecommunication, GPS-enabled navigation, NextGen-coordinated air traffic management and causing massive electrical power blackouts around the world, space weather prediction capabilities don't advance rapidly. In 2024 when the next solar maxima occurred, solar wind forecast systems still can't make accurate predictions of the trajectories of solar storms and provide lead times for government agencies to protect assets from damage and ensure continuity of services.

Years 2021 to 2035

Worldwide gigatonnes of carbon (GtC) per year emissions from CO_2 rise from 27 in 2008 to 32 in 2035. But they decline worldwide after reaching 33 GtC in 2030.

Throughout the scenario, scientists can't agree on whether abrupt climate change is taking place. However, while the changes are muted they're still visible in a number of places. The Greenland and West Antarctic ice sheets don't appear to be moving any faster but do appear to be getting thinner. Scientists estimate that sea levels overall have risen by 1 inch from 2008 to 2035, but the data are generally uncertain. Drought conditions in the Southwestern United States don't appear to be more frequent or severe, although conditions were very difficult in a 10-year stretch from 2010 to 2020. Hurricanes continue regularly, and many are quite severe, but any linkage to climate drivers remains uncertain. In the Atlantic, the ocean transport of heat northward (the Atlantic Meridional Overturning Circulation [AMOC]) appears to be decreasing, but it's still too hard to confirm. Arctic perennial ice is down to 2.5 million km^2 in 2035 from approximately 3.0 million km2 in 2008, but appears not to be getting any smaller. Surface ocean pH doesn't appear to be dropping if at all, and it's uncertain how much it can or will drop by 2100.

What is clear by 2030 is that society is adapting to the changing conditions and new opportunities. By the end of the scenario, we see a sophisticated green consumer worldwide and many new industries established, with Asian players usually controlling the biggest share. Would-be new green products and services continue to have to do battle with traditional alternatives as well as previous green-generation alternatives to gain co-

A battery-powered Chinese-made Great Wall vehicle at the Auto China 2008 Auto Show in Beijing, China.

sumer acceptance and overcome the technical barriers to a more energy-efficient way of life. Green products and services in developed economies are slowly replacing energy-intensive solutions, while green products and services growth in developing countries occurs as a result of their rapid economic change.

In the United States, the electrification of transport is having a significant economic impact. Consumers are buying plug-in hybrids and electric cars, although it is the Japanese and Chinese companies that are manufacturing them. Another major change is that utilities are getting 20 percent of their power from clean, renewable energy sources by 2025 (up from 9 percent of U.S. electricity supply in 2006) and 25 percent by 2030. But the big winner in Green Chaos is nuclear power, where capacity increases to 30 percent of total U.S. electricity generation by 2035, despite all the controversy in its use. Offshore wind development also begins by 2015 and grows to provide about one-fifth of total wind capacity. Ocean tidal and wave resources also emerge as high-potential renewable energy sources but are relatively small contributors to U.S. electricity generation by 2030 (nearly 2 percent of U.S. electricity), although experts predict that ocean energy could supply about 10 percent of U.S. electricity needs in the future.

Alternative-fuel vehicles of all sorts are doing well in the Asian markets because of the open and very competitive markets and the low prices of alternative-fuel vehicles (particularly after import duties on the alternative fuel vehicles are eliminated to encourage adoption). Electric cars flourish, and demand for electric-car components rapidly increases. Demand for small internal combustion engine (ICE) vehicles also rises as ICE technology rapidly improves. After the recession, overall motor vehicle growth begins to reach moderately good levels, averaging 1 percent to 2 percent per year in the United States and 8 percent to 10 percent per year in China. However, in all markets, demand/supply market cycles persist.

In the end, world energy demand rises to 17000 Mtoe in 2035 compared to approximately 12000 Mtoe in 2008. Fossil energy is still dominant around the world, but global crude oil demand peaks in 2020 at 96 million barrels per day and global oil demand falls to 94 mb/d in 2030 (84 mb/d in 2005).

The Arctic nations never reach agreement on sovereignty claims, development of the Arctic, and how to best protect the environment. Russia is constantly using its Navy to try to resolve disputes over the seabed, navigation, and fishing, but lacks the investment funds to pursue much industrial development. The United States, Canada, and Norway generally coordinate, but still largely go their separate ways. The Western countries do pass significant environmental protection laws for the Arctic, and companies must spend significant amounts of money in planning and mitigation to operate in the region. Despite the high costs, industrial activity in the Arctic region booms and significant innovations are made in addressing the hostile environment.

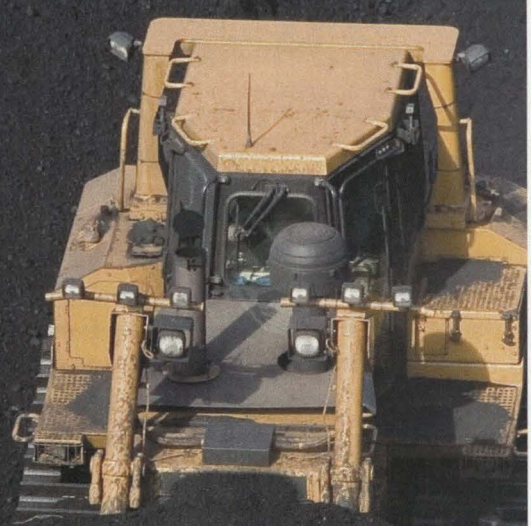
In general, maritime trade increases, but that increase is modest because trade protectionism and buy-local policies of many countries combine to reduce transport requirements' energy use.

Water scarcity is getting worse around the world, while at the same time demand for food is rising faster than anyone expected because of low prices and effective implementation of technology in developing countries, reaching levels 60 percent greater than those in 2008. Aggressive water and agricultural policies are implemented in many nations to protect their water supplies and improve their food supply independence. In the United States, the success of the carbon tax leads several states in the West to implement new water-pricing schemes to address water shortages.

Finally, the world's fish stocks improve—not because of international cooperation among governments but because of new fisheries regulations and enforcement by countries and fishing innovations by large commercial

fleet owners. Many nations pass laws extending their jurisdiction for protecting fish stocks and managing minerals development beyond the 200-mile economic zones, but often have to use their navies to enforce the new laws. The Asian and Russian fishing fleets are severely restrained.

CARBON JUNKIES



Key Drivers: Governments develop innovative policies and collaborative mechanisms, but business-as-usual forces are powerful and continue to prevail. The environment starts to change significantly while the U.S. economy and the rest of the world appear unable to respond.

AFTER THE RECESSION IN 2009 AND 2010, the world (including the United States) focuses on stimulating an economic recovery as quickly as possible and attempts to get back to business as usual, fueled by cheap energy. But this scenario confirms what many scientists (and Al Gore) long predicted: The world is running out of time in its use of carbon. Certainly, it is true in the United States, which sees productive agricultural land shrink significantly and Arctic ice in summer months disappear in the wake of the dramatically warming climate.

Years 2009 to 2020

In both developed and developing countries, the old economic systems continue to exploit energy in stimulating economic growth, and it is this traditional formula for increasing economic prosperity in a nation, particularly in developing countries with their rapidly industrializing economies, where the real sad story is told. Driven by supportive governmental policies (in developing new energy resources, opening up markets, and encouraging new consumer consumption) and an increasingly open global economy, consumers in developing countries purchase, quickly and with few hesitations, new homes and cars in a manner that mirrors—but on a somewhat larger scale—the economic development pathway of the Organization for Economic Co-operation and Develpment (OECD) countries. Information technology continues to drive business innovation, and new heavy consumer products, like cars and appliances, are cheap and available due to global demand, the success of global trade agreements, and massive energy- and water-development investments.

The U.S. population strongly believes survival and then prosperity and happiness are a function of personal financial wealth, and that GDP growth should be the

Coal truck.

highest priority for policy makers. In 2009 and 2010, U.S. government efforts to stimulate the U.S. economy by helping to restore the credit markets and invest in infrastructure projects generally succeed and businesses begin to recover by the middle of 2010. The United States is wedded to free markets and individual entrepreneurship and these forces help the U.S. economy recover. But the economy never regains its dominance in the world as the world has changed. U.S. economic growth is relatively low for the scenario period: less than 1 percent for 2009, 1 percent for 2010, 2.5 percent for 2011, and ranging from 2.0 percent to 2.5 percent until 2030.

With the U.S. economy never getting back to pre-recession levels, the federal government deficit grows significantly for the first 3 years of the scenario and then stays large through the year 2020. After reaching a level of 80 percent of GDP in 2010, U.S. national debt stays at that level for the rest of the scenario. A severe budget crisis exists at all levels of government and a number of programs have to be cut (particularly those related to the environment and energy) or curtailed (like Social Security). The priorities for a long time are short-term—economic recovery and health care, not the environment and energy conservation.

While there are growing requirements to limit emissions of CO_2, policy measures are developed to expand low-cost supplies wherever they may be. No carbon taxes are imposed because of the potential impact to the U.S. economy, while large, centralized electricity generating plants are encouraged to keep up with demand. Energy demand overall grows in the United States from 2009 to 2035 by almost 40 percent, fueled by heavy industry using low-cost energy. But supply disruptions occur regularly and the United States experiences a series of brownouts. Efficiency measures are often taken to minimize the chances for disruption and to try and keep costs low, but total energy efficiency gains are quite small.

New energy policies are passed in 2011 to be a cornerstone of U.S. efforts to reduce its energy dependence on OPEC producers and begin addressing climate change concerns. The policies have little impact because crude oil prices are low (ranging from US$40/b to US$60/b in real terms), and there are no incentives or penalties for changing energy supply or demand.

Worldwide energy resource exploitation increases significantly; hydrocarbon energy resources under development in the United States and nuclear generating plants also see major increases. Renewables grow but represent less than 10 percent of total world supply by 2035. In the United States, utilities only get 15 percent of their power from clean, renewable energy sources by 2025 (up from 9 percent of U.S. electricity supply in 2006) and 17 percent by 2030.

Water shortages in the developing world are a problem throughout the scenario, as are major catastrophes from floods, earthquakes, typhoons, and solar storms. National institutions around the world are cooperating on environmental and disaster-relief issues and creatively so, but unlike with trade issues the politicians often end up pointing fingers and are not in sync with each other or their publics. Commodity-rich countries prosper generally, although most portions of Africa don't see any growth; many South American countries lag; and the economies of Europe and Japan actually decline because of decreases in working-age populations. World economic growth averages only 2.7 percent after the world emerges from the recession in 2011.

In the United States, with growth as the primary criteria, policy makers do little to restrain economic development in coastal regions. The result is large changes in the physical environment around the world, urban sprawl being much worse, and many unintended consequences from frequent hurricanes, tornadoes, and floods. Estuarine areas impaired rise to over 35%, and

HALLMARKS OF "CARBON JUNKIES"

- In developed and developing countries, the old economic systems continue to exploit cheap, fossil energy in stimulating economic growth.
- What many scientists (and Al Gore) long predicted has been confirmed: The world is running out of time in its use of carbon.
- In the United States, productive agricultural land shrinks significantly.
- Arctic ice in summer months disappears in the wake of the dramatically warming climate.
- Scientists agree that large-scale change in the climate system is taking place and the change cannot be reversed, even with major mitigation efforts worldwide, for decades.

70% of U.S. coastal rivers and bays are moderately to severely degraded by nutrient runoff. At the same time, federal and local disaster mitigation and relief services struggle to meet the continual need for catastrophic-event support because of deep cuts in private and corporate funding of mitigation and relief services.

Throughout the scenario, problems with the world's fish stocks keep getting worse and in 2015 several fish stocks the world relied on effectively disappeared. Now, over 50 percent of the world's fish stocks are overexploited. In the United States, 30 percent of U.S. major fish stocks are overfished or close to overfished by 2020, up from 20 percent in 2008.

On the bright side, the damaging economic effects of the solar maxima of 2012 spawn a large increase in government funding to improve space weather prediction capabilities. By 2024 when the next solar maxima occurred, the international solar wind forecast systems are capable of accurate predictions of the trajectories of solar storms and can provide lead times of 1 to 4 days for government agencies to protect assets from damage and ensure continuity of vital services.

"A severe budget crisis exists at all levels of government, and a number of programs have to be cut, particularly those related to the environment and energy."

For the Arctic, a resource race among nations develops as nations move quickly to stake claims to the seabed. Oil companies begin to invest significant amounts of money in new oil and gas developments. Joint international agreements are quickly developed to cover overlapping development issues, but they lack many oversight provisions. In all the Arctic nations, major ports are built to service the increased marine and trade activity in the northern climes. New ships are also needed for the severe weather and ice-flow conditions.

Looking back on the first decade of the scenario, it's sad to see the direction the world took because it could easily have gone another way. A new U.S. administration entered in 2009, riding on a wave of optimism despite the recession, with a strong commitment to develop and implement smart energy, environmental, and climate change policies that would make a difference. New international agreements were pursued in a variety of fields, and there was a strong push for rational decision-making and action at all levels of government. But the optimism and commitment weren't enough to come up with climate change mitigation solutions or new sustainable development policies that could be implemented. Key international agreements on the oceans and climate change were reached in 2010, but they were largely ignored. At the same time, while the initial agreements and efforts were ineffective, it was also clear that free markets were making climate change and environmental conditions substantially worse. After 2015, a new collaborative model emerged—based on successes at regional and local levels in places like Alaska and Washington/British Columbia in aligning stakeholders to take significant action—where those taking the action (i.e., those on the bottom) have the biggest say in the decisions and execution, and government simply facilitates. The federal government is the facilitator, not the decision maker.

In 2018, the effects of climate change drive both the developing and developed countries to the table in a desperate attempt to reduce GHG emissions and more importantly address the climate change impacts. The consequences of climate change are too real, and new agreements are developed with binding commitments to severely reduce GHG emissions from economic activity and to triage on the major needs for climate change adaptation. The goal is to stabilize the atmospheric concentration of emissions at 450 parts per million CO_2 equivalent. This will be a formidable challenge.

While the public didn't support environmental and climate change priorities at all in the beginning compared to economic ones, now the impact of climate change is real, and climate change adaptation quickly becomes the public's most important issue. In addition, privatization of government functions is

now occurring to help address climate change whereas before privatization it was driven largely by budget considerations.

Despite the availability of new high-performance computers, climate science doesn't advance very quickly in the scenario because of funding issues, and many international and domestic programs can't be implemented. But after the irrefutable evidence of climate change in 2015, the United States, EU, and China agree to supply the significant monies to get the research programs back on track. Information sharing is a shared principle, and national agencies and government research groups, under the auspices of the United Nations, coordinate a global climate science program.

Years 2021 to 2035

The building of models for climate science evolved in cycles, and the problems turned out to be much harder to address than was thought in the early 2000s. Eventually a new level of capability to predict the evolution of the earth's climate system was created. By 2025, advances in computer technology allow more complex climate models to be run, and the spread in outcomes allows the confidence one can place in the model predictions to be more reliably quantified. Climate predictions were made at scales as small as the Chesapeake Bay, which, like decadal predictions for the oceans, have usable skill with quantifiable uncertainties over portions of the globe. And while progress was initially slow in implementing the GEOSS vision because of funding problems, the United States, EU, and China agreed to support the effort in 2018 and the project was completed in 2025. A global environment information utility, including all sources and accessible to all applications, became available in 2035.

With all the modeling and observation capabilities, CO_2 emissions are observed at their highest level of all the scenarios, releasing 40 GtC in 2035 into the environment, up from 27 GtC from CO_2 emissions in 2008. From 2020 to 2025, the price of emissions in the United States is in the range of $50 per ton of CO_2-equivalent, rising to $100 per ton of CO_2-equivalent during 2025 to 2035 as the entire global economy is phased in. This emissions system provides the financial incentive for utility companies to begin capturing and sequestering CO_2 emissions from power plants on a large scale around the world—although it takes until 2030 for the technology to catch up.

Much worse than in the other two scenarios, the Greenland and West Antarctic ice sheets accelerate their movement and are rapidly losing mass. Scientists estimate that sea levels overall have risen by 3 inches from 2008 to 2035, and could reach 6 inches by 2050. Water precipitation problems throughout the Western United States and drought conditions in the Southwestern United States are permanent conditions. The entire Rockies region is also being affected. By 2035 September ice extent is 50 percent lower than conditions were in the 1970s to 2000s, effectively opening up the Arctic for summer maritime traffic. The Arctic perennial ice is down to 1 million km^2 in 2035 from approximately 3.0 million km^2 in 2008.

Unlike in the scenario "Too Little Too Late?," in the scenario "Carbon Junkies" scientists agree that large-

Murres in Prince William Sound covered in oil from the Exxon Valdez spill.

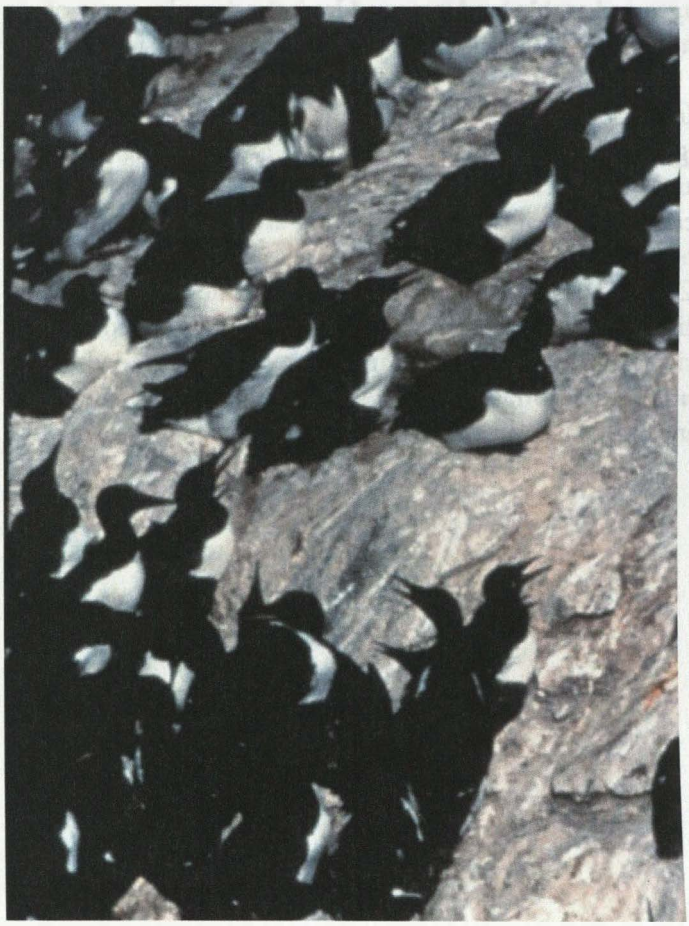


PHOTO: EXXON VALDEZ OIL SPILL TRUSTEE COUNCIL

scale change in the climate system is taking place and the change cannot be reversed for decades, even with major mitigation efforts worldwide. The change is occurring faster than most thought possible and could be more severe by 2100 than the highest estimates in the IPCC Fourth Assessment report issued in 2007. Healthy coral reefs effectively don't exist, anywhere.

With 5 billion people living in cities in 2030, the migration patterns in Asia and Africa change rapidly as water shortages and arable land issues influence people's decisions as much as perceived economic opportunity. Demand for food has risen by 40 percent by 2030, lower than in the other scenarios because of slower economic growth worldwide and high prices. Supply problems are extreme in many developing countries, particularly as cropland has disappeared in many countries because of climate change, leading to frequent conflicts among the countries. Where food is produced, it is definitely distorted by national policies, and food prices fluctuate significantly as politicians attempt to keep prices down for urban populations and supply programs are subsidized. In 2030 the UN establishes a civil force funded by developed countries for helping regions devastated by water shortages and arable land issues address the complex array of housing, sanitation, food supply, and transport issues.

In response to the climate change effects and lack of mitigation efforts, fish stocks in Alaska are changing rapidly, and well-documented impacts of migrating marine species in many of the world's fishing areas lead to conflicts between foreign-flag fishing vessels and national navies. On the coasts, the percentage of estuarine areas impaired rises to over 35 percent, and 70 percent of U.S. coastal rivers and bays are moderately to severely degraded by nutrient runoff. Coastal erosion is a significant issue in California and all along the Gulf Coast, and storm surges, hurricanes, and rising sea levels all contribute to significant damage to existing property.

In "Carbon Junkies," the coastal population in the United States continued to grow through 2015, but the increasing effects of bad weather and the changing coastal and water conditions convinced many that northern climates were better. The migration to the coasts effectively ceased by 2020, and the northern states saw an increase of 20 percent from 2020 to 2035.

On the other hand, marine transport activity is increasingly significant because of economic growth in developing countries and open trade policies around the world. With the opening of the Arctic waters by 2020, traffic along the coast of Alaska and the East coast of Canada among the provinces is 20 times the volume of 2008.

By 2035, substantial industrial activity is already occurring above the Arctic Circle, but a transformation is also taking place in infrastructure and policy to get ready for a significant population migration to just below the region. A Canadian trading company and Finnish ship manufacturer create a joint venture and are awarded the Arctic Seas Sustainable Development Audit and Certification (ASSDAC) services contract, beating out all proposals from national government agencies.

By 2035, even with efforts to change the world's momentum, world energy demand has risen the most of all scenarios to 19000 Mtoe in 2035 compared to approximately 12000 Mtoe in 2008. Over 70 percent of the increase in demand comes from developing countries, with China responsible for 30 percent. Global oil demand is at 110 million barrels per day in 2035, up from 84 mb/d in 2005, while coal sees a big increase in demand, driven by power generation requirements in China and India.

COMPARISON OF SCENARIO VARIABLES

COMPARISON OF SCENARIO VARIABLES

Force	Too Little Too Late?	Green Chaos	Carbon Junkies
Computer Technology	Advances in computing and the availability of high-performance hardware and software are significant for the three scenarios. Today's state-of-the-art petaflop machines will be supplanted by exaflop and beyond capabilities by 2020. The new machines and software require significant investment. In "Too Little Too Late?," many advances are stimulated by government investments. In "Green Chaos," Asian investments are leading. In "Carbon Junkies," private industry around the world continues to drive advancements.		
Water Supply	Water supply issues do not vary for the different scenarios. "Half the nations of the world will face freshwater stress or shortages by 2025," January 2008, United Nations Secretary General. "The provision of adequate fresh-water resources for humans and ecosystems will be one of the most critical and potentially contentious issues facing society and governments at all levels during the 21st century. "Water resources policy of the American Meteorological Society. By 2030, U.S. electricity demand is to grow by 50% placing an additional burden on freshwater supplies. Water availability and utility continue to be linked to population growth, development, and weather patterns. Water discharge into the oceans continues to impact the health of lakes and coastal estuaries, and plays a role in algal blooms, declining oyster productivity, and similar hazards.		
Catastrophic Events	Catastrophic events are frequent, severe, and often surprising in the impacts in all three scenarios. Natural (volcanic eruptions, earthquakes, tsunamis, and hurricanes) and manmade (terrorist attacks, fires, and infrastructure failures) events occur regularly. But new catastrophic events—defined by their economic and natural-system impacts—are occurring in the Arctic region because of increased industrial and marine transport activity in the area.		
Demographics	Demographics do not vary for the different scenarios. Population development shows growth in the United States of about 10% per decade, while Europe the European Union and Japan will experience essentially no changes. China will grow at approximately 0.5% per year, while India will grow at 1.5% per year.		
Carbon Emissions	Worldwide gigatonnes of carbon (GtC) per year emissions from CO_2 rise from 27 in 2008 to 37 in 2035. Carbon tonne emissions per year per person rise from 1 ton per year in 2000 to 1.4 tons per year in 2030.	Worldwide GtC per year emissions from CO_2 rise from 27 in 2008 to 32 in 2035. But they are declining worldwide after reaching 33 GtC in 2030. Carbon tonne emissions per year per person rise from 1 ton per year in 2000 to 1.2 tons per year in 2030.	Worldwide, 27 GtC from CO_2 were emitted in 2008. In 2035 this reaches 40 GtC. Per capita emissions continue to grow, rising from 1 ton per year in 2000 to 1.7 tons per year in 2030.
Climate Change	Impacts definitely observed throughout the scenario: migrating marine species in all the world's fishing areas; severe summer storms; sea levels beginning to rise (3 inches in some places from 2008–2035). In 2020, some scientists believe that large-scale change in the climate system is taking place and the change cannot be reversed for decades, even with major mitigation efforts worldwide. It's uncertain whether an abrupt climate change threshold has been passed, but the impact of mitigation policies and the dynamics of human and natural systems are still clearly not very well understood.	Impacts muted throughout the scenario, but still visible in a number of places: Marine species appear relatively adaptable and only modest impacts seen; summer storms not substantially worse; sea levels may be rising, but only 1 inch documented in a few places by 2035. Throughout the scenario, scientists can't agree on whether abrupt climate change is taking place. In fact, many believe the natural systems are driving whatever change is occurring and that human activities are largely being accommodated with nature.	Well-documented impacts highlighted early in the scenario: Migrating marine species in many of the world's fishing areas lead to conflicts between foreign-flag fishing vessels and national navies; severe summer storms; sea levels beginning to rise (4 inches in some places from 2008–2035). Like in "Too Little Too Late?," in Carbon Junkies the scientists agree that large-scale change in the climate system is taking place and the change cannot be reversed for decades, even with major mitigation efforts worldwide. The change is occurring faster than most thought possible and could be more severe by 2100 than the highest estimates in the IPCC Fourth Assessment report issued in 2007.

Population (millions) in Year			
	2010	**2020**	**2030**
North America	344	380	415
European Union	497	507	515
India	1180	1380	1580
China	1350	1430	1510

COMPARISON OF SCENARIO VARIABLES

Force	Too Little Too Late?	Green Chaos	Carbon Junkies
Rapid Changes in Glaciers and Ice Sheets	The Greenland and West Antarctic ice sheets accelerate their movement and continue to lose mass. Scientists estimate that sea levels overall have raised by 2 inches from 2008–2035, and in some places 3 inches.	The Greenland and West Antarctic ice sheets don't appear to be moving any faster but do appear to be getting thinner. Scientists estimate that sea levels overall have risen by 1 inch from 2008–2035, but the data is generally uncertain.	Much worse than "Too Little Too Late?," the Greenland and West Antarctic ice sheets accelerate their movement and are rapidly losing mass. Scientists estimate that sea levels overall have risen by 3 inches from 2008–2035, and could reach 6 inches by 2050.
Water Supply Variability and Change	Drought conditions in the Southwestern U.S. appear more frequent and severe, and spreading northward. Overall, precipitation levels are predicted to decrease.	Drought conditions in the Southwestern U.S. don't appear to be more frequent or severe, although conditions were very difficult in a 10-year stretch from 2010–2020.	Water precipitation problems throughout the Western U.S. and drought conditions in the Southwestern U.S. are permanent conditions. The entire Rockies region is also being affected.
Ocean Circulation Potential for Abrupt Change in the Atlantic Meridional Overturning Circulation (AMOC)	In the Atlantic, the ocean transport of heat northward (AMOC) decreases by 5% from 2000–2035, and Europe experiences a significant warming trend.	In the Atlantic, the ocean transport of heat northward (AMOC) appears to be decreasing, but it's still too hard to confirm.	In the Atlantic, the ocean transport of heat northward (AMOC) decreases by 10% from 2000–2035.
Arctic Sea Ice	By 2035 September ice extent is 50% lower than conditions in the 1970s–2000s, effectively opening the Arctic for summer maritime traffic. The Arctic perennial ice is down to 1 million km^2 in 2035 from approximately 3.0 million km^2 in 2008.	By 2035 September ice extent is only 15% lower than conditions in the 1970s–2000s, effectively opening the Arctic for summer maritime traffic. The Arctic perennial ice is down to 2.5 million km^2 in 2035 from approximately 3.0 million km^2 in 2008, but appears not to be getting any smaller.	Same as "Too Little Too Late?" By 2035 September ice extent is 50% lower than conditions in the 1970s–2000s, effectively opening the Arctic for summer maritime traffic. The Arctic perennial ice is down to 1 million km^2 in 2035 from approximately 3.0 million km^2 in 2008.
Atmospheric Methane	No abrupt release of methane occurs in the scenario period, but large northern high-latitude CH_4 emissions are now projected.	No abrupt release of methane occurs in the scenario period, and none is expected.	No abrupt release of methane occurs in the scenario period, but significant northern high-latitude CH_4 emissions are projected.
Ocean Acidification	Surface ocean pH drops by 0.1 unit (on the logarithmic scale of pH) by 2030, and it is estimated that it will drop by a further 0.3 unit by 2100 as the ocean absorbs more anthropogenic CO_2. Observation of upwelling water undersaturated in aragonite in all shelf areas occurs throughout the scenario, and acidification along the coasts is increasing at a rate much higher than was previously predicted.	Surface ocean pH doesn't appear to be dropping, and it's uncertain how much it can or will drop by 2100.	Same as "Too Little Too Late?"

COMPARISON OF SCENARIO VARIABLES

Force	Too Little Too Late?	Green Chaos	Carbon Junkies
Coastal Population Growth	Between 1980–2003, coastal population throughout the United States increased by 28% to 153 million. In "Too Little Too Late," the coastal population continues to grow steadily through 2020, increasing another 10%. A large segment of the U.S. population is vulnerable to severe climate effects, and this has the result of stopping the flow. A reverse migration from the Southern Gulf States occurs from 2020–2035. Overall, the U.S. coastal population shows no net change from 2020–2035.	In "Green Chaos," the coastal population continues to grow steadily throughout the entire scenario period, increasing a total of 35% from 2008–2035, from 160 million to 190 million.	In "Carbon Junkies," the coastal population continues growing through 2015, but the increasing effects of bad weather and changing coastal and water conditions convince many that northern climates are better. The migration to the coasts effectively ceases by 2020 and the northern states see an increase of 20% from 2020–2035. Florida's coastal population shrinks by 35%, or 5 million people. California also has a negative 10% growth in the same period.
Aquatic Resources	• Presssure on the world's fish stocks remains high because of increased food demand, and despite new regulations and coordination among governments, 30 percent of the world's fish stocks remain overfished. • In 2020, U.S. major fish stocks that are overfished or close to overfished, decrease to less than 10%, down from 20% in 2008. Good progress is also made with the minor fish stocks because of better oversight. • Alaska still accounts for over half the fish caught in the United States, although there is considerable uncertainty about the effects of climate change on its fish stocks. • Sustainable aquaculture practices are developed and implemented.	• The pressure on the world's fish stocks continues but new fisheries regulations and enforcement by many governments, including the U.S., and new innovations by the fishing industry, help to reduce the overexploitation of the world's fish stocks from 30% in 2008 to 25% in 2030. Many nations pass laws restricting access to areas outside their 200-mile economic zone and often have to resort to using their navies to enforce those laws. Relations between China and Vietnam are tense because of long-standing disputes about their territorial waters and national fleets of fish boats. • The U.S. passes strict laws for fishing in its economic zone and beyond, and is able to reduce the major fish stocks overfished to 15% in 2020, down from 20% in 2008. Fishing fleet owners serve as effective monitors of fishing practices in their areas. • Sustainable aquaculture regulations are reinforced and implemented.	• The problems with the world's fish stocks keep getting worse and in 2015 several fish stocks the world relied on effectively disappeared. Now, over 50% of the world's fish stocks are overexploited. • In the U.S., 30% of U.S. major fish stocks are overfished or close to overfished by 2020, up from 20% in 2008. • Fish stocks in Alaska are changing rapidly in response to climate change effects. • Sustainable aquaculture practices are not being implemented.
Marine Species	• Increasing ocean acidification and extensive coastal pollution from agricultural runoff are linked to an increase in marine species extinctions. Several large fish species can no longer be found.	• Economic incentives are used by states and federal agencies to change agricultural practices, land development plans near coasts, fishing practices, and coast tourism to implement sustainable use of the oceans. Many marine species are no longer threatened; few extinctions occur.	• In an overfished ocean with increasing ocean contamination near shore, marine species disappear at an alarming pace. Several large fish species can no longer be found. • Healthy coral reefs effectively don't exist, anywhere.

COMPARISON OF SCENARIO VARIABLES

Force	Too Little Too Late?	Green Chaos	Carbon Junkies
Coastal and Ocean Water Quality	Major efforts are undertaken to reduce the threats of pollution to coasts and ocean, and good strides are taken in many areas to address both point and nonpoint source pollution. While in 2001, 23% of estuarine areas were impaired, that number is only 20% in 2030. But many efforts to address the nonpoint source pollution (runoff from agricultural land and streets) are insufficient because of the sheer volume of new economic activity along the coasts and the difficulties in modifying agricultural practices.	Protection of coastal and ocean water is built into state and city development plans. Federal government investments vary, and there is a lack of coordination at the international level. Overall, the impaired estuarine areas stay approximately the same from 2008–2035. California implements an aggressive nonpoint source pollution program, focused on the agricultural industry, that has some success.	While there is more information on the damaging effects of coastal population and economic activity near the coasts, in the early part of the scenario there is minimal coordination or change in the deteriorating coastal and ocean water quality. Estuarine areas impaired rise to over 35%, and 70% of U.S. coastal rivers and bays are moderately to severely degraded by nutrient runoff. Major efforts are undertaken to reduce the threats of pollution to coasts and oceans.
Coastal Zones	Threats to coastal watersheds are rising with the increased population densities and changing coastal conditions because of climate change. Coastal wetlands acreage is down 5% since 2008, although strong measures are in place to protect coastal ecosystems.	Coastal watersheds are stable, even with the increased population densities. Little change is seen in wetlands acreage, and strong measures are in place to protect coastal ecosystems.	Threats to coastal watersheds are increasing with increased population densities. A large number of coastal wetlands are threatened by changing conditions.
Coastal Erosion, Inundation	Coastal sprawl is generally contained through strict planning measures, but the landscape is still changing and coastal erosion is significant throughout the scenario. Hurricanes and storm surges continue to wreck major property damage in the Gulf Coast states.	Coastal sprawl is somewhat contained by creating no-development zones and implementing creative property taxes schemes. Coastal erosion is still significant.	Coastal erosion is a significant issue in California and all along the Gulf Coast. Storm surges, hurricanes, and rising sea levels all contribute to significant damage to existing property.

COMPARISON OF SCENARIO VARIABLES

Force	Too Little Too Late?	Green Chaos	Carbon Junkies

International Laws and Agreement	• Comprehensive international agreements are made early in the scenario. A détente between developing and developed countries on efforts to combat increased GHG emissions and water scarcity and stimulate world economic development. A sustainability worldview then develops, leading to GHG emissions trading and tax incentive schemes for developed countries being implemented in 2012, strict emission limits being adopted in China and India in 2015, new recommended water management policies, and the elimination of trade barriers between developing and developed countries.
	• The U.S. is party to several newly negotiated agreements:
	  • Law of the Sea Convention
	  • Super Kyoto
	  • Convention on Biodiversity
	• To obtain the agreement of developing countries, many compromises are reached, particularly with respect to the of timing for the adoption of new emissions technology and reducing GHG emissions.
	• Near the end of the scenario, it's clear that new agreements (and major economic sacrifices) are needed.
		• No global agreements, but some regional international ones are negotiated. A rash attempt in 2009 at linking trade and emission reductions in both developed and developing countries fails. The mood of the times favors customized solutions to problems, so regulations vary among the different regions and trading blocks. The EU is the most stringent and remains an advocate of sustainable development initiatives. Mitigation against global warming varies.
		• The U.S. is often at odds on international issues with other major powers and the developing countries. Bilateral agreements are the primary means for creating international order, but these are weak arrangements that often leave problems unresolved.
			• No global agreement on climate change can be reached initially, and instead the European and U.S. Governments focus on energy conservation as a means to increase energy security and independence. But in 2018, the effects of climate change drive both the developing and developed countries to the table in a desperate attempt to reduce GHG emissions and address climate change impacts. The consequences of climate change are too real, and new agreements are developed to severely reduce GHG emissions from economic activity and triage on the major needs for climate change adaptation.

U.S. Ocean Policy	The National Ocean Policy Act of 2013 is passed to protect, maintain, and restore marine ecosystems. The Act includes goals and standards for ocean activities, has mechanisms for ensuring compliance with the policy, and establishes the institutions for carrying out the policy. Regional ocean ecosystem councils are set up with broad stakeholder involvement and have ocean zoning authority. A new marine reserves system is also established.	U.S. ocean policy remains a hodge-podge of individual laws. No new comprehensive federal policy is passed, but a small bill is passed to develop and implement an ocean zoning process.	Same as "Too Little Too Late?"

COMPARISON OF SCENARIO VARIABLES

Force	Too Little Too Late?	Green Chaos	Carbon Junkies
Cap and Trade Legislation	• In 2009, the U.S. helps lead international negotiations and agrees to binding commitments to reduce greenhouse gas emissions, with the goal of stabilizing the atmospheric concentration of emissions at 450 parts per million CO_2 equivalent—although this goal is not ultimately achieved. • In late 2009 a U.S. cap and trade system is adopted with widespread business support whereby the federal government set limits on the level of greenhouse gases that companies are allowed to emit. Regulated companies have to have allowances for every ton of greenhouse gases they emit but they trade, save, and borrow emission allowances from each other. The government will reduce the number of emission allowances each year in order to lower overall greenhouse gas emissions throughout the economy. • The system has goals for cutting US CO_2-equivalent emissions to 10% below 2005 levels by 2020 and to 20% below 2005 levels by 2030. Many environmentalists (and California) claim the system is too lenient for large emitters and that the timetable is too long for reducing GHG emissions, but the legislation passes and quickly becomes the international standard for developing countries. • In 2020, efforts are taken to revamp the system in response to accumulating evidence that the climate is deteriorating. • The USCAP national system replaces several regional greenhouse gas-trading initiatives that were already in place—the Regional Greenhouse Gas Initiative in the Northeast, the Western Climate Initiative, and the Midwestern Greenhouse Gas Reduction Accord, and is linked to the trading schemes in Europe, Canada, Japan, and later in 2015 to schemes in China and India.	• The U.S. implements an aggressive cap-and-trade system for GHG emissions in 2012, after 3 years of strident debate. Most states have implemented their own state requirements to encourage new equipment to be installed to reduce emissions. The U.S. system has goals for cutting U.S. CO_2-equivalent emissions to 20% below 2005 levels by 2020 and to 40% below 2005 levels by 2030. • The price of emissions starts out in the range of $30–$40 per ton of CO_2-equivalent during the 2012 to 2020 time period, and prices rise to $50–$70 per ton of CO_2-equivalent during 2020–2030 as the entire economy is phased in and the number of annual permit allocations decline. This system provides the financial incentive for utility companies to begin capturing and sequestering CO_2 emissions from power plants on a large scale—although it takes until 2020 for the technology to catch up. • A major key to success for the trading system (to actually lower greenhouse gas emissions) was comprehensive oversight—and legal enforcement when necessary • Restrictive GHG-emission mandates continue in the EU and Canada supported by trading systems.	• The U.S. implements a cap-and-trade system in 2011, but not without a major fight from business. The U.S. system has goals for cutting U.S. CO_2-equivalent emissions to 1990 levels by 2020 and to 20% below 1990 levels by 2030. • After serious climate change effects are observed, in 2018 the U.S. helps lead international negotiations and agrees to binding commitments to reduce greenhouse gas emissions, with the goal of stabilizing the atmospheric concentration of emissions at 450 parts per million CO_2 equivalent. This will a formidable challenge. • The price of emissions starts out in the range of $50 per ton of CO_2-equivalent during the 2020 to 2025 time period, and prices rise to $100 per ton of CO_2-equivalent during 2025–2035 as the entire global economy is phased in. This system provides the financial incentive for utility companies to begin capturing and sequestering CO_2 emissions from power plants on a large scale around the world—although it takes until 2030 for the technology to catch up.
Carbon Taxes	No carbon taxes are imposed in the U.S. but a series of agreements are made with the auto industry to increase new-combined fleet fuel efficiencies by 2.5% per year.	The U.S. Congress and Administration agree on a series of subsidies for the auto and utility industries in 2015 to establish carbon taxes on petroleum products and coal. The effect is to double oil prices (reaching $150/b).	No carbon taxes are imposed because of the potential impacts to the U.S. economy.

COMPARISON OF SCENARIO VARIABLES

Force	Too Little Too Late?	Green Chaos	Carbon Junkies
Climate Science Research	• National agencies and government research groups, under the auspices of the United Nations, coordinate a global climate science program. • Significant new monies are applied to gather more data and develop modeling tools with major improvements in simulation fidelity and predictive skill.	• Climate science in academia and government remains curiosity-driven research despite widespread acceptance that humans affect the evolution of atmospheric composition, land use, and so on. • National agencies can't coordinate their research or data gathering very well. The United Nations can't replicate the success of the IPCC in the early 2000s. • In pursuing new opportunities in green and sustainable-development products and services, private industry conducts extensive research and development work with benefits for climate science.	• National agencies and government research groups, under the auspices of the United Nations coordinate a global climate science program. • Initially, not enough monies are applied to the climate science, and many programs can't be implemented. But after the irrefutable evidence of climate change in 2015, the United States, EU, and China agree to supply the significant research monies to get the research programs back on track.
Maritime Trade	• The rapidly expanding global economy generates an explosion in increased maritime trade. New, larger, more-efficient ports are built in all the major coastal regions, and several new ones are built in Canada, Alaska, and Russia to take advantage of the new Arctic activity. • In 2020, traffic along the coast of Alaska and East coast of Canada among the provinces is 10 times the volume of 2008.	• Maritime trade increases modestly, because of trade protectionism and buy-local policies in many countries to reduce transport requirements and use of energy. • In 2020, traffic along the coast of Alaska and the east coast of Canada among the provinces is two times the volume of 2008.	• Marine transport activity increases significantly because of economic growth in developing countries and open trade policies around the world. • By 2020, traffic along the coast of Alaska and the east coast of Canada among the provinces is 20 times the volume of 2008.
Industrial Activities in Arctic	• After initial actions by Russia and Canada to claim extra sovereignty over areas of the Arctic, the major nations bordering the Arctic quickly negotiate agreements for protecting the environment and implementing sustainable development practices. As part of the negotiating process, the nations involve Arctic indigenous groups, major NGOs, and regional government entities, like the State of Alaska, and the Chukotka and Murmansk regions of Russia. Oil and gas developments are allowed to move forward, but the time scale is very slow. • Some new port facilities are built to service the increased marine and trade activity in the northern climes. New ships are also needed for the severe weather and ice-flow conditions. • Once the climate change realities appear, pressures grow to open up the northern climates more rapidly. • Several large shipping accidents occur in the Arctic during the scenario with catastrophic effects.	• The Arctic nations never can reach agreement on sovereignty claims, development of the Arctic, and how to best protect the environment. Russia uses its navy aggressively in all sorts of disputes over the seabed, navigation, and fishing, but lacks the investment funds to pursue much industrial development. The United States and Canada and Norway generally coordinate, but still largely go their separate ways. But the Western countries do pass significant environmental protection laws for the Arctic and companies must spend significant amounts of money in planning and mitigation to operate in the region. • Despite the high costs, the industrial activity booms and significant innovations are made in addressing the hostile environments. Major ports are built to service the increased marine and trade activity in the northern climes. New ships are also needed for the severe weather and ice flow conditions. • New catastrophes are recorded in the Arctic region because of the intersection of increased industrial activity and the hostile environment.	• A resource race among nations initially occurs in the Arctic as nations move quickly to stake claims to the seabed. Oil companies begin to invest significant amounts of money in new oil and gas developments. Joint international agreements are quickly developed to cover overlapping development issues, but they lack many oversight provisions. • In addition, all the Arctic nations build major ports to service the increased marine and trade activity in the northern climes. New ships are also needed for the severe weather and ice-flow conditions. • New catastrophes are recorded in the Arctic region because of the intersection of increased industrial activity and the hostile environment. • In 2035, substantial industrial activity already occurs above the Arctic Circle, but a transformation is taking place in infrastructure and policy to get ready for a significant population migration to the region.

COMPARISON OF SCENARIO VARIABLES

Force	Too Little Too Late?	Green Chaos	Carbon Junkies
U.S. Economy	• The recession in the United States is deep through 2010 but measures taken in early 2009 to stimulate alternative energy sources, sustainable manufacturing, and energy efficiency technology are adopted quickly in most parts of the country because of strong popular support. • The landscape of American industry has been radically changed and job-creation results are spectacular as costs fall in many traditional industries and demand for new services, materials, and systems for sustainable systems increase rapidly. • U.S. GDP growth is <1% for 2009 and 0% in 2010, rising to 3% in 2011–2015. Thereafter, GDP growth continues in the 2.5%–3.5% range until 2030.	• The U.S. Government's efforts to stimulate the economy—while often dramatic—mostly fail. In 2011, 3 years after the recession began, companies in traditional industries are still going bankrupt, unemployment is still close to 9%, and consumer spending remains low. But history teaches important lessons—that innovation is often strong when companies and individuals are threatened, and that entrepreneurship is stimulated by commercial opportunity. Small investments of money in sustainable energy and green R&D, government programs to buy next-generation technology, and most importantly, tax incentives for supplying and buying green products and services bear fruit in 2010–2015. • U.S. GDP growth is <2% for 2009, <1% in 2010, and 0% in 2011, before rising to 2% in 2012 and 2.5% thereafter. U.S. GDP growth is never really strong, as the world is very competitive and many smart growth policies are expensive. • The U.S. population and many academics are disillusioned with globalization and free trade; political efforts to reach new global trade agreements fail.	• The world is in a recession in 2009 and 2010 because of the financial credit crisis and the surge in oil prices in 2007 and 2008 that affect businesses and consumers alike. Government efforts to stimulate the U.S. economy by helping to restore the credit markets and invest in infrastructure projects generally succeed and businesses begin to recover by the middle of 2010. The U.S. is wedded to free markets and individual entrepreneurialism and these forces help the U.S. economy recover. But the economy never regains its dominance in the world as the world has changed. Economic growth is relatively low for the scenario period: <1% for 2009, 1% for 2010, 2.5% for 2011, and ranging from 2.0%–2.5% until 2030. At the end of the scenario period, the U.S. economic prospects are dim as climate-change mitigation and adaptation costs are increasing to gigantic proportions of total GDP spending.
Government Budgets and Debt	• The federal government budgeting process is overhauled to better allocate resources to needs and capabilities and begin reducing unfunded obligations as a percent of GDP for Medicare, Medicaid, and Social Security. • After the recession, federal government budgets increase again as the economy improves, but at a rate no greater than the growth of the economy. The deficit and national debt as a percent of GDP come down rapidly after the recession is over. • Environmental agencies receive additional funds in order to administer the growing requirements.	• No change in the federal government budgeting process. Relations between the states and federal government are tense during the recession and for many years after. • Federal government budgets increase faster than the economy, but at least new revenues are coming in from carbon taxes and the new cap-and-trade system. • Environment-oriented agencies receive more funds to enforce the laws. • U.S. gross debt as a percent of GDP reaches 80% in 2010 and only shrinks to 70% by 2020. Federal budget deficit comes down only slowly.	• The federal budgeting process doesn't change • A severe budget crisis at all levels of government persists for many years and a number of programs are cut, particularly those related to the environment and energy. The priorities are economic recovery and health care. • U.S gross debt as a percent of GDP reaches 80% in 2010 and continues to rise a little each year. The deficit grows significantly for the first 3 years of the scenario and then stays large through 2020.
Public Opinion	• The public strongly supports government agencies and their actions to preserve and protect ecosystems, biodiversity, habitat, etc., for the future. Individuals still make many purchase decisions based on short-term utility and cost, but generally support green political candidates and the new budget priorities.	• The public is generally out of sync with government actions to preserve and protect ecosystems, biodiversity, habitat, etc. • The public also resists strongly for several years any notion of a carbon tax. But an innovative policy solution is developed whereby some of the carbon tax revenue is returned to individuals by contributing to their retirement accounts and health care insurance costs.	• Initially, the public doesn't support environmental and climate change priorities at all compared to economic ones. As the impacts of climate change become real, climate change mitigation and adaptation quickly become their most important issue. • The public's willingness to pay for mitigation and adaptation costs changes when the climate change threats to themselves and their families becomes real. • The public protests carbon taxes of any sort until late in the scenario.

COMPARISON OF SCENARIO VARIABLES

Force	Too Little Too Late?	Green Chaos	Carbon Junkies
U.S. Urbanization	• Throughout the U.S., a new urbanization trend is evident from a shift from the car-centric development of suburbia and the business park, to concentrated pedestrian and transit-centric, walkable, mixed-use communities. Urban areas stop losing population to the suburbs, and cities become more dense. • Under the revised U.S. Mayors' Climate Protection Agreement, most cities (and all the major ones) commit to the Super Kyoto smart growth principles.	• In "Green Chaos," redevelopment schemes mean that new arrivals in cities no longer necessarily settle in the center, and in many cities around the U.S. we continue to see counter urbanization, with cities losing population to rural areas. This is due to better living conditions in the suburbs and such factors as the fear of crime and poor urban environments. Experiments in new urbanism with high-density city living are mixed. Some major successes in the Pacific Northwest and Northeast occur, but largely the Southern state plans fail. Smart growth principles are implemented by cities sporadically.	• Smart-growth plans by cities and regions are generally unsuccessful. Cities expand without planning. The mass transit system between Los Angeles and the Bay Area never gets built, but a new toll system for the freeways in the State is implemented.
Economic Growth Around the World	• Despite the major recessionary bump in the road, the developing countries of the world, particularly China, India, and Indonesia, adjust quickly to the new world economy based on information technology and sustainable development. Many new products and services are needed and Brazil, China, and India all position themselves to meet the world's new demand. • Despite the early implementation of comprehensive sustainable development practices and systems in developing countries, demand for energy, food, and water resources continues to grow in the world. World economic growth averages 4.1% from 2015–2030; China's growth is 8% per year from 2010–2020, but only 5% per year from 2021–2035.	• Countries vary in how quickly they respond after the global recession. No country in the world, including the U.S., shows much global leadership as politicians focus largely on domestic problems. In addition, the growing clout of the state-based funds changes the dynamic for how contracts are awarded and products are traded. New protectionism policies are implemented by many nations, despite the efforts of the U.S. and EU, and trade tensions among nations are unresolved by any new international agreements. • But the greatest growth in green and sustainable-development products and services comes from developing country markets in China, India, and other Asian countries. Under the spur of a drive toward increased economic sufficiency, sustainable water management, and energy independence, and with a belief in the leverage of a strong computing infrastructure, China undergoes a radical economic policy change to become the leader in high-performance computing and encourage energy-efficient and green industries. The government also has a "new economy" focus that prompts policies encouraging green investments by foreign parties and multinationals. • China's growth is higher than any other major country, averaging 7% per year. But India's doesn't rise above 4%, and the African nations are stagnant. Oil-producing nations experience rapid rises and declines.	• The energy and climate change threats facing the global economy are graver than ever before, and the free market forces are at the center of the mess. National institutions are cooperating and creatively so, but politicians are pointing fingers and not in sync with each other or their publics around the world. Commodity-rich countries prosper generally, although most portions of Africa don't see much growth; many South American countries lag; the economies of Europe and Japan could decline because of decreases in working-age populations. World economic growth averages only 2.7% after the world emerges from the recession in 2011. China's growth averages only 5% per year after 2011.

COMPARISON OF SCENARIO VARIABLES

Force	Too Little Too Late?	Green Chaos	Carbon Junkies
Megacity Development	• By 2030, 5 billion people live in cities around the world, up from 3.2 billion in 2008. That is three out of five people in the world. By 2025, Asia has 10 megacities (more than 10 million people). Chinese cities contain 800 million people by 2020. • Over 90% of the urban growth in the world is in Asia and Africa, and to a lesser extent in Latin America and the Caribbean. • Smart growth principles are adopted by most megacities, as part of the Kyoto protocols, but implementation is often extremely slow. Most cities are unprepared for the change in migration that occurs near the end of the scenario in response to climate change conditions.	• Like "Too Little Too Late?," there are 5 billion people living in cities around the world by 2030, but in "Green Chaos," the urban migration keeps increasing. • Smart growth principles are adopted by many megacities, as a means of minimizing the negative environmental consequences. Still, Asian and African countries struggle to factor in water shortages and environmental consequences in their growth plans, although there are some surprising exceptions in China.	• While 5 billion people live in cities in 2030, the migration patterns are changing rapidly in Asia and Africa as water shortages and arable land issues influence people's decisions as much as perceived economic opportunity. • In 2030 the UN establishes a civil force funded by the developed countries for helping regions devastated by water shortages and arable land issues address the complex array of housing, sanitation, food supply, and transport issues.
Food Demand and Supply	• Demand for food worldwide grows by 50% by 2030 because of world population growth, rising affluence, and shifts to Western dietary preferences by a large middle class. But the food is there because of smart agricultural policies, and global cooperation on reducing subsidies in the developed countries. • Better water management practices in agriculture are in effect because of increased investments, but water shortages continue to get worse.	• Demand for food rises faster in Green Chaos than expected by anyone because of generally low prices and effective implementation of technology in the developing countries, reaching levels 60% greater than those in 2008. Aggressive agricultural policies are implemented in many nations to improve their food supply independence. Where food is produced is distorted by those national policies, and food prices fluctuate as politicians attempt to keep prices down for urban populations and supply programs are subsidized. But technology innovations and productivity increases occur, and many countries experience major conversions of land into large croplands.	• Demand for food rises by 40% by 2030, lower than in the other scenarios because of slower economic growth worldwide and the high prices. Supply problems are extreme in many countries, particularly as cropland begins disappearing in many countries because of climate change, leading to frequent conflicts among developing countries. Where food is produced is definitely distorted by national policies, and food prices fluctuate significantly as politicians attempt to keep prices down for urban populations and supply programs are subsidized.

COMPARISON OF SCENARIO VARIABLES

Force	Too Little Too Late?	Green Chaos	Carbon Junkies
Governance and Decision Making; Adoption of Collaboration Methodologies	• In "Too Little Too Late?," a new ethic takes hold early in the scenario period to improve the processes for making joint decisions involving many actors and implementing decisions. Similar to the holistic re-engineering business and re-inventing government efforts in the 1990s, substantial investment is made at the international, federal, state, and local levels to educate and train government employees (and many businesses and NGOs) to learn and implement skills and models for achieving effective multi-party agreements on environment, economic, and social issues through collaboration. • Collaborative approaches to management and to multiparty problem-solving is an active area of research, combining elements of business decision-making, political science, economics, and social psychology.	• In "Green Chaos," government bodies act as autonomous units attempting to meet goals with limited budgets. The result is constant battles among units (among federal agencies, between federal and state agencies, and between state and local agencies) over budgets, priorities, and responsibilities. Too many government agencies are chasing too few dollars. In-fighting abounds, and Congress can rarely pass budget legislation. New administrations continually attempt to reform the system but to little avail. • In addition, there is little cooperation between government agencies, particularly at the federal and state levels, with business and NGOs. In this environment, the most powerful forces for change are market ones. Governments generally apply market incentive policies like taxes, subsidies, and fees, and develop and implement strong command and control regulations.	• Riding on the optimism of a new administration, in the initial years of "Carbon Junkies" federal, state, and local government push for rational decision-making and action, taking a strong hand in pushing new policies. But this approach is ineffective in coming up with climate change mitigation solutions or new sustainable development policies that can be implemented. Key international agreements on the oceans and climate change are reached in 2010, but they are largely ignored. While the initial agreements and efforts are ineffective, it's also clear that free markets are making climate change and environmental conditions substantially worse. After 2015, a new collaborative process emerges—based on successes at regional and local levels in Alaska and Washington/ British Columbia, for aligning all parties on taking significant action, and that is one where those taking the action (the bottom) are involved, facilitated by government. The federal government is the facilitator, not the decision maker. • Collaborative approaches to management and to multiparty problem-solving is an active area of research, combining elements of business decision-making, political science, economics, and social psychology. The focus is on developing good solutions for very large, complex problems that can be effectively implemented.

COMPARISON OF SCENARIO VARIABLES

Force	Too Little Too Late?	Green Chaos	Carbon Junkies
Privatization	• Underlying the new governance ethic is a performance-measurement principle that ultimately allows government agencies to "lose" their mandate (or be fired) for poor performance. Consistent with that principle, many non-policy making or enforcement functions are privatized during the course of the scenario because the private sector is more innovative, efficient, and effective. A new growth industry helping to stimulate the economy is privatized government functions. • By 2030, all non-defense satellites are owned and operated by private-sector organizations. Many companies and governments now receive their telecommunications and data management services from state-funded private companies located in the United Arab Emirates.	• Partly for budget reasons and partly because of market forces, the private sector assumes some new government functions, but the process is largely reactive and unplanned, and many functions revert back to government control because of cost and quality issues.	• Initially, privatization of government functions occurs largely because of budget considerations, but as the environmental problems get larger, the private sector and general public are asked to assume more and more responsibility in joint decision-making. • A Canadian trading company and Finnish ship manufacturer create a joint venture and are awarded the Arctic Seas Sustainable Development Audit and Certification (ASSDAC) services contract, beating out all proposals from national government agencies.
Organization of Environmental Responsibilities in Federal Government	A national policy act on the environment is passed and signed into law in 2012. It focuses on developing better processes for developing new environmental policies, gathering information about ecosystems, developing prediction capabilities for the economy, society, and the environment, and enforcing laws and regulations. A new Department of Commerce and Environment (that is later renamed Department of Sustainable Development) is established and new powers, information systems, and capabilities are implemented.	Efforts are undertaken to improve the effectiveness of federal agencies in administering environmental laws and policies, by reorganizing the executive departments and integrating them all (including the NRCS, EPA, USGS) into one department. But results are disappointing and don't result in decision-making or service improvements. A state of confusion, misalignment of duties, duplicative services, and overlapping mandates still exist.	No major effort is undertaken to reform the environmental agencies in the U.S. Government. But a new ethic takes hold after 2015 as the seriousness of climate change implications take hold. Significant turnover occurs in environmental agencies as the organizations struggle to exert leadership in the time of crisis.
Local and Regional Demand for Emergency Management Services	Local officials and the public express strong needs for better accuracy and lead times in weather forecasts and warnings. Federal and local officials coordinate well in their development of innovative disaster mitigation, disaster response, recovery, and reconstruction tools.	Local officials request better accuracy and lead times in extreme weather forecasts and warnings, and seek better coordination and integration with federal emergency management services. But local and federal efforts remain largely uncoordinated in design, planning, and execution. Several NGO initiatives with strong foundation support result in effective new tools and best practices in disaster mitigation, response, recovery, and reconstruction. The private sector also provides a number of competitive solutions.	Local and state officials seek new tools and services from the federal government to help prepare for and respond to disasters, but the federal government lacks the resources to provide much relief. Near the end of the scenario, local and federal authorities for emergency response develop strong ties and coordinate a new generation of disaster management services.
Private Sector Capabilities in Weather, Water, Climate Services	Private sector information services in water and climate information grow in magnitude and capability like today's weather industry.	Private sector information services in water and climate information grow in magnitude and capability like today's weather industry	Private sector information services in water and climate information grow in magnitude and capability like today's weather industry.

COMPARISON OF SCENARIO VARIABLES

Force	Too Little Too Late?	Green Chaos	Carbon Junkies
Information Sharing	A key success factor in international agreements is information sharing of all data among the parties facilitated by the development of interoperability standards and access technology. Throughout the scenario, information about the external environment and man's effect on the environment is growing rapidly because of advances in sensors, modeling, and information-processing technology.	Information about the environment, while exploding in volume around the world, remains hard to share because of the lack of interoperability standards and intellectual property concerns of all the parties—both government and private. Even in the U.S., it remains very hard to integrate information quickly.	The government benefits from rapid advances in information technology and the ability to share information. Early environmental agreements all have extensive information sharing requirements.
(Satellite) Observing Gaps	New satellites are funded and launched early in the scenario in order to obtain the information required to improve models and monitor sustainable development performance.	Delays in satellite acquisition and launch result in coverage gaps for the polar regions and many ocean areas. The gaps are not addressed effectively for 10 years; when the satellites are in place, at much cost, they confirm that the planet's ecosystems are generally thriving.	Businesses lobby the U.S. government to put up new satellites and provide access to information to private-sector companies. But the real impetus for a new fleet of satellites is climate change and the shared opinion that new and better information is needed.
Space Weather Prediction Capabilities	Space weather prediction, which was in its infancy in 2009, rapidly develops after the solar maxima of 2012 spawns an unprecedented number of severe geomagnetic and radiation storms, disrupting satellite telecommunication, GPS-enabled navigation, NextGen-coordinated air traffic management and causing massive electrical power blackouts around the world. By 2024 when the next solar maxima occurred, the international solar wind forecast systems are capable of accurate predictions of the trajectories of solar storms and is able to provide lead times of 1 to 4 days for government agencies to protect assets from damage and ensure continuity of vital services.	Even after the solar maxima of 2012 spawns an unprecedented number of severe geomagnetic and radiation storms, disrupting satellite telecommunication, GPS-enabled navigation, NextGen-coordinated air traffic management and causing massive electrical power blackouts around the world, space weather prediction capabilities don't advance rapidly. In 2024 when the next solar maxima occurred, solar wind forecast systems still can't make accurate predictions of the trajectories of solar storms and provide lead times for government agencies to protect assets from damage and ensure continuity of services.	The damaging economic effects of the solar maxima of 2012 spawn a large increase in government funding to improve space weather prediction capabilities. By 2024 when the next solar maxima occurred, the international solar wind forecast systems are capable of accurate predictions of the trajectories of solar storms and can provide lead times of 1 to 4 days for government agencies to protect assets from damage and ensure continuity of vital services.
Geographic Information Systems, Tools, and Data	GIS technology rapidly advances, allowing data fusion for improved applications and decision-making, including change detection, time-based change (evolution), intersection of independent data sets, and association with user-decision needs and parameters.	Same as "Too Little Too Late?"	Same as "Too Little Too Late?"

COMPARISON OF SCENARIO VARIABLES

Force	Too Little Too Late?	Green Chaos	Carbon Junkies
U.S. Energy Policy	• Comprehensive new energy policies are passed in 2010 as a cornerstone in U.S. efforts to develop a sustainable U.S. economy and achieve a balance with the environment. Key elements of the energy policy included: • *Fuel economy standards.* The federal government accelerates automaker CAFE standards for conventional (gasoline/diesel engine) vehicles to 37 mpg by 2020, 40 mpg by 2025, and 45 mpg by 2030. • *Advanced biofuels development.* The federal government supports the development and commercialization of advanced biofuels that are far more sustainable than first-generation biofuels from food crop feedstocks. • *National renewable energy standard (RES).* The RES requires every utility in the country to produce 20% of its power from clean, renewable energy sources by 2025 (up from 9% of U.S. electricity supply in 2006). The RES is later extended to 25% by 2030. • *Carbon emissions trading.* In late 2009, the U.S. implements a national carbon emissions trading scheme (known as USCAP) to cut U.S. CO_2-equivalent emissions to 10% below 2005 levels by 2020 and to 20% below 2005 levels by 2030.	• Energy policy is fragmented at the federal and state levels, and supply and demand remain largely unregulated. But some significant policies are still passed by Congress and have a dramatic effect on energy supply and demand in all sectors. • *Carbon tax.* In 2013 the federal government establishes carbon taxes on petroleum products and coal. The effect is to double oil prices (reaching $150/b), and drive average gasoline costs at the pump to $7 per gallon. • *Fuel economy standards.* The federal government accelerates automaker CAFE standards for conventional (gasoline/diesel engine) vehicles to 40 mpg by 2020, 45 mpg by 2025, and 55 mpg by 2030. But these standards are largely made irrelevant by the carbon tax effects. • *National RES.* The RES requires every utility in the country to produce 20% of its power from clean, renewable energy sources by 2025 (up from 9% of U.S. electricity supply in 2006). The RES is later extended to 25% by 2030. But this standard is also made irrelevant by the impact of the carbon taxes, driving utilities to move into non-fossil fuel sources. • *Carbon emissions trading.* In late 2012, the U.S. implements a national carbon emissions trading scheme to cut U.S. CO_2-equivalent emissions to 30% below 2005 levels by 2020 and to 50% below 2005 levels by 2030.	• New energy policies are passed in 2011 to be a cornerstone in U.S. efforts to reduce its energy dependence on OPEC producers and to begin addressing climate change concerns. But the policies have little impact because there are no incentives or penalties for changing energy supply or demand. • *Fuel economy standards.* No change from the 2007 Act. CAFE standard for conventional (gasoline/diesel engine) vehicles is 35 mpg by 2020. • *Advanced biofuels development.* The federal government supports the development and commercialization of advanced biofuels that are far more sustainable than first-generation biofuels from food crop feedstocks. • *National RES.* The RES requires every utility in the country to produce 15% of its power from clean, renewable energy sources by 2025 (up from 9% of U.S. electricity supply in 2006). • *Carbon emissions trading.* The U.S. implements a cap-and-trade system in 2011, but not without a major fight from business. The U.S. system has goals for cutting U.S. CO_2-equivalent emissions to 1990 levels by 2020 and to 20% below 1990 levels by 2030. • This all changes in 2018 when stiff demand-reduction and renewable source requirements are adopted.
U.S. Energy "Independence" Offshore Oil and Gas Alternative Energy	• A driving force of U.S. energy policy is the desire to be more energy independent. But reducing GHG emissions and achieving a sustainable economy in balance with the environment is much more important.	• The U.S. endeavors to become energy independent and reduce its heavy reliance on carbon fuels—both goals are just smart. U.S. energy policy includes expanding offshore oil and gas development as well as "wind farms" in coastal waters. However, high fees are levied on development efforts to address potential user conflicts (fishing, migratory birds, marine transportation, etc.) and environmental impacts.	• Energy independence by the U.S. is desirable but largely doesn't occur.
Energy Prices	Crude oil prices swing wildly for most of the scenario period, but generally the price band is from US$100/b to US$200/b.	After the recession, crude oil prices rise again and remain high throughout the scenario period: US$150/b.	Crude oil prices range from US$40/b to US$60/b in real terms for the scenario period.

COMPARISON OF SCENARIO VARIABLES

Force	Too Little Too Late?	Green Chaos	Carbon Junkies
Energy Demand Growth	• World energy demand rises less in "Too Little Too Late?" to 15000 Mtoe in 2035 compared to approximately 12000 Mtoe in 2008. • Fossil energy remains dominant, but by 2020 OECD oil imports begin to fall. Global oil demand reaches 102 million barrels per day in 2035 from 84 mb/d in 2005. • Coal sees an increase in demand, driven mainly by power generation requirements in China and India.	• World energy demand rises to 17000 Mtoe in 2035 compared to approximately 12000 Mtoe in 2008. • Fossil energy remains dominant. Global oil demand is 94 million barrels per day in 2030 from 84 mb/d in 2005. • Coal sees an increase in demand, driven mainly by power generation requirements in China and India.	• World energy demand rises the most in "Carbon Junkies," Free Will, Free Fall to 19000 Mtoe in 2035 compared to approximately 12000 Mtoe in 2008. Over 70% of the increase in demand comes from developing countries, with China responsible for 30%. • Global oil demand reaches 110 million barrels per day in 2035 from 84 mb/d in 2005. • Coal sees the biggest increase in demand, driven by power generation requirements in China and India.
Electrification of Transport	• U.S. policy makers push car manufacturers through CAFÉ standards and other mechanisms to make fuel-efficient cars and provide incentives to consumers to buy those cars. And with crude oil prices swinging wildly between US$60/b–US$200/b, the transport industries begin the transition away from fossil fuels to plug-in hybrids and electric vehicles. Success in electrifying the transport industry is still some years away though.	• In the electrification of transport, the U.S. is the leader in buying plug-in hybrids and electric cars, but Japanese and Chinese companies manufacture most of those cars and the components. • Alternative fuel vehicles of all sorts do well in the Asian markets because of the increasingly open, but very competitive, societies and the low prices of the alternative fuel alternatives (particularly after import duties on the alternative fuel vehicles are eliminated to encourage adoption).	• U.S. policy makers push car manufacturers to make more fuel-efficient cars, and they do. But no significant shift in car technology occurs; most electric car manufacturers fail and only a few succeed as niche suppliers.

COMPARISON OF SCENARIO VARIABLES

Force	Too Little Too Late?	Green Chaos	Carbon Junkies
Alternative Energy Supply	• Renewable energy sources—especially solar, wind, and geothermal—grow rapidly in the scenario because of the RES for utilities requiring them to get 20% of their power from clean, renewable energy sources by 2025 (up from 9% of U.S. electricity supply in 2006) and 25% by 2030. In fact, the total share of renewable energy used for electricity generation overall reaches nearly 35% by 2030 as technologies improved and costs dropped. • Progress in developing a larger and more flexible smart-grid infrastructure enables the shift to large amounts of intermittent renewables, especially wind power. • Nuclear power capacity increases to 25% of total U.S. electricity generation by 2030, but controversies about its use continue. The ongoing shift to renewable sources reduces the need for nuclear. • Renewable energy sources also enjoy strong popular support with a majority of people strongly favoring renewables for large-scale investment over such alternatives as coal and nuclear power. • Solar technologies find wide use from small (a few kilowatts or less) to very large (more than 100 MW) applications. Starting from a low base, grid-connected photovoltaic (PV) enjoys the fastest growth rates—above 50% per year—of any renewable energy technology in the U.S. PV panels reside on more than 20 million U.S. homes and many commercial rooftops by 2030. • By 2015, the Solar America Initiative has already met its goal of bringing the cost of PV down to price parity, with conventional generation in many locations. Many large, high-temperature solar-thermal farms (some with built-in energy storage capacity) are built in very sunny areas, such as southern California's Mojave Desert and in Arizona and Nevada. By 2030, U.S. grid-connected PV capacity reaches nearly 110 GW, with thermal solar system capacity at 44 GW. Together, these solar energy technologies provide more than 90% of U.S. electricity-generation needs.	• In "Green Chaos," renewable energy sources—particularly the high-tech solar and wind—grow rapidly around the world because of countries' efforts to create new industries. The carbon taxes in the U.S. and China as well as the policies in both countries to electrify transport also have a significant impact on renewable energy plans and innovation in those new industries. • Utilities get 20% of their power from clean, renewable energy sources by 2025 (up from 9% of U.S. electricity supply in 2006) and 25% by 2030. • But the big winner in "Green Chaos" is nuclear power, where capacity increases to 30% of total U.S. electricity generation by 2035, despite all the controversies about its use. • Nuclear and renewable energy sources enjoy strong popular support. • Whereas the U.S. is the leader in solar and wind technologies in "Too Little Too Late?," in "Green Chaos" the Chinese are just as big a leader. • Offshore wind development also begins by 2015 and grows to provide about one-fifth of total wind capacity. • Ocean tidal and wave resources also emerge as high-potential renewable energy sources but are relatively small contributors to U.S. electricity generation through 2030. Commercialization efforts only begin to take off after 2012 and by 2030 a variety of ocean energy technologies are providing nearly 2% of U.S. electricity demand. Experts predict that ocean energy could supply about 10% of U.S. electricity needs in the future. • Of the other renewables, biomass energy (from sources such as wood and municipal solid waste) is an established technology that continues to grow, but at slower rates than the newer technologies. • Many countries (especially industrializing countries, such as China and India) build nuclear power facilities as fast as they can during the scenario time period.	• In "Carbon Junkies," renewable energy sources simply don't grow very fast because of abundance of relatively cheap hydrocarbons. • Utilities get only 15% of their power from clean, renewable energy sources by 2025 (up from 9% of U.S. electricity supply in 2006) and 17% by 2030. • Nuclear power does well in "Carbon Junkies," where capacity increases to 25% of total U.S. electricity generation by 2035, but not without extensive battles. • Nuclear and cheap hydrocarbons enjoy strong popular support. • Markets grow for solar and wind and biomass, but not for ocean tidal and wave resources. • Offshore wind development also begins by 2015 and grows to provide about one-fifth of total wind capacity. • Many countries (especially industrializing countries, such as China and India) build nuclear power facilities as fast as they can during the scenario time period.

COMPARISON OF SCENARIO VARIABLES

Force	Too Little Too Late?	Green Chaos	Carbon Junkies
Alternative Energy Supply (continued)	• In "Too Little Too Late?," the U.S. adds more new wind power than anywhere else in the world. The national RES and earlier long-term extensions of federal renewable energy production tax credits are the major drivers for the development of wind-farms across the country. In 2007, wind power accounted for about 1% of U.S. electricity generation (17 GW of capacity), but by 2030, the goal of 150 GW of wind capacity is reached and wind power provides 12.5% of U.S. electricity generation needs and is the largest source of renewable power. Total investment costs have been over $100 billion, but the net cost has been much lower because of significant savings from decreased fuel expenditures. • Offshore wind development also begins by 2015 and grows to provide about 20% of total wind capacity. • Geothermal. The U.S. continues to be the world leader in geothermal electric-power capacity, growing from 3 GW of conventional hydrothermal capacity in 2008 to 25 GW supplying 4% of U.S. electricity demand by 2030. • Ocean tidal and wave resources emerge as high-potential renewable energy sources but are relatively small contributors to U.S. electricity generation through 2030. Commercialization efforts only begin to take off after 2012 and by 2030 a variety of ocean energy technologies are providing nearly 2% of U.S. electricity demand. Experts predict that ocean energy could supply about 10% of U.S. electricity needs in the future. • Of the other renewables, biomass energy (from sources such as wood and municipal solid waste) is an established technology that continues to grow, but at slower rates than the newer technologies.	• By 2015, the Solar America Initiative has already met its goal of bringing the cost of PV down to price-parity with conventional generation in many locations. Many large, high-temperature solar-thermal farms (some with built-in energy storage capacity) are built in very sunny areas, such as southern California's Mojave Desert and in Arizona and Nevada. By 2030, U.S. grid-connected PV capacity reaches nearly 110 gigawatts (GW), with thermal solar system capacity at 44 GW. Together, these solar energy technologies provide more than 9% of U.S. electricity-generation needs.	