ISSUE BRIEF

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Managing the Transition to a Secure, Low-Carbon Energy Future

Sarah Ladislaw, Kathryn Zyla, and Britt Childs

Introduction

Over the coming decades, the world faces a daunting challenge in meeting the energy needs of a growing and developing world population while mitigating the impacts of global climate change. There is now broad-based scientific and political agreement that climate change is occurring and that the increase in atmospheric greenhouse gas (GHG) concentrations is the single biggest factor in global temperature rise. Stabilizing GHG concentrations at levels that will not dangerously interfere with the climate system requires an urgent and fundamental change in the way we produce and use energy. At the same time, concern over energy security grows deeper as global energy demand increases, prices continue to rise, and the ability to bring new supplies to market is called into question. Although the world is not running out of energy resources overall, significant geopolitical, economic, environmental, and technical challenges lie in accessing, producing, converting, and delivering those resources to the people who need them.

Until recently, energy security and climate change were considered separate issues to be dealt with by different communities of experts and policymakers. The two issues are now converging, challenging the security and climate communities to develop a better understanding of how to deal with both issues simultaneously. This policy brief seeks to establish a framework for

Summary

In the years to come, the world must meet the energy needs of a growing and developing world population while mitigating the impacts of global climate change. This policy brief seeks to establish a framework for considering the complex and evolving links between energy security and climate change, and identifies three challenges:

- the evolving and interconnected nature of energy security and climate change definitions and goals,
- the variables that contribute to an uncertain future, and
- the trade-offs and unintended consequences involved in addressing both issues.

A workable strategy must be concerned not just with how to design a future in which climate change and energy security concerns are met, but also with the pathway to get there. To guide this transition, this brief offers several guiding principles for devising energy and climate policies that are both effective and politically viable.

Center for Strategic and International Studies
1800 K Street, NW
Washington, DC 20006
Tel: 202-887-0200
www.csis.org

World Resources Institute
10 G Street, NE, Suite 800
Washington, DC 20002
Tel: 202-729-7600
www.wri.org

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considering the complex and evolving links between energy security and climate change. The framework addresses three categories of challenges that must be explored when shaping energy and climate policies:

- the evolving and interconnected nature of energy security and climate change definitions and goals,
- the variables that contribute to an uncertain future, and
- the trade-offs and unintended consequences involved in addressing both issues.

Finally, the brief offers several guiding principles for making sound energy and climate policy. Over the course of 2008, the Center for Strategic and International Studies (CSIS) and the World Resources Institute (WRI) will use the framework outlined here to examine the crucial areas for decision-making and to make recommendations in the areas of U.S. energy and climate policy, international agreements under the WTO or the UNFCCC, and technology development and deployment efforts.

The First Challenge: Defining the Problems and Goals

Energy security and climate change have broad economic, political, and societal consequences. A lack of energy security can exacerbate geopolitical tensions and impede development. The impacts of climate change and efforts to address the problem will have numerous security implications, including water scarcity, crop decline, forced migration, and changing conflict dynamics. If a priority of policymakers is to ensure that energy choices do not produce major security problems, then these choices should also avoid the security impacts of climate change. While these are critical concerns, this discussion will focus specifically on the interplay between climate change and energy security, given the direct relationship between climate change mitigation and the energy system.

Before setting concrete targets, it is important to note that both climate change and energy security issues will evolve as greater levels of scientific and technical understanding emerge and political and economic circumstances change. These developments, although hard to predict, will affect the policy and decision-making processes. Nevertheless, there are broad goals central to addressing both of these issues successfully.

Climate Change Goal: Stabilizing atmospheric greenhouse gas concentrations at a safe level, and adapting to unavoidable impacts.

The overarching goal for climate protection is "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system."[1] However, exactly what is meant by "dangerous anthropogenic interference" is unclear, partly because it reflects individual judgments about what is dangerous, and partly because science is limited in its ability to predict future outcomes of present actions.

Defining Dangerous

While any warming may have consequences, many scientists believe global warming must be limited to no more than two degrees Celsius above pre-industrial levels to avoid the worst impacts of climate change. As indicated in Figure 1, two degrees is not a guaranteed "safe" amount of warming — even at this level of change, serious impacts are predicted. However, it is often considered the maximum amount that the climate system can withstand before tipping points are reached that could rapidly accelerate the rate of warming and increase the risk of serious danger.

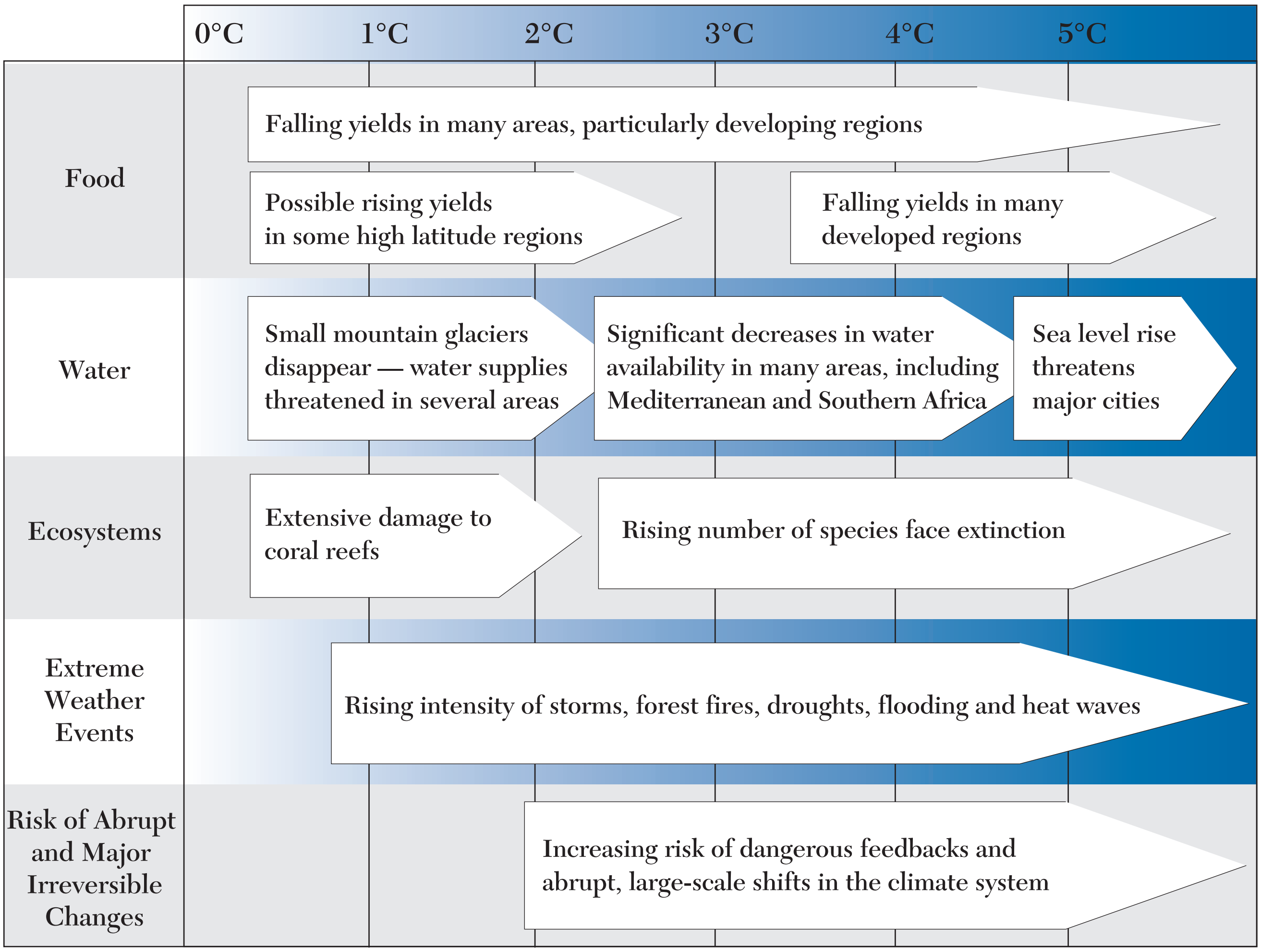
In order to limit global warming to less than two degrees Celsius, atmospheric carbon dioxide concentrations must not exceed 450-500 parts per million.[2] To achieve this, global GHG emissions would need to decrease dramatically during this century, reaching 50-85% cuts from current levels by 2050 (depending on emissions trajectories over time and the responsiveness of the climate system).[3] Although the optimal emissions reduction cannot be known, common-sense actions to avoid or mitigate the most severe climate events should be taken to provide future generations with greater latitude in dealing with the climate issue. In addition, near-term reductions are expected to be less disruptive in both economic and environmental terms than policies that delay action for several years.[4]

Climate science is a moving target — our scientific understanding of the climate system, of the impacts of climate change, and of how best to mitigate those impacts, is continuously evolving. Although the best available science cannot provide the certainty that many policymakers desire, it can, with a relatively high degree of confidence, provide likely ranges, both of the extent of warming expected in a given range of GHG concentrations, and of the scope and scale of impacts that will result from these

FIGURE 1

Projected Impacts of Climate Change

Global temperature change (relative to pre-industrial period)



Source: Nicholas Stern, Presentation to the Convention Dialogue, Nairobi.
Available online at: http://www.hm-treasury.gov.uk/media/E/3/stern_presentation_nairobi.pdf.

temperature increases. Policymakers should be prepared to adjust the stringency and urgency of action based on new discoveries regarding the severity of impacts as well as evolving scientific understanding of the climate system.

Regardless of the level of mitigation achieved, inertia in the climate system means that some amount of climate change is unavoidable and, in fact, already occurring. Recent research emphasizes the scale and speed of changes in the climate system. For example, sea level rise is rapidly accelerating; previous assessments may have underestimated the ice loss in Greenland, Antarctica, and the Arctic; water scarcity will threaten parts of Latin America and Africa more than previously anticipated; and many ecosystems are already struggling to adapt to such changes.[5] For this reason, climate policy should address the need for people and the environment to adapt to some level of inevitable change while simultaneously working to minimize these impacts.

Energy Security Goal: Secure, adequate, reliable, and affordable energy supplies

Under the strictest terms, energy security is defined as the availability of reliable and affordable energy supplies in adequate quantities to satisfy demand and maintain economic growth.

An expanded definition also includes notions of geopolitics, sustainability, and social acceptability.[6] Perceptions regarding an acceptable level of energy security change over time primarily due to the relative nature of many terms within the definition. Efforts to construct metrics to assess energy security often fall short or oversimplify a complex undertaking; therefore, directional goals may be more useful.

Relative Levels of Security

There is no such thing as absolute energy security. Because the word "security" is itself a subjective term, so too is the concept of energy security. Policymakers often think of energy security in terms of oil supply disruptions and energy price volatility, which can wreak havoc on economic growth and, as was the case during the 1970s oil embargoes, create significant international tension. Energy security concerns today are still very much driven by high and volatile prices and the geopolitical dynamics of energy trade. Furthermore, current global energy trends are driving much greater concern over the current system's long-term stability. These trends include strong growth in energy demand from developing economies like China and India, concentration of conventional oil and natural gas resources in a handful of regions, resource nationalism and geopolitical tension over the development and consumption of increasingly scarce resources, and failure to invest in and protect energy infrastructure adequately.

While oil dependence is an issue for oil importers globally, energy security concerns vary by country depending on resource endowment, population distribution, economic makeup, and a number of other factors. In the United States, energy security is most commonly discussed in terms of oil supply, largely because it is the area in which the country feels most vulnerable. The United States is 70 percent self-sufficient in terms of total energy consumed, but is increasingly reliant on imported sources of oil and natural gas, and the public discourse about energy security frequently devolves to proclamations about reducing oil imports from unstable regions and increasing domestic production. Europeans are increasingly reliant on imported natural gas from Russia; therefore natural gas is an energy security priority for them. In Brazil, energy security is closely linked with over-reliance on hydropower. Because so much of its electricity — 84 percent in 2005[7] — comes from hydropower, Brazil has experienced energy shortages in times of drought. In China, the reliability of coal-based electric power is a principal energy security concern following blackouts in 2004-2005.

In the United States, the concept of energy independence is predicated on the notion that relying on domestic fuels will insulate the U.S. economy from risks posed by imported energy. However, because these fuels are sold on global markets, energy security is a global issue and U.S. energy security is inextricably linked with the energy security of other countries. While reducing reliance on imported energy sources may enhance energy security in the face of certain threats, it does not insulate economies from actions or events in global markets nor ensure price stability. Domestic fuels and delivery systems are also susceptible to cost increases and reliability or security problems. Complete energy self-sufficiency is, therefore, a misplaced goal.

Instead, energy security can be improved by reducing consumption through efficiency, increasing production of conventional resources both domestically and abroad, diversifying fuels and suppliers, encouraging trade and investment, and protecting critical infrastructure. However, energy supply cannot be considered in isolation. Policymakers must consider the links between fuel choices, energy demand, infrastructure needs (both existing and future), investment requirements, and the environmental impacts of energy use. Because of the global nature of energy markets, policies must address international trade and investment flows as well.

The Second Challenge: Managing the Integration and Tradeoffs of Energy Security and Climate Change

Energy security and climate change interests sometimes conveniently align. In particular, improvements in energy efficiency and reductions in energy demand provide a "double win". Increased efficiency has the potential to reduce GHG emissions throughout the economy by decreasing the amount of energy needed for society to function. For example, in the near term, increased vehicle fuel economy can potentially reduce the amount of oil required to power the U.S. transportation sector by about 3-5 million barrels per day from the increased base in 2030, decreasing emissions by as much as 19 percent.[8] In many cases, efficiency gains yield significant cost savings to both producers and consumers of energy. A recent study released by the McKinsey Global Institute states that nearly 40 percent of a projected possible 3-4.5 gigatons of carbon dioxide equivalent emissions reduction in the United States by 2030 could be achieved at "negative marginal cost," primarily due to efficiency measures.[9] They are, therefore, an important component of any policy solution to address climate and energy security.

The benefits of supply measures are mixed, depending on the type and source of fuel and the production methods. Some benefit both energy security and climate change. For example, lower-carbon energy sources such as wind, solar, biomass, and hydropower provide domestically produced energy that can substantially reduce emissions compared to fossil fuels. Depending on domestic resource endowment and disposal facilities, nuclear power can also improve energy security while reducing emissions; however this is not always the case.[10] Despite reliability issues and some concern over the impact of adding too many combinations of fuel sources into the electricity system, these energy sources add diversity to an energy mix that is overwhelmingly dominated by fossil fuels. While their contribution may be small for now, in tight markets even the current contribution from these resources is extremely important. Research and development to increase commercialization of current technologies and to create new clean energy technologies is an essential component of meeting energy security and climate goals.

On the other hand, some supply-side measures present conflicts between energy security and climate goals. For instance, as concern over the reliability of imported fuels continues to grow and energy prices increase, economies tend to turn to domestic fuels. Many of these fuel options (e.g., oil shale, oil sands, and extra-heavy oil deposits) result in higher carbon emissions than traditional resources. Greater use of these fuels (without the ability to capture and sequester the carbon emissions at a large scale) would dramatically increase GHG emissions.

Likewise, climate change strategies that replace high-carbon fuels with lower-emitting energy sources can increase energy insecurity. For example, switching from coal combustion to natural gas in the power sector is an effective means to reduce GHG emissions. However, many regions rely on imported natural gas. For instance, Europe relies on Russia, which puts them at risk should Russian supplies become unstable. Similar concerns exist in the United States, given an expected decline in natural gas production in North America and the import dependence on major natural gas reserve holders that would result from greater demand. Box 1 (next page) illustrates the impacts of selected energy policy options for both energy security and climate change.

Economic conditions influence the scale of each of these trade-offs. Rising prices drive reduced demand, with the positive effects on security and climate described above. However, they may also drive increased fuel substitution that could put security and climate goals in conflict and potentially increase energy insecurity. In addition, energy options that are compatible with existing infrastructure (e.g., pipelines, vehicles, power generation facilities, etc.) have a natural advantage over those energy sources that require new or altered infrastructure. In part, it is this economic advantage that has driven businesses and policymakers to choose energy sources that can be used in the existing infrastructure despite the trade-offs or undesirable consequences. Likewise, the timing of policy action also affects the scale of trade-offs. Climate priorities steer toward more aggressive near-term policies to reduce emissions. However, this timetable may create challenges for energy security if climate targets outpace the ability of the energy supply infrastructure to keep up at "affordable" prices.

This series of analyses starts from the premise that any sustainable long-term energy policy will need to move quickly to reduce GHG emissions to low levels while avoiding major security impacts. In both developed and developing countries, policymakers will be seeking to balance these two political priorities. Where the two are in tension, for instance in high-carbon fuel choices in coal-rich countries, this needs to be clearly recognized and addressed. Where win-win solutions exist, they should be treated as priorities. The choices will sometimes be tough, but navigating the transition to a secure low-carbon energy mix will only be possible with a clear-eyed understanding of those choices and their implications.

The Third Challenge: Preparing for an Uncertain Future

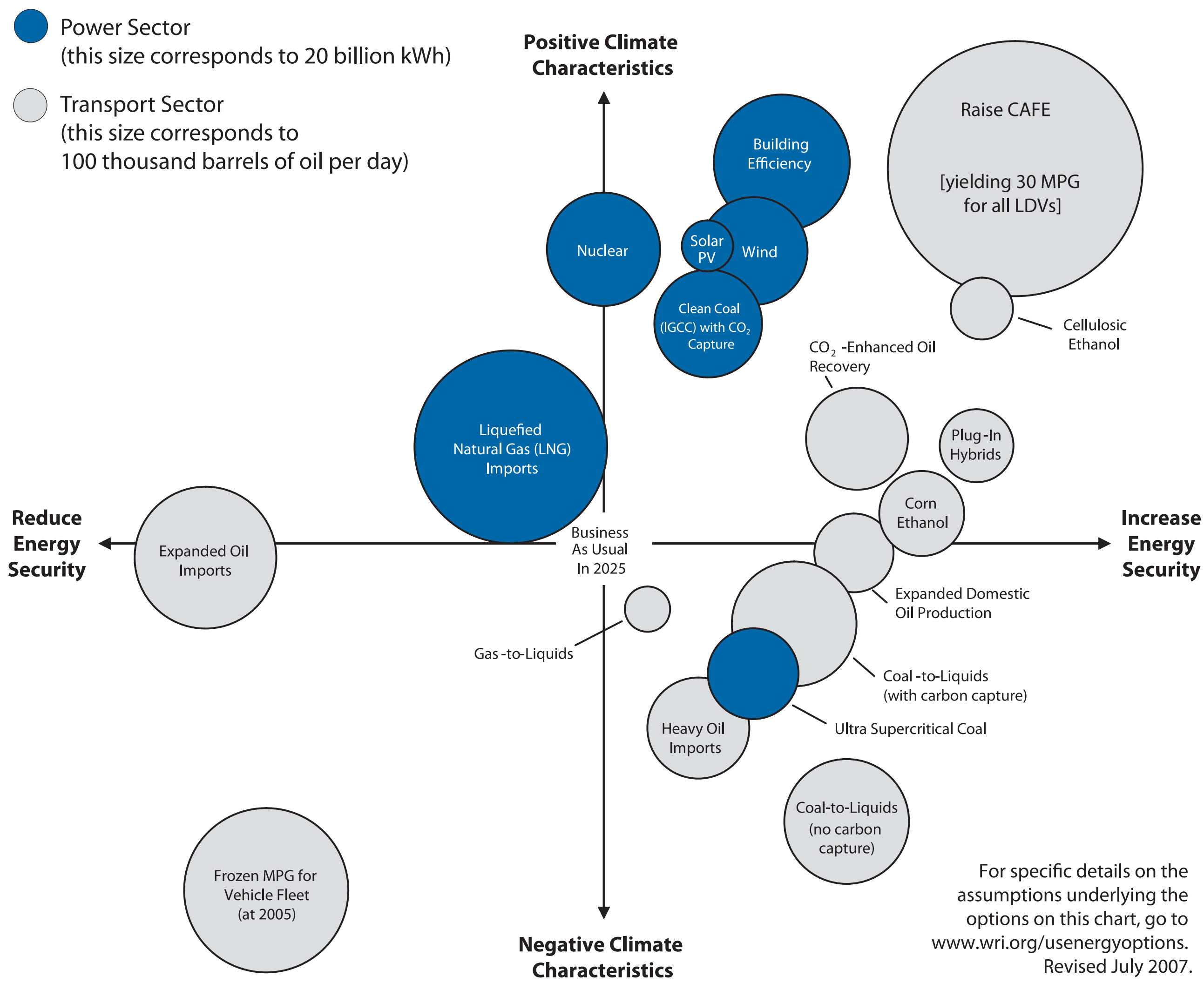
Compounding the challenge of dealing with climate change and energy security is the fact that they develop over time horizons that are much longer than current political cycles. As a result, policymakers and industry are forced to make near-term, complex decisions that affect both energy security and climate change in the face of a highly uncertain future. During the longer time horizon a number of variables can influence the effectiveness and longevity of policies. It is important for decision-makers to recognize the range of different pressures and forces shaping the policy environment within which they must craft the pathway toward a stable climate and more energy-secure future.

Box 1

In July 2007, WRI analyzed the energy security and climate change impacts of a variety of energy measures, and found several options with positive energy security and climate characteristics, but also some options that helped one issue and hurt the other. The following "bubble chart" was developed to inform the policy choices under consideration, placing each energy option on the graph according to positive or negative impact on each of these issues. (Note: the definition and criteria for measuring energy security includes sustainability, geopolitics, and social acceptability criteria, and is more expansive than the definition used in this paper.)

A Snapshot of Selected U.S. Energy Options Today: Climate and Energy Security Impacts and Tradeoffs in 2025

This chart compares the energy security and climate characteristics of different energy options. Bubble size corresponds to incremental energy provided or avoided in 2025. The reference point is the "business as usual" mix in 2025. The horizontal axis includes sustainability as well as traditional aspects of sufficiency, reliability, and affordability. The vertical axis illustrates lifecycle greenhouse gas intensity. Bubble placements are based on quantitative analysis and WRI expert judgment.



Source: Jeffrey Logan and John Venezia, *Weighing U.S. Energy Options: The WRI Bubble Chart*, WRI Policy Note, July 2007. Washington, DC: World Resources Institute. Available online at: http://pdf.wri.org/weighing_energy_options.pdf.

- **Public Perceptions of Climate Change and Energy Security**

  Policymakers should be aware that public support for energy security and climate change measures may fluctuate over time depending on overall levels of public concern and the perceived cost or impact of the policies being implemented. The public tends to be particularly concerned about energy security when energy prices are high, markets are volatile, infrastructure is vulnerable, and countries are competing over scarce resources. These concerns tend to be heightened by instances of conflict such as the current U.S. engagement in Iraq, civil unrest in Nigeria, nuclear concerns in Iran, as well as many others. Similarly, concern over climate change appears to be high after the occurrence of extreme weather events or significant new discoveries about the rate of climatic changes. As policymakers strive to develop and implement appropriate policies, several different political environments are possible, depending on the level of public awareness and concern over these issues. These circumstances will affect the ease with which policymakers can affect the desired changes.

  For example, the public may be very concerned about both energy security and climate change. In this case, there is likely to be significant political support for alternative energy sources and emissions mitigation, but increased isolationist attitudes may complicate international cooperation on solutions. If the climate impacts are severe, then there may be competition for resources from those who believe that adaptation should be a higher priority than mitigation.

  If public concern over energy security is much more pronounced than concern over climate change, policy priorities will likely include greater support for domestic, low-cost, but possibly emissions-intensive fuel options, and may undermine support for other mitigation options.

  The opposite may be true, however, where there is much higher concern over climate change than energy security. In this case, there could be strong support for mitigation and adaptation efforts, as well as a greater willingness among nations to work together on solutions. However, less concern over energy security tends to coincide with periods of low prices, in which higher-cost clean energy technologies are less likely to be deployed.

  Finally, public concern over both of these issues could be low. In this situation, there is little political support for development of alternative fuels and technologies, and low energy prices provide little opportunity for new alternatives to compete. Table 1 summarizes a few of the ways in which public perception of climate change and energy security might affect the political climate in which policy decisions are made.

  It is likely that the next few years will see public perception shifting between several or all of these environments (the boxes in Table 1), and therefore it is useful to explore the potential range of conditions. For example, current political discourse on these issues rarely considers what will happen to the policies put in place if the price of oil should drop precipitously or if climate changes occur more rapidly than expected. The table does not seek to answer such questions definitively, but merely to illustrate the range of potential challenges as public perception of these issues changes over time.

TABLE 1 Possible Near-term Political Environments

	High Public Concern over Climate Change	Low Public Concern over Climate Change
High Public Concern over Energy Security	High degree of public support for alternative energy sources and mitigation efforts, but… Potential for competition over funds between mitigation and adaptation efforts Drive for increased isolation/less international cooperation	Temptation to return to domestic, low-cost fuel options that may be emissions-intensive Risk of undermining support for mitigation efforts
Low Public Concern over Energy Security	Greater public support for mitigation and adaptation Increased international cooperation on adaptation efforts possible Less focus on ensuring diversity and security	Reduced sense of urgency for development of alternative fuels Low prices risk undermining efforts to drive technological development

- **Rate of Technology Development**
  Clearly, new and existing technologies will play a significant role in addressing both energy security and climate change concerns. Major innovations will be needed in the production, transport, and use of energy. Some innovations — such as emerging carbon capture and sequestration technologies and many renewable energy options — are well along their way. Others may take decades or centuries to emerge, by which time society will need to be far along in the process of emissions reduction. However, it is impossible to predict when and what technological breakthroughs will occur, and therefore dangerous to create policies that depend on them. At the same time, unexpected technological breakthroughs can transform the entire industry and policymakers must be prepared to react if such a breakthrough should occur.

- **Energy Price Fluctuations**
  Fluctuations in conventional energy prices affect both the economic viability of policy solutions as well as the political support for implementing them. A high-price energy environment facilitates development and deployment of new technology because new and more costly energy technologies have a better chance of competing on the open market. When conventional energy prices are low, cheap fuels and readily available technologies are often chosen first. Both environments pose unique policy and investment considerations. Under high energy prices, clean energy technologies like renewables and nuclear power are better able to compete on the basis of cost. Emissions-intensive fuels like oil sands, oil shale, and coal-to-liquids, however, also have a chance to gain market share. When the price is low, there is very little market incentive to develop and deploy high-cost fuels and technologies. In this case, government support programs to develop these technologies are required, and it becomes increasingly difficult to dissuade people from using traditional low-cost technologies and fuel sources, regardless of their security and climate credentials.

- **Pace of Climate Change**
  Despite continuing improvements in climate models, estimates of future climate change have consistently underestimated the rate of changes in natural systems.[11] If this pattern continues, policies may have to be strengthened midway through implementation. In addition, the current science on climate change does not rule out the potential for abrupt changes in the climate system. If current impacts become more severe than otherwise expected, limited resources may be diverted away from mitigation efforts to focus more intensely on adaptation.

Coping with Uncertainty

While policymakers cannot predict with certainty how each of these factors will shape the world in the decades to come, it is useful to anticipate the potential range of outcomes to ensure that policies made today can be adjusted for a range of potential futures. When policymakers anticipate a range of potential outcomes, they are generally more prepared to deal with the less likely events that sometimes occur and are better able to weigh the potential costs and benefits of the policies they put in place today. In addition, future energy and climate conditions are not entirely outside of our influence — measures enacted today can help drive technology development and scientific understanding, and will certainly have an effect on energy prices. Indeed, the limited availability of low-carbon technologies today is in part a function of policy choices made in the past. Policy signals can play a powerful role in pushing forward innovation.

Navigating the Transition: Guiding Principles

Both energy security and climate change are moving targets. Over time, resource constraints may emerge, technologies will change, and planning horizons will come and go, each of which will have unpredictable economic and political ramifications. A workable strategy must be concerned not just with how to design a future in which climate change and energy security concerns are met, but also with the pathway to get there. At each stage of this transition to a smarter energy future the policies driving it must give the right signals to encourage investment and command political support. WRI and CSIS do not wish to prejudge what these policies will be, as this is the subject of our collaborative work. In this section we lay out a set of guiding principles for developing and evaluating policy options for an energy-secure, low-carbon future. These principles fall into two categories: effectiveness and political feasibility.

Effectiveness

The key measures of the effectiveness of policies will be their ability to limit and adapt to global climate change and secure adequate supplies of reliable and affordable energy within the parameters discussed above. Several factors are important to ensure that a climate change mitigation and energy security policy framework can achieve these goals. To be successful, policies should do the following:

- **Adopt a global and integrated approach**
  The effects of climate change are global in nature, as are the sources of GHG emissions. Combating climate change, therefore, will require coordinated action by the key emitting countries; no country can solve the problem acting alone. Participation by all of the world's largest emitters is essential to crafting an effective solution. To secure the participation of major new emitters like China and India, the United States (the leading contributor of cumulative GHG emissions) must both take action to reduce emissions internally and engage constructively in international negotiations. While these negotiations face several challenges, securing an effective global response to the climate challenge hinges most immediately on U.S. action and constructive re-engagement.

  Similarly, the interdependent nature of the global economy makes U.S. energy security inextricably linked to global energy security. Because energy security relies on diversity of fuels and suppliers, companies and policymakers should adopt a global approach to energy security. Despite growing calls for energy independence, global energy markets offer flexibility, efficiency, and savings that are important to maintain. Countries must learn to recognize the interdependent nature of their energy security. Given the interconnected nature of global energy markets, countries will continue to rely on one another for their energy supplies for the foreseeable future. It is important to resist the isolationist pursuit of energy independence at the expense of global cooperation and trade.

- **Promote but don't depend on technological breakthroughs**
  Addressing climate change and energy security will require new technologies, so investment in new technology solutions will clearly be important. Decision-makers must take a long-term view and make a sustained commitment to technology development so that we are properly positioned to take advantage of new market opportunities.

  However, policy solutions must not be based on overly optimistic assumptions about the pace of technological development. It is important to recognize the limitations of existing technology and not to underestimate the time it takes for new technologies to reach commercial- or wide-scale deployment. Development of new technologies that enable widespread use of cellulosic ethanol, carbon capture and sequestration, hydrogen fuel cells, and even nuclear fusion in the distant future, as well as transformative materials and battery technologies, have the potential to transform current energy systems. Innovation and development will clearly be important, but solutions should not be based on assuming technological miracles. Policies must be crafted to drive innovation and diversity while allowing markets and behavior to change in a way that is consistent with policy goals.

- **Apply to a robust range of future scenarios and adjust to evolving circumstances**
  Because future climate change and energy security scenarios are so uncertain, policies to address these issues cannot depend on any given set of energy supplies or climate impacts. Instead, policies must be flexible and adaptable enough to succeed in any of the political environments described above and should be designed with enough foresight that they continue to push toward the desired outcomes regardless of unanticipated developments along the way.[12] At the same time, policies must provide enough certainty and stability to encourage adequate investment.

Political Feasibility

It is not enough for a policy framework to be effective. To be implemented it must also have support from a number of political constituencies; broad political consensus is necessary. To be politically feasible, policies that attempt to address climate change and energy security must build this political consensus by addressing a number of issues.

- **Develop an appropriate time horizon**
  Climate change and energy security exist on a time horizon that extends beyond current political and investment cycles. Both problems require solutions that are implemented today and sustained and adjusted over the medium- to long-term. Therefore climate mitigation and energy security both involve confronting the inertia of our current energy system (the cost and business advantage built up through a century of infrastructure projects and trillions of dollars of investment) as well as adapting to future uncertainties. It is highly unlikely that policymakers today could fashion energy and climate policies that will withstand the test of time, because the problems will continue to change and

our understanding and capabilities will continue to evolve. Given the sheer number of variables in play, policymakers will need to establish a long-term process that is broken down into manageable pieces, with measurable milestones on the way toward the ultimate goals. This approach allows for time to implement a policy, evaluate its effectiveness, and make changes based on new information, tools, and external conditions.

- **Recognize costs**
  Combating energy insecurity and climate change will require a fundamental transformation in the way we produce and use energy. As such, policymakers should recognize that the steps necessary to address energy security and climate change will not be easy or without costs. It will be important to create opportunities for economic gain in an effort to counterbalance the costs. However, it is also important to consider the eventual costs to society of doing nothing. While certain forms of energy may be more expensive today, the costs incurred over time by not dealing with energy security and climate change now will likely be much higher in the future. A number of reviews estimate that preparing for and mitigating climate change will cost significantly less the earlier efforts begin. Mitigation will be more difficult and costly if we put it off and have to deal with severe impacts as well.[13] Therefore, potential solutions need not be cost-free to be economically viable. While the public's willingness to pay may be high if it is serious about addressing these issues, demonstrating cost-effectiveness will be necessary to make the case for such disbursement of public funds.

- **Integrate with other political priorities**
  Creating policy contradictions or unintended consequences is a danger that any policymaker faces, but it is particularly important to be aware of these challenges when making energy and climate policy. Energy and climate policy measures have a tendency to spill over and can quickly run up against other policy priorities such as trade, security, foreign policy, agriculture, and science and technology policy. Policymakers must recognize the links between these sectors and plan accordingly.

  As it is unlikely that policies or investments made will be entirely without impacts on other sectors, it will be important to become more aware of the trade-offs and make educated and well-communicated decisions while endeavoring to manage such trade-offs. Policymakers must effectively manage the competing political constituencies that will be involved because their interests have somehow become intertwined. For instance, efforts to promote greater production and use of biofuels have yielded some unintended consequences, such as the increased price of corn and corn-derived products, stress on land and water resources, the potential for stranded assets going forward, and an expensive and far-reaching subsidy program on top of existing farm subsidies. Managing these trade-offs and the impacted constituencies is crucial to building the necessary buy-in for an approach to be politically feasible.

- **Create space for development needs**
  Developed countries are largely responsible for the historical emissions that have led the world to the current climatic precipice. At the same time, developing countries are a large and influential source of emissions going forward. Thus, it is crucial for emerging economies to be engaged in global climate mitigation efforts. International agreements must recognize the inherent need of societies to develop and increase standards of living, especially for the large portions of society living in poverty and without access to modern energy services. Many developing country economies rely heavily on revenues from the sale of fossil fuels. In a low-carbon world, revenues from these resources will diminish over time. The geopolitical implications of this change, as well as the impact on their domestic stability, are yet unknown. Policymakers must engage internationally to recognize and deal with these concerns. Different types of commitments, commensurate with developing countries' national circumstances, must be incorporated into any lasting framework.

Conclusions

Addressing the dual challenges of energy security and climate change while balancing economic, social, and political trade-offs will require a new and sustained approach to energy policymaking. It is no longer adequate to consider these issues in isolation — policymakers must integrate the two concerns to ensure that their policies deal with both issues simultaneously.

As climate science and the factors that determine affordability and reliability evolve, so too will the benchmarks for success change. Policymakers will need to evaluate and make difficult trade-offs on issues that will not come to fruition within a given political cycle or maybe within their lifetimes. In the face of so much uncertainty, policymakers will need to consider a range of potential futures that may or may not ever materialize. However, there are principles that can guide policymakers to making the best possible decisions with regard to energy and climate policy.

Given the nature of both challenges, productive international engagement and cooperation will be essential. Policymakers will need to consistently reassess and review their progress on the energy security and climate change fronts, as well as manage the inevitable unintended consequences of the policies they put in place. The transition to a secure, low-carbon energy future will not be smooth and uneventful — after all it requires changing the basic underpinning of the global economy. Policymakers would do well to integrate these notions of energy security and climate change and make a sustained commitment to dealing with both simultaneously and over the long term.

About the Authors

Sarah Ladislaw is a Fellow in the Energy and National Security Program at the Center for Strategic and International Studies, where she concentrates on the geopolitical implications of energy production and use, energy security, energy technology, and climate change. Before joining CSIS in January 2007, Ladislaw worked in the U.S. Department of Energy's Office of Policy and International Affairs.

Kathryn Zyla is a Senior Associate in the Climate and Energy Program at the World Resources Institute, where she focuses on emissions markets, design of U.S. federal climate policy, and the intersection of climate change and energy security. Before joining WRI, Ms. Zyla served as a Senior Research Fellow for Domestic Policy at the Pew Center on Global Climate Change. She holds a master's degree in environmental management from Yale University and a bachelor's degree in engineering from Swarthmore College.

Britt Childs is a Research Analyst in the Climate and Energy Program at the World Resources Institute. Her research primarily focuses on clean technology deployment, including regulatory and investment frameworks to facilitate market penetration of new energy technologies internationally. She holds a bachelor's degree in international politics from Georgetown University's Walsh School of Foreign Service.

Notes

1. This goal was established in the 1992 United Nations Framework Convention on Climate Change, ratified by 191 countries including the United States.
2. Intergovernmental Panel on Climate Change (IPCC), "Issues related to mitigation in the long-term context." November 2007. Chapter 3 of the Fourth Assessment Report of the IPCC. Available online at: http://www.mnp.nl/ipcc/pages_media/FAR4docs/final%20pdfs%20of%20chapters%20WGIII/IPCC%20WGIII_chapter%203_final.pdf.

   The current level is approximately 380 ppm and rising at more than 2 ppm per year. See NOAA/ESRL Global Monitoring Division's Mauna Loa data. Available online at: http://www.cmdl.noaa.gov/projects/web/trends/co2_mm/mlo.dat.
3. Nicholas Stern, 2006, *Stern Review on the Economics of Climate Change*. Available online at: http://www.hm-treasury.gov.uk/independent_reviews/stern_review_economics_climate_change/stern_review_report.cfm; and IPCC, 2007.
4. Stern, 2006.
5. See Kelly Levin and Jonathan Pershing. *Climate Science 2006: Major New Discoveries.* Washington, DC: World Resources Institute. March 2007.
6. World Resources Institute. "A Snapshot of Selected U.S. Energy Options Today: Climate Change and Energy Security Impacts and Tradeoffs in 2025." July 2007. Available online at: http://pdf.wri.org/us-energy-options.pdf.
7. Energy Information Agency (EIA). "World Net Electricity Generation by Type, 2005." U.S. Department of Energy. September 2007. Available online at: http://www.eia.doe.gov/emeu/international/electricitygeneration.html.
8. *Facing the Hard Truths about Energy: A Comprehensive View to 2030 of Global Oil and Natural Gas.* National Petroleum Council, July 18, 2007. Available online at: http://downloadcenter.connectlive.com/events/npc071807/pdf-downloads/NPC-Hard_Truths-Ch6-Recommendations.pdf, p 241.
9. *Reducing U.S. Greenhouse Gas Emissions: How Much at What Cost?.* McKinsey & Company, December 2007. Available online at: http://www.mckinsey.com/clientservice/ccsi/pdf/Greenhouse_Gas_Emissions_Executive_Summary.pdf, p. xiii and 69.
10. Global uranium reserves are just as unevenly distributed as oil and natural gas, meaning that for many countries, securing adequate supplies of uranium requires importing. In addition, difficulty in disposing of depleted uranium and concerns about nuclear proliferation can mean that nuclear power is actually less energy secure in some regions than traditional fossil-based power generation.
11. E. Engelhaupt. "Models underestimate global warming impacts." *Environmental Science & Technology*, July 1, 2007.
12. For a discussion of Robust Decision Making (RDM) with regard to climate change, see David G. Groves, Robert J. Lempert, 2007. "A new analytic method for finding policy-relevant scenarios." Global Environmental Change 17, 73–85. Santa Monica, CA: RAND.
13. IPCC, 2007; and Stern, 2006.

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