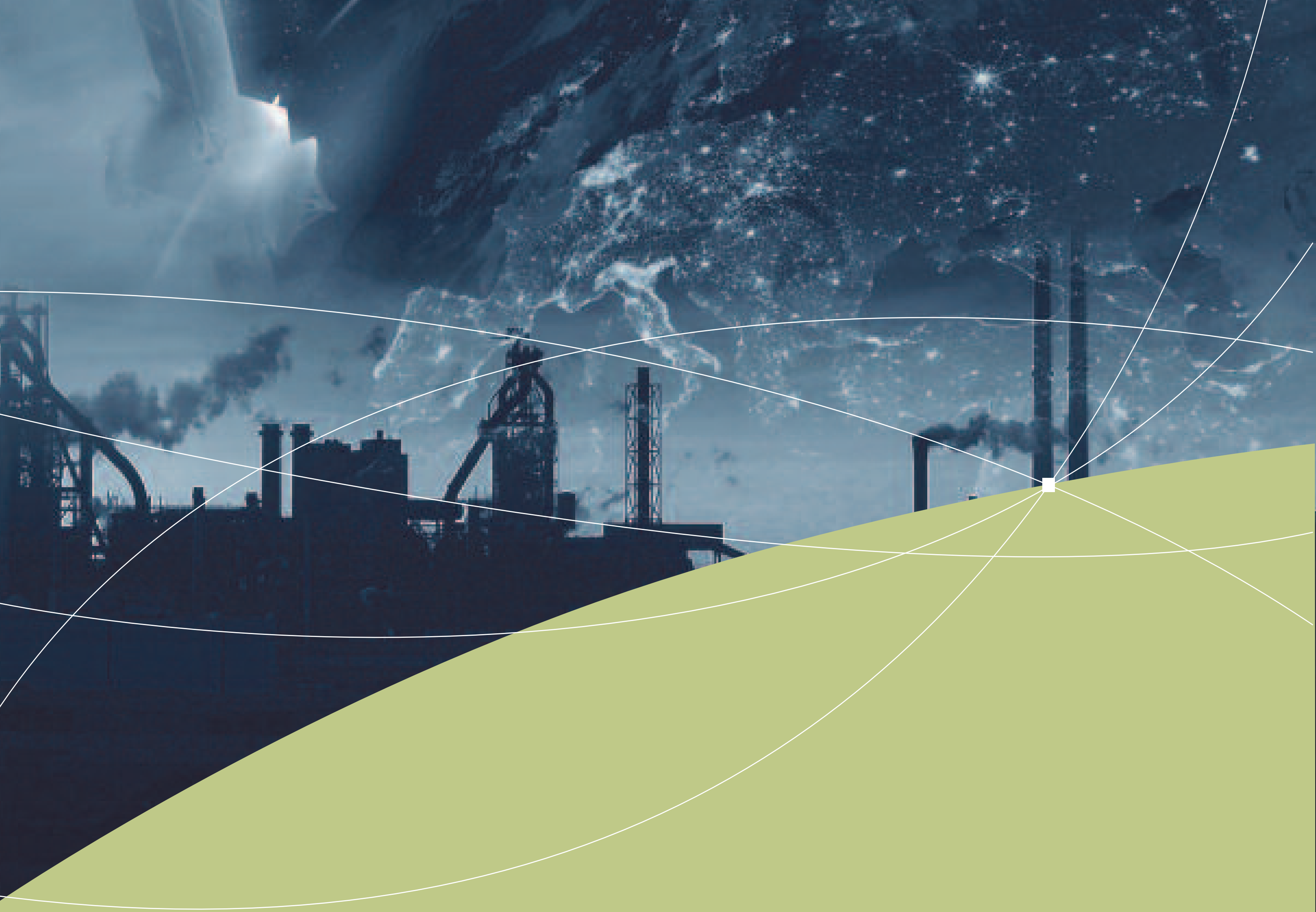

55

AICGSPOLICYREPORT

ENERGY AND SECURITY RISKS: A TRANSATLANTIC COMPARISON

Achim Maas
Max M. Mutschler
Paul Sullivan

AMERICAN INSTITUTE FOR CONTEMPORARY GERMAN STUDIES THE JOHNS HOPKINS UNIVERSITY

American Institute
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German Studies

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TABLE OF CONTENTS

The American Institute for Contemporary German Studies strengthens the German-American relationship in an evolving Europe and changing world. The Institute produces objective and original analyses of developments and trends in Germany, Europe, and the United States; creates new transatlantic networks; and facilitates dialogue among the business, political, and academic communities to manage differences and define and promote common interests.

ISBN 978-1-933942-43-8

ADDITIONAL COPIES:
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FOREWORD

In the twenty-first century, energy and security have become an intertwined policy area. Securing our energy supply is a vital concern, with ramifications for other policy areas, including climate policy and space policy.

Concerns over the future of resource sustainability have driven political debates for decades, with varying degrees of successful policy change and implementation. However, the continued slow pace of progress in international forums on energy has only heightened fears about coping with a changing climate, and specifically the ensuing risks to national and global security.

This Policy Report analyzes three key areas associated with debates over security concerns related to energy, including the risks inherent in not properly addressing them on the international stage. Paul Sullivan (Georgetown University) outlines the challenges in securing energy supplies by looking at four critical risks: volatility, uncertainty, complexity, and ambiguity. His approach highlights the interconnectedness of the systems related to energy security, ranging from water usage to financial markets. Achim Mass (IASS Potsdam) explores the growing agenda on climate engineering. While the use of such a policy may be increasingly viewed as an effective tool in combating climate change, further research is needed to better understand the benefits and risks associated with increased implementation on a global scale. Finally, Max M. Mutschler (Stiftung Wissenschaft und Politik) analyzes the risks associated with the lack of an international approach to pursuing a sustainable future in space. With many of the world's critical civilian and military systems hinging on the safe deployment and continued use of satellites, increasing levels of space debris and the possibility of an arms race in space threaten the global interests and security in space.

This publication is part of AICGS' project on "New Systemic Risks: Challenges and Opportunities for Transatlantic Cooperation," carried out in cooperation with the Stiftung Wissenschaft und Politik in Berlin. The project aims to answer questions on differing risk cultures and risk perceptions across the Atlantic in order to identify the need and potential for cooperation as well as points of conflicts between the transatlantic partners. AICGS is grateful to the Transatlantic Program of the Government of the Federal Republic of Germany, through funds of the European Recovery Program (ERP) of the Federal Ministry of Economics and Technology, for its generous support of this publication and project. Further, we would like to thank the authors of this report for sharing their insights and Jessica Riester Hart for her work on the publication.

Jackson Janes
President, AICGS

ABOUT THE AUTHORS

Achim Maas is coordinator of the cluster “Sustainable Interactions with the Atmosphere” at the Institute for Advanced Sustainability Studies (IASS) in Potsdam, Germany. His current work focuses on climate engineering, short-lived climate-forcing pollutants, and the governance and risks of anthropogenic environmental change. Previously, he was a senior project manager at adelphi, advising the German government and several international organizations on environmental peace-building and the security implications of climate change in a variety of regions, including multiple Asian and European regions, the Pacific, and Latin America.

Dr. Max Mutschler is a research associate in the Americas division at the German Institute for International and Security Affairs (SWP) in Berlin. He was a lecturer and research associate at the University of Tübingen’s Institute of Political Science from 2007 to 2009. In 2010, Dr. Mutschler was a visiting researcher at the European Space Policy Institute (ESPI) in Vienna, and in 2012 he completed his doctoral research with the Konrad-Adenauer-Stiftung. He received his MA from the University of Tübingen in 2007, and his PhD from the University of Tübingen in 2012 with a focus on arms control in space.

Dr. Paul Sullivan is a Professor of Economics at the National Defense University, where he also leads the Gulf/Turkey Regional Security Study and is on the Energy Industry Study faculty team. He is an Adjunct Professor in the Security Studies Department at Georgetown University where he teaches a very popular class on “Energy and Security.” He is an Adjunct Senior Fellow for Future Global Resource Threat at the Federation of American Scientist, and a columnist for newspapers in Mongolia and Turkey. Dr. Sullivan is often called to advise leadership and others on issues related to energy, the energy-water-food-security nexus, and on various economic, political, and military issues in the MENA region. He also has a focus on energy and environment issues in East Asia and parts of Africa. He obtained his PhD from Yale and graduated Summa Cum Laude from Brandeis University. He is also a graduate of the Seminar XXI Program at the Massachusetts Institute of Technology.

01

FOUR RISKS IN ENERGY SECURITY

FOUR RISKS IN ENERGY SECURITY

PAUL SULLIVAN

This is a fascinating, complex, and exciting time to be studying, writing about, and working on energy security issues. To use a term that is most often associated with military issues energy security involves a lot of VUCA: volatility, uncertainty, complexity, and ambiguity. Looked at separately we can see that each of these can contribute significantly to the problems of energy security. When these four are put together and connected with the many nexus and systems within systems connections related to energy security, it becomes clearer that energy security involves a lot more than one energy source, given that oil is often the focus of discussions on energy security, or many energy systems. It also involves how energy systems and energy security are connected with water, food, land, economic, and other systems. Policies to help alleviate energy security threats need to be considered in the VUCA framework while considering energy as part of a much more complex holistic whole of security issues and options.

Volatility

Volatility in energy supply can come from the prices of oil, gas, electricity, coal, uranium, the raw materials for new energy technologies (such as lithium or rare earths), and so much more. Volatility can also come from technology changes that lead to a drop in the costs of finding, extracting, refining, transporting, and even in the end use of energy sources. Such technology changes can lead to a decrease in the costs per kilowatt hour produced from solar panels, concentrated solar power, wind power, geothermal, and more.

There is also volatility that can come from policymakers. As governments change, energy policy can change along with it. The election of President Barack Obama produced within the United States government a much increased emphasis on “green energy” not only in domestic energy policies, but also in the government’s international energy activities.

Volatility can also be produced out of the “paper markets” associated with the physical markets for energy. The futures, derivatives, and other such markets in energy can help drive volatility in the market as billions of dollars are moved about when, for example, there are significant political or military events in various energy resource-rich areas like the Middle East and North Africa. The volatility of the “Arab Spring,” which I call the “Arab Storm,” also creates a lot of volatility in the “paper markets” for oil. These events can also add volatility to the actual physical markets as recent significant declines in the production and export of oil from Libya have shown.

The global shale gas revolution will likely cause a certain degree of volatility in gas prices as more countries start to exploit their shale gas reserves for domestic use and for global trade via pipelines and LNG (liquefied natural gas) transport by ship.

Climate changes and changes in weather patterns can also cause a great deal of volatility. Given the large amounts of water that are needed in the energy industry, sharp shocks to the water cycle can cause significant effects in energy supply and energy demand. If climate change brings with it increased weather volatility with stronger and more frequent storms, then energy markets will likely also experience increased volatility in both their physical presence and security, and in their paper and physical markets. One need only look at the damage that was caused by Hurricane Katrina on the oil, gas, electricity, and other networks in the United States to see some of the volatility that could come from climate change.

There is also volatility that can be caused by the "Black Swan" events, such as earthquakes, tsunamis, and other major "unexpected" events. Earthquakes can take nuclear power plants and other energy facilities off line. Tsunamis thousands of miles away can affect the price of energy in various parts of the United States via complex chain reactions in both physical and paper markets globally and domestically.

Energy security is not something that lives in a vacuum. It is initially measured by the ability of a country and its people to access reliable, affordable energy sources without much volatility. However, reality often gets in the way. Given that energy systems are connected with water, land, food, economic, diplomatic, political, military, and other systems, and given that each energy system is often connected with other energy systems in nested ways, then a certain degree of volatility is inherent in energy security.

Electricity is needed to run all of the most important linkages in the oil production, refining, transport, and sales chains. When the electricity is out one cannot get gasoline, for example. The reason for that might be that there is a localized blackout due to a localized storm or it could be that the refineries hundreds of miles away were shut down from severe damage to electricity systems there and pipelines bringing the refined products up hundreds of miles are not working because of larger blackouts along the pathways of the pipelines.

If there is ever a massive cyber-attack on the electricity systems of the United States, the volatility in energy markets well beyond electricity could be quite severe. If there are ever attacks on major switching stations in major metropolitan areas, the volatility those events would create would likely cascade into other energy markets in very complex and maybe even some unpredictable manners.

Macroeconomic volatility can also affect energy market volatility. The recent "Great Recession" in the United States and globally brought great shocks to local, country, and international oil markets. Any significant economic volatility in China in the future could bring considerable volatility to certain energy markets. That volatility could have significant effects on U.S. energy markets.

POTENTIAL MASSIVE VOLATILITY

Let us look into the future a bit. Let's say, as a *gendankenexperiment*, that it is now the year 2040. The U.S. has built numerous LNG facilities to export natural gas to China and other parts of East Asia. Now let us say that the political situation in China becomes brittle and significant domestic instability results. This could be due to water shortages, massive income and wealth inequalities, or sharp increases in unemployment due to energy and other resource price shocks. If this instability becomes extreme, the industrial, services, and other markets from East Asia and across the globe will be thrown into turmoil. Energy markets will experience massive volatility.

Now let us look at a possible shorter-term event: an attack on Iran. Under some scenarios an attack on Iran could be the trigger for far wider Sunni-Shia conflict. It could also be a trigger for Iranian attacks on Saudi, Emirati, and other Gulf oil and gas facilities. If that situation gets out of control, it should not be a great surprise that oil and natural gas prices will be extremely volatile, rising as the markets look at one attack and counterattack after another. A price of $250 to $350/barrel of oil would hardly be surprising as a result of some of the worst scenarios, including, for example, an attack on the massive oil processing and sweetening facility of Ab Qaiq in Saudi Arabia. If Ab Qaiq goes offline, then the world is out six to seven million barrels of oil per day for potentially months or longer. Seriously damaging this one facility would send shock waves throughout nearly every energy market. The rise in oil prices would affect the world economy in drastic ways and likely would push many countries into recession or worse. China, Japan, South Korea, Taiwan, and India would be the most strongly affected countries of the worst scenarios that could result from an attack on or by Iran. Given that these countries are a massive part of the overall world economy, the secondary effects of the economic shocks to their economies to the global economy, and to the United States, could be quite significant and negative.

For a country to have energy security, actual price and output volatility and potential volatility have to be kept in check. Efforts have to be put forth domestically and internationally to contain volatility. However, one thing is certain: volatility and changes in volatility in energy markets and related activities and events contain a lot of uncertainty.

Uncertainty

Uncertainty can be found in many aspects of energy security. As the famous American baseball player Yogi Berra once said: "It is tough to make predictions, especially about the future." There is a lot of wisdom that can be applied to energy security from that seemingly syntactically stressed statement. Predicting the price of various types of energy sources involves a lot of uncertainty. Anyone who does not add that sense of uncertainty to their predictions is effectively not telling the truth—or is ignorant of the realities of the energy world.

For example, it is never really known how much oil, gas, coal, uranium, or other energy-related minerals and materials are in the ground and will be technically and economically extractable until they are extracted. In the energy industry, especially in oil and gas, the statement is often "you do not know until you know." There are many examples of conventional oil and gas fields that were expected to be tapped out many years ago, but are still producing. The use of enhanced recovery techniques has aided in the extension of the productive lives of many fields, but also the knowledge of what we know is down in the ground has changed from the times when some of the older fields were first discovered.

The vast improvements toward three-dimensional and even four-dimensional holograms of energy fields have been astonishing in the last few years. The knowledge we can have on what is under the ground is well beyond that which was available to the first oil prospectors in Saudi Arabia or Pennsylvania. However, there are still uncertainties about what the pressures of the fields might be and the exact amount of oil or gas in the ground. That may always be there, but the industry is getting a lot better at understanding what may be there and getting it out. Still a lot of oil is left in oil wells once they are capped. A lot of natural gas is also left in the fields once their economic and technical use is outlived based on the technologies and economics of the times they are capped. However, things can change and these oil and gas wells could be reopened if the economics and technologies change. This has happened many times in the past. There is actually a huge amount of oil and gas in capped wells in the United States.

SHALE GAS UNCERTAINTY

The shale oil, shale gas, and oil sands "revolutions" of the last few years are other examples of uncertainty in play. It is not that these sources were not there, nor that the technologies of fracking and many methods of extracting bitumen did not exist. The size of the proved reserves of many fields in the United States changed drastically as the technologies were improved, as companies learned more about how to use them, and as they followed up their learning curves—driving down their costs. The much higher prices of various oil types also drove greater exploration and production of shale oil and oil sands. Yes, things change. Some of these technologies have been around for decades and are only now being exploited to supply oil and gas because the timing and the economics are right. Global and hence U.S. domestic prices of oil remain relatively quite high for various reasons. These high prices continue to spur greater production in places like the Bakken fields in North Dakota.

MIDDLE EAST UNCERTAINTY

There is continued uncertainty about where the "Arab Storm" may be heading. There is also considerable uncertainty about how Israel, the United States, and the rest of the world may react to a nuclear Iran or an Iran on the edge of having a nuclear weapon. There is increasing uncertainty about where some major European and Asian economies might be going. There is uncertainty about whether Al Qaeda in its various forms or other extremists might decide to attack major energy facilities and systems in the Middle East, North Africa, and elsewhere. The recent attack on the In Amenas natural gas plant in Algeria could be a signal or a warning shot of things to come.

Note that much of this has been about what is happening outside of the United States adding to uncertainty in the energy security of the United States, even in times of increased oil production in the country.

MARKET UNCERTAINTY

Again, energy security is not just a measure of the access to and supply of energy, but also the affordability of it. Even if the United States is someday in the position of producing most of its oil and only needs to import from a stable, democratic Canada, outside events in the Middle East, Russia, China, and beyond can affect the price of oil and its refined and subsidiary products within the United States.

Natural gas is not an integrated global market as oil markets are, but it may be heading in that direction. The price of natural gas in the United States has dropped drastically as shale gas and other tight gas has been extracted in increasing amounts in recent years. The shale gas output from places like the Marcellus fields has been increasing so quickly that Canada is now exporting far less gas to the U.S. and the U.S. is increasing its exports of natural gas to Canada. Some of the most important things that may happen to the U.S. natural gas markets may be the development of further LNG facilities globally and on the shores of the U.S., the delinking of the price of oil with the price of natural gas on long-term natural gas contracts, and further developments of major spot markets for LNG and pipeline natural gas in many parts of the world. All of this could lead to the development of an increasingly integrated global natural gas market, much like what has happened in oil markets.

Depending on the timing of the investment and construction moves by many countries and companies in shale gas exploration and production, LNG export plants, pipelines, and ports, an integrated world natural gas market could increase the energy security of many places in the word, not just the United States. For the U.S. this could lead to some increases in natural gas prices as the country exports more gas, but these increased prices would also lead to greater investment in exploration, extraction, and transport of the natural gas within the country. The development of a global natural gas market could also help global natural gas prices converge. The price of LNG in China and Japan is now about $15 to $16 per MMBTU. In the EU it is about $0 to $10 per MMBTU. The price of natural gas in the U.S. is likely to hover in the $3 to $4 range for some time to come. The natural gas market is globally segmented. Integrating this market could cause an energy and economic revolution much greater than the shale gas revolution now happening in the United States.

The potential for U.S. natural gas companies to make giant profits is great, depending on how this plays out. The U.S. federal budget and many state budgets could benefit greatly from exports of natural gas from the U.S. Jobs have been created by the drop in the price of natural gas and in the expansion of natural gas production in the shale fields. The lowest unemployment rates in the U.S. can be found in areas in North Dakota and Texas where the shale gas boom has taken hold. The drop in natural gas prices has also helped employment in companies that use natural gas as input to their production processes, such as in chemicals, fertilizer, and other important industries. Energy security can also add a great deal to economic and human security.

However, as the U.S. can focus on the upside of the global integration of natural gas markets, it can also look at the downside of this integration. If major consumers and producers experience great economic shocks or domestic turmoil the more integrated the market is, more uncertainty could develop for all involved. An integrated global natural gas market could bring prices down as stranded gas is open to global markets and contracts are brought into more economically rational frameworks. However, it could also act as a transmitter of shocks from suppliers and producers, much like global oil markets of today. On the other hand, if there are a very large number of very large suppliers to the world markets with some excess capacity present via natural gas storage and natural gas strategic stock piles having a truly global gas market might tend to temper some shocks to the markets.

Yet the uncertainty will always be lurking.

Complexity

Complexity is a very big part of energy security in the United States. The U.S.' energy system is actually many energy systems nested within other energy systems, which are also connected with other systems, such as those for water, land, food, other minerals production, the economy, and so much more.

Within the complexity of the energy systems, there is a lot of risk. Complexity can act as an uncertainty multiplier at times. For example, the electricity system gets much of its fuel from the coal and natural gas systems of the country. If there is a problem with the coal and natural gas systems, for example a transport crisis with rail lines down or natural gas pipelines damaged (and especially pumping stations damaged), then the electricity system is at risk because of its connections with the coal and natural gas systems. The networks for these rail lines and pipelines to work also need electricity, which creates what could be deemed recursive complexity.

WATER

The electricity system in the U.S. uses massive amounts of water. The biggest use is for the cooling systems for thermal power plants. Concentrated solar power also uses a lot of water. Hydropower plants rely a lot on water. Massive amounts of water are used in the extraction, processing, and refining of oil. Shale oil uses more water than conventional oil; refining gasoline uses more water than refining diesel. Water can be produced from oil fields, but all along the supply chain for refined products there is a great need for water.

Biofuels from irrigated crops are the transportation fuels that use the most water in their production. These crops also require a lot of land. Increased production of biofuels can also put pressure on food prices and land prices, which can reverberate through an economy. The natural gas industry also needs massive amounts of water. This is more so now than ever before because of the increases in the use of fracking to obtain shale gas.

If for reasons of climate change, droughts, and changes in the water cycle, water is not sufficiently available for energy systems, these systems would either need to be cut back or shut down. A power plant that needs a lot of water for cooling will not be able to keep up with its nameplate capacity if the local rivers and lakes are going dry. A hydropower plant can lose 3 percent of its power output for every 1 percent drop in water flow. A dry reservoir cannot produce water power. Refineries will have to cut back on production, and this has happened in the past, if water levels nearby are low.

Water systems also use a lot of energy for the pumping, treatment, and transport of water to homes, office buildings, and factories. The water-energy nexus is one of the most important and complex interactions that could determine the energy security of the United States. One could say that there is a lot of virtual water in a kilowatt of electricity and in a gallon of gasoline. The lights on in the office or library where this paper is being read likely have a lot of water as part of their production.

VIRTUAL ENERGY

Virtual energy is another part of the complexity of energy security. Everything that is produced in the United States has some energy content, whether it is a good or a service. Energy security is intimately connected with economic security and economic growth. When the U.S. imports a product or service from Germany, China, Japan, or South Korea, for example, it is also virtually importing the energy that went into making those products and services. Another interesting offshoot to this idea involves the sanctions against the importation of Iranian oil into the United States. If the United States imports products from a company that uses Iranian oil or any derivative of Iranian oil in its production methods, then the United States is in many ways still importing Iranian oil. A toy from a Chinese factory or a car from a Japanese plant landing in a port on the West Coast of the U.S. could, with some complex calculations and massive administrative burden, have a stick on it stating how much Iranian oil went into producing and even shipping it. Cargo ships and aircraft use lots of oil-cased fuels. Some of that oil is likely of Iranian origin in some way or another.

FINANCIAL COMPLEXITY

The financial aspects of energy security are quite complex. The prices of oil, gas, and electricity can also be determined by speculation via electronic actions on various markets via futures, hedging, and spot speculation. Some of the major banks in the U.S. have large investments in the physical energy products, not just the financial energy products. Some of these banks have been accused and fined for manipulating prices of electricity, for just one example. Some of these banks own large warehouses and other storage sites for energy products. Recently articles have brought to light how important some of these actions could be for the pricing and even availability of energy in the United States.

The engineering, economics, finance, and administration that go into the production of oil, gas, coal, electricity, and other energy sources, either primary or not, are complex enough. When the complexity of the energy-water-food-land-economy-national security and other nexus connections within and across energy systems are added in, we see massive interconnected complexity.

Ambiguity

Ambiguity is an inherent part of energy security. Ambiguous is from the Latin *ambigere*, to be undecided. If ambiguous is used as an adjective it can mean “unclear or inexact because a choice between alternatives has not been made.” Ambiguity can lead to bad decisions and the misreading of what is happening and what might be happening. Ambiguity in energy security can sometimes be like a thick fog getting in the way of good decisions.

The history of energy in the United States has been one full of decisions and tradeoffs. The country is facing some very significant tradeoffs for the future of its energy sources and systems. One of the most notable is the “green energy” versus “hydrocarbons” debate. What energy systems will win out in the future will likely be determined by how the economics of each energy system and source will work out in comparison to the others. Subsidies of energy systems can help their development as well. There is now a debate raging comparing the subsidies to alternative energy systems to hydrocarbon based systems. In the U.S., many states have subsidies, mandates, and standards for the use of energy, their environmental impacts, and other aspects of energy and energy’s connections with other nexus systems.

The federal government has numerous agencies and departments involved in the distortion of what otherwise might have been free market choices on energy. Some of these distortions are to internalize the externalities of pollution from certain energy sources. Others seem more like ideologically imposed regulations with little solid scientific support. There are many national security institutions involved in energy security. This may distort the choices the U.S. may face and make in the future.

There is nothing ambiguous in the energy security decisions of the country at any given moment in the past. Those decisions have been made. The ambiguity comes in when the volatility, uncertainty, and complexity are added in when companies, states, households, the federal government, and others have to make choices for the future—even if that future is in the short run of just a few days.

The United States finds itself in the difficult situation of increasing plenty mixed in with risk. The increasing plenty is represented by the vast and increasing proved reserves of tight oil and tight gas. Coal is immensely plentiful in the United States. Potential wind, solar, geothermal, and other alternative sources are also plentiful and the country’s capability to tap these resources at lower prices is also increasing.

There really is no energy crisis or energy shortage in potential terms in the United States. The energy crisis, if there is one, is found in the inability and seeming unwillingness of federal leadership and some state and private sector leaders to make the tough decisions that need to be made. Part of this is understandable. The science of climate change has uncertainty attached to it. Many people have a hard time making decisions based on uncertainty. It is even more difficult when that uncertainty is related to some things that may or may not happen for a long time. People in general have a difficult time making intergenerational decisions that go into the future in general. It is even more difficult for leaders to make these decisions given that they need to respond to their constituencies of today during their six, four, or two year terms. Future generations cannot vote for them today.

Conclusions and Policy Recommendations

The dysfunctional nature of certain decision-making among some in political leadership in the U.S. does not help the country deal with the volatility, uncertainty, complexity, and ambiguity of energy security. Many states within the United States have energy security and overall energy policies that are far more progressive and effective than those found at the federal level. Some of the most important agencies and departments in the federal government are taking on the problem of energy security independently of congressional actions. The Department of Defense has been most particularly focused on energy security and energy creativity as a whole department, and even more so within the respective services, such as the energy efficiency and energy change programs in the Navy, the Marines, the Air Force, and the Army. That makes sense given that the largest single consumer in the U.S. is the Department of Defense. The single largest user of energy within the Department of Defense is the Air Force. The services and DOD see that it is very important to have more diversified and secure energy sources for the future. They also want to see how they can reduce the gigantically expensive and miles-long logistics trails for energy in operations and in normal fleet and force activities. The new budgetary situation for DOD could be a forcing function for them to look further into how to provide a more energy-secure future for its people and operations.

The private sector has a major part in providing energy security to the United States. Whether that energy is from regulated or partially regulated utilities, integrated massive energy companies, small oil and gas wildcatters, or giant companies that run nuclear power plants, the private sector needs to look more at the VUCA aspects of energy security.

However, the best way of dealing with the VUCA aspects of energy security in the future may be to develop more public-private partnerships and teaming arrangements so that the many important sectors and levels of the U.S. economy and government can work together more smoothly when the troubles come. This is not an “if” comment. It is a “when” comment. Universities and think tanks that look into energy issues and how to deal with VUCA and risks in general should also be brought in. Sometimes the best ideas develop when many people from many different backgrounds are put on the VUCA issues and they work out the solutions both as teams, separately and in integrated, creative groups that may change over time.

If there are going to be any collaborative, private-public-university-think tank efforts on energy security, these should also bring in the VUCA of the many systems within systems that are connected within energy and between energy and other systems. Policies on energy security will need to incorporate an understanding of the VUCA of the nexus among water, land, food, and other resources (for example with lithium for batteries or silicon and rare earths for some possible new energy technologies). These many stakeholders also will need to incorporate and think about the VUCA of energy efficiency, which is a big part of the energy security systems within systems. The energy-water nexus is rife with massive inefficiencies. Consider how much water and energy are wasted when about 60 percent of the BTU content of the fuel that went into an electricity generation plant goes into the air as steam, when there are many ways of capturing this heat for other uses. Consider how much water is used in the production of gasoline. The typical car in the U.S. uses about 3 to 5 percent of its gasoline to move the driver, passengers, and cargo of the typical car. The rest of that energy and water goes into pushing the metal, plastics, and other overly heavy aspects of the typical car. Now think about what the alternative uses might be for that water, especially in times of drought and possible warming that may be on our way.

The meta-conclusion for policy options is quite clear: policymakers, business leaders, academics, and others involved in helping to understand and improve energy security need to more fully incorporate VUCA in all of its nexus and systems within systems realities. If they do not incorporate these systematic aspects, it will be at their and our peril.

All opinions expressed are those of the author alone.

Bibliography and Recommended Readings

Andrews-Speed, et al., “The Global Resource Nexus,” The TransAtlantic Academy, March 2012, <http://www.transatlanticacademy.org/publications/global-resource-nexus-%E2%80%93-struggles-land-energy-food-water-and-minerals>.

Bareisaite, Asta, et al., “The Business Landscape for Unconventional Natural Gas: Report to Credit Agricole,” 9 May 2013, <http://new.sipa.columbia.edu/sites/default/files/AY13_CreditAgricole_FinalReport.pdf>.

Carter, Nicole, “Energy’s Water Demand: Trends, Vulnerabilities and Management,” <http://www.fas.org/sgp/crs/misc/R41507.pdf>.

Consumer Energy Alliance, “North America’s New Energy Future,” <http://consumerenergyalliance.org/wp/wp-content/uploads/2012/09/ExecSum-North-Americas-New-Energy-Future-F-9-17-12.pdf>.

Hebling, Thomas, “On the Rise,” *Finance and Development*, March 2013, <http://www.imf.org/external/pubs/ft/fandd/2013/03/helbling.htm>.

Humphries, Marc, “U.S. Crude Oil and Natural Gas Production in Federal and Non-Federal Areas,” Congressional Research Service, March 2013, <http://energycommerce.house.gov/sites/republicans.energycommerce.house.gov/files/20130228CRSreport.pdf>.

IHS, “Energy and the New Global Landscape: Tectonic Shifts?” <http://www.ihs.com/info/all/wef/download-executive-summary.aspx>.

Institute for Energy Research, “Hard Facts: An Energy Primer,” 2012, <http://www.instituteforenergyresearch.org/hardfacts/>.

International Energy Agency, “Golden Rules fo a Golden Age of Gas,” 12 November 2012, <http://www.worldenergyoutlook.org/goldenrules/>.

International Energy Agency, “Measuring Short-Term Energy Security,” 2011, <http://www.iea.org/publications/freepublications/publication/Moses.pdf>.

KPMG and Oxford Economics, “U.S. Oil and Gas Outlook,” 2012, <http://www.kpmginstitutes.com/global-energy-institute/insights/2012/pdf/us-oil-and-gas-outlook.pdf>.

Lavell, Marianne, et al., “Water Deamdn for Energy to Double by 2035,” National Geographic, <http://news.nationalgeographic.com/news/energy/2013/01/130130-water-demand-for-energy-to-double-by-2035/>.

Lawson, Richard, et al., “Fueling America and the Energy Water Nexus,” <http://www.acus.org/publication/fueling-america-and-energy-water-nexus>.

Maugeri, Leonardo, “Oil: The Next Revolution,” Belfer Center, Harvard University, <http://belfercenter.ksg.harvard.edu/files/Oil-%20The%20Next%20Revolution.pdf>.

Mielke, Erik, et al., “Water Consumption of Energy Resource Extraction, Processing and Conversion,” Belfer Center, Harvard University, 2010.

Mitchell, John, “US Energy: The New Reality,” Chatham House, May 2013, <http://www.chathamhouse.org/publications/papers/view/191405>.

Omaeova, Sale T., “Large U.S. Banking Organizations’ Activities in Physical Commodity and Energy Markets: Legal and Policy Considerations,” <http://www.banking.senate.gov/public/index.cfm?FuseAction=Files.View&FileStore_id=6d49a599-f7dc-4c1f-9455-fa8d891f04c6>.

Ratner, Michael, et al., “An Overview of Unconventional Oil and Natural Gas: Resources and Federal Actions,” Congressional Research Service, 15 July 2013, <http://www.fas.org/sgp/crs/misc/R43148.pdf>.

Ratner, Michael, et al., “U.S. Natural Gas Exports: New Opportunities, Uncertain Outcomes,” Congressional Research Service, 8 April 2013, <http://www.fas.org/sgp/crs/misc/R42074.pdf>.

REN21, “Renewables Global Status Report 2013,” <http://www.ren21.net/REN21Activities/GlobalStatusReport.aspx>.

Saxum.Com, “The United States of Energy,” <http://www.saxum.com/united-states-of-energy/>.

Shell, “The Future of Energy,” <http://www.shell.com/global/future-energy.html?gclid=CLnwsPzS_7gCFU7NOgodr3gAhQ>.

Terzic, Brnako, “Energy Independence and Security: A Reality Check,” Deloitte University, <http://www.deloitte.com/assets/Dcom-UnitedStates/Local%20Assets/Documents/Federal/us_fed_Election_Series_101012.pdf>.

U.S. Bureau of Labor Statistics, “The effects of shale gas production on natural gas prices,” <http://www.bls.gov/opub/btn/volume-2/the-effects-of-shale-gas-production-on-natural-gas-prices.htm>.

U.S. Congressional Budget Office, “Energy Security in the United States,” March 2012, <http://www.cbo.gov/sites/default/files/cbofiles/attachments/05-09-EnergySecurity.pdf>.

U.S. Congressional Budget Office, “Federal Financial Support for the Development and Production of Fuels and Energy Technologies,” March 2012, <http://www.cbo.gov/publication/43032>.

U.S. Department of Energy, “Quadrennial Technology Review,” 2012, <http://energy.gov/quadrennial-technology-review>.

U.S. Department of Energy, “U.S. Energy Sector Vulnerabilities to Climate Change and Extreme Weather,” July 2013, <http://energy.gov/sites/prod/files/2013/07/f2/20130716-Energy%20Sector%20Vulnerabilities%20Report.pdf>.

U.S. Department of Energy, National Renewable Energy Laboratory, “United States of America Country Update, March 24, 2013,” <http://task39.org/files/2013/05/USA-Country-Report-March-2013.pdf>.

U.S. Energy Information Administration, “Annual Energy Outlook, 2013,” <http://www.eia.gov/forecasts/aeo/>.

U.S. Energy Information Administration, “International Energy Outlook 2013,” <http://www.eia.gov/forecasts/ieo/>.

U.S. Energy Information Administration, “Short Term Energy Outlook,” <http://www.eia.gov/forecasts/steo/>.

U.S. Energy Information Administration, “U.S. States,” <http://www.eia.gov/state/seds/?src=email&src=Total-f3>.

U.S. Energy Information Administration, “2012 Uranium Marketing Report,” May 2013, <http://www.eia.gov/uranium/marketing/>.

Wang, Zhongmin, et al., “U.S. Shale Gas Development: What Led to the Boom?” May 2013, <http://www.rff.org/RFF/Documents/RFF-IB-13-04.pdf>.

WaterFootPrint.Org, <http://www.waterfootprint.org/?page=files/home>.

World Economic Forum, “Energy Vision 2013: Energy Transitions: Past and Future,” <http://www.weforum.org/reports/energy-vision-2013-energy-transitions-past-and-future>.

World Economic Forum, “The Water-Food-Energy-Climate Nexus,” <http://www.weforum.org/reports/water-security-water-energy-food-climate-nexus>.

02

RISKS IN SPACE

RISKS IN SPACE: A EUROPEAN PERSPECTIVE

MAX M. MUTSCHLER

Today, outer space is used for many applications that have become very important to modern societies. Most space technologies are inherently dual-use, i.e., they can be used for a civilian as well as a military purpose. Space has become part of the critical infrastructure of modern societies. The United States and Europe, in particular, have a stake in ensuring the use of space for these applications. This makes it advisable to consider the risks that exist for the sustainable use of space such as the increasing amount of orbital debris and the prospect of an arms race in space. These risks can only be tackled in a meaningful way through international cooperation. Increased transatlantic cooperation matters particularly because the United States and Europe are significant actors in space, with the United States being the primary space power. While there are certain differences in preferences of how to tackle those risks, there are important similarities that create opportunities for stronger transatlantic cooperation in risk governance in outer space.

Risks for the Sustainable Use of Space

There are roughly 1,000 active satellites in orbit, but they are not the only objects in space. There is a growing amount of space debris consisting of, among other things, upper stages of rockets and pieces of satellites that have broken apart. Currently, there are more than 17,000 pieces of debris in orbit each with a diameter of at least ten centimeters and more than 300,000 objects with a diameter of at least one centimeter.[1] These objects can stay in orbit for many years before they reach a point where they burn up in the atmosphere and because of their tremendous speed—7 km/second and more—they pose a risk to active satellites. A collision with a small object of only one centimeter in diameter produces the energy of an exploding hand grenade. The International Space Station (ISS) had to conduct several maneuvers in order to avoid significant risks of collisions with larger pieces of debris.

In addition, there is a security dimension. The use of space for military purposes that started with the launching of reconnaissance satellites in the 1960s created the incentive to develop technologies to attack satellites in order to deny their military benefits to an opponent. During the Cold War, both the United States and the Soviet Union began work on such anti-satellite (ASAT) weapons. However, despite testing some ASAT technologies, both superpowers refrained from full scale development and deployment of such space weapons. The reason for this restraint was likely the strategic value of early warning satellites that the United States and the Soviet Union did not want to put at risk because attacks on those satellites could have triggered a dangerous escalation dynamic.

The issue of an arms race in space received a new wave of attention after 2001 when the Bush administration proclaimed a need for the United States to be able to exercise “space control.” This was expressed in the official U.S. Space Policy of 2006: “[…] the United States will […] deny, if necessary, adversaries the use of space capabilities hostile to U.S. national interests.”[2] In parallel, funds for research and development of respective technologies such as lasers or microsatellites increased. It is important to note that several technologies that are developed under the heading of missile defense can be modified so as to have a certain ASAT capability as well. Other space-faring countries, in particular Russia and China, worry about the United States having advanced space weapon capabilities and have threatened to develop space weapons. Such threats should not be neglected. From the Soviet era, Russia is still in possession of considerable know-how of ASAT technology. China demonstrated in 2007 its capability of developing ASATs when it destroyed its own weather satellite with a modified ballistic missile.

An arms race in space would add another risk to space systems. Satellites would not only be in danger of colliding with orbital debris but could become targets of purposeful attacks. Particularly for those states that are less dependent upon space, satellites could become attractive targets in times of crisis. In addition, there is a direct link between an arms race in space and the proliferation of orbital debris. If the ASAT technology used is based on the principle of destroying the satellite, for example, in the case of the so-called "hit-to-kill" technology or by using explosions, testing such technologies can increase the amount of debris significantly. The Chinese ASAT test of 2007, for example, produced roughly 2,000 new pieces of debris each larger than five centimeters, which meant an increase of 8 percent in the overall debris population.

Space Debris

Both the United States and EU member states recognize orbital debris as a growing risk to their space systems. In the 1970s, the first technical studies on orbital debris were conducted by the National Aeronautic and Space Administration (NASA) of the United States. In 1987 NASA and the European Space Agency (ESA) began to hold bilateral meetings to discuss the issue. On the basis of those meetings, which were soon thereafter conducted together with the space agencies of additional states, the Inter-Agency Space Debris Coordination Committee (IADC) was established in 1993.

The main approach in Europe and in the United States to the management of the risk of orbital debris is the establishment of preventive measures that aim at the mitigation of newly created debris. In the 1990s, NASA developed its "Orbital Debris Mitigation Standard Practices," which established four central goals and measures for debris mitigation. Examples of such measures are improved designs of upper stages that create less debris when releasing a satellite into orbit or the avoidance of explosions in orbit by releasing the remaining fuel. Another example is the disposal of satellites after the end of their active use by letting them burn up in the atmosphere or by placing them in less crowded orbits. Of course, all these measures increase the costs of launching and operating a satellite. Nevertheless, Europe's space agencies followed the U.S. example and developed similar guidelines that were formalized in the "European Code of Conduct for Space Debris Mitigation," which was signed in 2006 by the space agencies of Germany, France, Great Britain, and Italy, as well as by ESA.[3]

Such technical guidelines were promoted at the international level as well. On the basis of the work done by the national space agencies and in particular the IADC, a set of preventive measures similar to the ones mentioned above was adopted by the United Nations Committee on the Peaceful Use of Outer Space (UNCOPUOS) in its Debris Mitigation Guidelines in 2007.[4] However, compliance with the Debris Mitigation Guidelines of UNCOPUOS is voluntary and there is no international agreement on rules that go beyond these technical standards. It can be expected that a growing number of actors in space will put the existing rules under stress. Such growth should be expected as a result of both the emergence of new space-faring countries and the increasing privatization of space flight.

Space Security

The transatlantic partners have not yet managed to come to an agreement on a common approach to space security. One major reason for this is the different preferences and perceptions that exist with regard to the assessment and management of the risk of an arms race in space. On the European side of the Atlantic, an arms race in space is perceived as a risk for the peaceful use of outer space in the future. Already in the early 1980s, even before the establishment of PAROS, western European states were concerned about the threat of an arms race in space. In contrast, the official position of the United States has been that there is no risk of an arms race in space.

Risk preferences of Americans and Europeans differ with regard to risk management as well. Several European states were quite active in the Conference on Disarmament (CD) and made various proposals to establish arms control in and for space. France, for example, with the support of other western European states, proposed an ASAT ban in 1983 and 1984. Like several similar proposals for treaty-based arms control, they were rejected by the United States, a position that has since not changed much. Instead of arms control, the United States pursues a strategy of deterring attacks on its space systems. Reference to such a strategy of deterrence can be found in the space policy of the Bush administration as well as the Obama administration. However, deterring attacks on one's satellites is more difficult the more you depend on them—in relation to the potential attacker. As a consequence, the United States seeks to increase the resilience of its space infrastructure. In sum, Europeans and Americans favor different strategies to manage the risk that space weapons could entail. While the Europeans prefer to prevent an arms race in space by means of arms control, the United States has focused on a combination of deterrence and the reduction of its vulnerability.

In recent years, however, there has been an approximation of positions toward the establishment of rules for responsible behavior in space. In December 2008, the EU issued a draft of a Code of Conduct for outer space activities. This can be seen as a reaction to the U.S. refusal to seriously consider treaty-based arms control. As the name already indicates, this recent EU proposal does not come in the form of a legally binding international treaty, but rather as a non-binding set of norms. Furthermore, instead of banning certain technologies, such as ASATs, the Code of Conduct would establish rules for behavior in space. One of the central provisions of the draft Code of Conduct commits states to "refrain from any intentional action which will or might bring about, directly or indirectly, the damage or destruction of outer space objects […]."[5] The EU draft was discussed with other space-faring nations and revised at certain points in the process. The EU plans to negotiate a Code of Conduct in 2013. The United States under the Obama administration also shifted positions on space security policy. While it's National Space Policy of June 2010 and the National Security Space Strategy of January 2011 point out that deterrence and the improvement of resilience of U.S. space systems play important roles in U.S. space policy, both documents refer at several points to the establishment of norms of responsible behavior in space.

Conclusions

On the basis of the preferences identified above, what can be said about the chances for transatlantic cooperation with regard to the risks for the sustainable use of space? First and foremost, the common interest in the mitigation of orbital debris and the recent approximation of positions toward the establishment of rules for responsible behavior in space create room for more transatlantic cooperation. It is in the interest of both the United States and Europe to make use of this leeway. As a first step they should consider the start of negotiations on a code of conduct for outer space in 2013 as a priority of international space policy.

While a code of conduct, as proposed by the EU, would establish the rule that states should refrain from the intentional destruction of any object in orbit, such a rule would not hinder states to further develop technologies that can be used as space weapons. It is doubtful whether a voluntary code of conduct will be enough to keep states from using these technologies in a time of intense crisis. Thus, it is important to take action in order to contain the arms dynamic in space and build trust among states. In this regard, Canada made an interesting proposal in 2009. According to the working paper Canada issued in the CD, states could pledge not to test or use a weapon against any satellite, not to place weapons in outer space, and not to test or use any satellite as a weapon against any other object.[6] Specifically, a moratorium on the further testing of space weapons could help to curb the arms race in space. The United States has the national technical means to monitor compliance of such a moratorium and would be free to revoke its pledge and react with appropriate measures in case it considers other states to be in violation of their pledges.

In regard to the mitigation of orbital debris, there is room for increased international and transatlantic cooperation as well. Setting up the IADC and UNCOPUOS debris mitigation guidelines was an important step and surely helped to slow down the growth of debris up until the Chinese ASAT test in

2007. However, these measures will likely be insufficient to keep the risk for satellites at a tolerable level in the long term—particularly if the trend toward the privatization of space continues. Consequently, the EU and the United States together could take the initiative in UNCOPUOS to make the voluntary space debris mitigations obligatory for all space-faring states. An alternative to such a strict, top-down licensing process would be to consider economic measures to offer incentives for all space actors, state and non-state, to prevent the creation of debris. An interesting proposal is the collection of fees for space launches. The fees would vary with the degree to which the operator applies measures that mitigate the creation of debris. Low fees would be the reward for those actors who apply debris mitigation standards and invest in respective technologies. In addition, the fees could be collected in a fund and be used to finance research and development of new technologies that can actively remove larger pieces of debris from orbit.

There is another field that offers opportunities for increased transatlantic cooperation that would help to cope with the risks in space: Space Situational Awareness (SSA). In short, SSA means knowing what is going on in space; it means observing space with the help of radars and high-performance telescopes. The data on the objects in space and their orbits gathered by these techniques is essential to assess the probabilities of potential collisions with other space objects. On the basis of the results, maneuvers can be planned in order to avoid collisions and the creation of debris that would result from the collision. In addition, if states managed to agree on rules of responsible behavior in space, SSA capabilities could be used to monitor whether states stick to the agreed rules or not. The United States is clearly the leading power with regard to SSA capabilities. The Space Surveillance Network (SSN), a global network of optical and radar sensors run by the U.S. military, provides the data for a catalogue of space objects. With the exception of classified data on military satellites, the United States shares this data with state and non-state partners in cooperation. ESA and other European satellite operators use this data for collision warnings as well. In 2008, the ESA started a SSA Preparatory Program in order to improve its own SSA capabilities and to reduce its dependence on the U.S. data. If this program succeeds and European SSA capabilities significantly improve in the future, it could pave the way for increased transatlantic cooperation in the form of a more intensive and less one-way data exchange.

Notes

1 Cesar Jaramillo, ed., “Space Security Index 2012,” September 2012, <http://www.spacesecurity.org/SpaceSecurityReport2012.pdf> (16 November 2012): 28f.

2 U.S. National Space Policy, 31 August 2006, <www.fas.org/irp/offdocs/nspd/space.pdf> (16 July 2012).

3 European Code of Conduct for Space Debris Mitigation, 28 June 2004, <http://www.cnsa.gov.cn/n615708/n676979/n676983/n893604/appendix/2008529151013.pdf> (17 September 2012).

4 United Nations, “Report of the Committee on the Peaceful Uses of Outer Space” (A/62/20), United Nations, 2007, <http://www.oosa.unvienna.org/pdf/gadocs/A_62_20E.pdf> (27 November 2012), Annex.

5 Council of the European Union, “Draft Code of Conduct for Outer Space Activities,” 3 December 2008, <http://www.eu2008.fr/webdav/site/PFUE/shared/import/1209_CAGRE_resultats/Code%20of%20Conduct%20for%20outer%20space%20activities_EN.pdf> (27 November 2012), 8.

6 Conference on Disarmament, “On the Merits of Certain Draft Transparency and Confidence-Building Measures and Treaty Proposals for Space Security” (CD/1865), 5 June 2009, <http://www.unog.ch/80256EDD006B8954/%28httpAssets%29/C40D0B92E5F37A9CC12575FC003BCE37/$file/CD_1865_E.pdf> (27 November 2012).

03

CLIMATE ENGINEERING

CLIMATE ENGINEERING: RESEARCH NEEDED – BUT FOR ASSESSMENT, NOT DEPLOYMENT

ACHIM MAAS[1]

Introduction

A fringe topic a mere ten years ago, intentional interventions in the climate system—colloquially called geo- or climate engineering—have moved up the research and policy agenda. The equivalent of millions of U.S. dollars has been allocated for research over the past few years, particularly in Europe, while several senior researchers have directly and indirectly called for field experiments in the recent months.

The recent upsurge of interest follows dissatisfaction with the slow progress of international climate negotiations. Indeed, some already call for a "Plan B" to tackle so-called climate emergencies. Current research is most advanced in North America and Europe. Political establishments and international regimes are increasingly aware of the topic. As climate change is a global issue affecting humanity as a whole, so is climate engineering. Accordingly, research, development, and possible deployment must be internationally coordinated.

For a number of reasons, however, climate engineering cannot be seen as the only response, but rather as part of a response portfolio, to climate change. However, fears have been voiced that it may also jeopardize climate negotiations by providing the mere possibility of a technical "quick fix." Given this background, I will first outline the current challenges of climate change, followed by an overview of climate engineering in general and selected risks and uncertainties in particular. I will then review the status quo on international governance as well as the state of research and politics in North America and Europe. Drawing from these insights, a set of key recommendations emerge:

- Research on climate engineering should continue; but
- research should focus on risks and uncertainties, not deployment;
- research should cover thereby the full spectrum of implications from the natural sciences on the one hand to the political, social, economic, and legal implications on the other;
- research should be structured by an internationally agreed code of conduct; which
- should be discussed, adopted, and implemented by the Belmont Forum, the coalition of the largest research funding agencies in the world; and
- an open-access international knowledge repository should be established where projects and results should be made publicly available.

The Climate Change Challenge

Current responses to climate change can be divided into two main categories. The first, referred to as mitigation, minimizes human interference in the climate system using measures that range from increasing fuel efficiency (versus switching to renewable energies) to capturing and sequestering greenhouse gases at power plants. The second strategy emphasizes adapting to changes of the climate system, the classic example being improving coastal defenses as response to sea-level rise.

Limiting global warming to 2°C compared to preindustrial levels has been internationally agreed as an appropriate aim that will hopefully keep climate impacts manageable and avoid excessive adaptation costs. However, if current pledges for emission reductions are kept, global warming could reach 2°C by mid-century and reach 3.3°C and more by the end of the century.[2] If, on the other hand, emissions continue to soar without much restriction, then a warming of 4 to 6°C by the end of the century, with global sea-level rise in excess of one meter, becomes more likely. Indeed, completely burning the current combined fossil fuel reserves of the largest energy companies would be sufficient to warm the Earth by 6°C.[3]

Global warming of that scale will not only be difficult to adapt to, but may actually destabilize the international order and has been identified as potentially causing major risks for national and international security.[4] Thus, climate engineering has been framed to offer a "Plan B" to address dangerous levels of climate change. It essentially constitutes a third strategy besides mitigation and adaptation by inverting the concept of mitigation: Instead of minimizing interference into the climate system, climate engineering aims at deliberate interference to achieve a certain predefined goal—such as limiting global warming to 2°C compared to pre-industrial levels.[5]

However, besides serving as "Plan B" for emergency response, climate engineering has also been proposed as a possible cost-effective alternative to mitigation.[6] Indeed, the estimated value of the largest energy companies at the end of 2012 is $4 trillion. This value includes all reserves and keeping the 2°C aim would mean leaving most fossil fuels unburned, thus resulting in a substantial devaluation of that industry.[7] Costs do not stop there: Additional investments would be necessary to switch from a fossil-based energy system to a low-carbon energy system. Furthermore, the World Bank estimated that adapting to 2°C warming by 2050 would imply costs of $70 to 100 billion per year.[8]

Climate Engineering: A Primer

Climate engineering is usually divided in two categories, each with multiple possible technologies and approaches. The first category focuses on removing greenhouse gases such as CO_2 from the atmosphere. This could be done by technical means such as scrubbing it from ambient air, but also biological approaches such as large-scale afforestation or fertilizing oceans with nutrients to spur algae growth. Often called "carbon dioxide removal" (CDR), these approaches generally require a large infrastructure and are at the expensive end of the cost spectrum. They work only in longer time frames, i.e., effects on climate parameters like temperature would take many decades to materialize. Furthermore, no single CDR method can compensate for all current annual global emissions—except perhaps when used on a tremendously large scale. A mix of methods, at the least, would be needed to compensate for a substantial part of current annual emissions. However, this would require an infrastructure on a scale similar to the current global energy system.[9]

The second category, often called solar radiation management (SRM), aims at reflecting more sunlight back into space, thus cooling the Earth. Again, the methods are varied, ranging from putting mirrors in space to injecting aerosols into the stratosphere, and from brightening clouds to increasing surface reflectivity. Stratospheric injections of aerosols and cloud brightening in particular have been identified as likely to exert a quick effect on global temperatures. They have also been considered as "cheap," i.e., operational costs may be approximately $10-20 billion per year.[10] However, if deactivated and atmospheric greenhouse gas concentrations have not been reduced in the meantime, temperatures would rapidly rise back to normal. Thus, it would be necessary for SRM to be continued indefinitely unless concentrations of greenhouse gases in the atmosphere are substantially reduced—and thus also creates a new critical infrastructure in need of protection. Furthermore, ocean acidification affecting ocean food chains, and thus millions of people depending on fisheries for income and food security, would remain unaddressed by SRM.

No proposed climate engineering technique is a silver bullet; each can only address parts of climate change. When aiming for a comprehensive response to climate change, climate engineering could thus only be seen as part of a portfolio of approaches.

Risk and Uncertainties

Though many climate engineering approaches are quite complex in their actual implementation, they are conceptually relatively simple. Few truly new technologies would need to be developed. What is new is the global scale application, for which there is no precedent, only imperfect natural analogues such as volcanic eruptions. This is particularly the case for SRM. True field tests of global-scale climate engineering would necessarily be a on a global scale, too, turning the planet into a laboratory. Research has thus far concentrated on computer simulations in many cases, plus isolated, comparatively limited field experiments.

Initial research shows that SRM would have a number of side effects.[11] While warming could be limited to a certain amount, the overall global average precipitation would decrease and precipitation patterns change. Also, the polar regions would be warmer than the global average, while the tropical regions would be cooler. This would have impacts on various sectors, such as agriculture. SRM would thus entail adaptation costs to essentially new climate patterns. While they may be lower than adapting to a 6°C world, making a cost calculation based simply on operating costs is misleading.

Some have suggested altering regional climates, rather than the global climate, in order to prevent thawing of the Arctic or assert regional geopolitical influence.[12] Yet, regions are not isolated units: for example, simulations show that cooling North Africa and the Sahara region would have a significant effect on the Indian monsoon and thus agriculture there.[13] Though such impacts may be manageable, few countries are likely to simply accept this. Indeed, similar to the Cold War, countries may engage in an “arms race” to control the weather, or at least be prepared should any other country engage in such activities.[14] Uncoordinated regional-scale climate engineering schemes would thus have international conflict potential.[15]

Climate engineering has large associated political, social, and economic costs, which are not yet fully understood. Framing climate engineering as a cheap alternative to climate mitigation and adaptation is therefore misleading, as it ignores the large ancillary costs. Furthermore, an important aspect is that climate engineering is a technological solution to an issue that is essentially not a technological problem: A fossil-fuel based economy is, after all, the result of certain political, economic, and social choices. Without reconsidering the underlying implications of these choices, purely technological solutions to non-technological problems may prove inadequate.[16]

International Governance of Climate Engineering

The comparatively low operating costs put particular solar radiation management options within reach of many countries. Internationally, however, few agreements or institutions exist to guide climate engineering research, not to mention deployment. The most advanced regime is the London Convention and London Protocol, which had been addressing ocean iron fertilization in the past; Member states are currently negotiating to address more marine-based climate engineering in general. However, there is no comparable regime for SRM and, in contrast to the larger legal framework of the UN Convention on the Law of the Sea, there is no comparable “Law of the Atmosphere.”

Furthermore, within the Convention on Biological Diversity (CBD), climate engineering has been discussed in 2008, 2010, and 2012, but its decisions are non-binding.[17] Beyond the CBD and the London Convention and Protocol, the Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques (ENMOD) from the 1970s outlaws the hostile use of environmental modification for military purposes, but does not restrict the peaceful use. However, ENMOD is generally considered a dormant treaty with its last review conference taking place in 1991. As current climate engineering research is essentially civilian in nature, ENMOD is also only of limited applicability.

The treaty that may most comprehensively address climate engineering is the United Nations Framework Convention on Climate Change (UNFCCC). Indeed, the Intergovernmental Panel on Climate Change (IPCC), as the scientific advisory body to the UNFCCC, is reviewing the literature on climate engineering within its next assessment report due in late 2013 and 2014. Given the current focus of the UNFCCC on a strong post-Kyoto agreement as well as the continued lack of knowledge on climate engineering or its risks and uncertainties, it is unlikely that the UNFCCC will take up the issue anytime soon—particularly as all approaches are currently just hypothetical and no technology even close to be deployable within the next decade or two. For these reasons, any move to include climate engineering into the negotiations would be distracting at this stage and should be avoided. Furthermore, given the limited knowledge on the full spectrum of issues climate engineering will affect, engaging now in negotiations within the treaty would be premature; more knowledge on risks and uncertainties is necessary to allow for purposeful negotiations and debate. The risks exist that regulation will be inappropriate and loopholes created.

Yet, such research should be coordinated given the focus of climate engineering and the issues it entails. Transparency and confidence-building will be of key importance to gain public trust in research results, but also prevent "arms races" as outlined above. Outside of treaties, norms are already emerging within the research community, but would benefit from codification on an international level. Furthermore, as several methods have international implications, knowledge on planned and active projects should be openly accessible for transparency reasons and advanced notice should be sent to possibly affected countries.

Perspectives Across the Atlantic

So far, research on climate engineering has been concentrated in North America and Europe. Though the history of climate engineering research actually spans several decades in the United States,[18] there is currently no coordinated or larger research program in North America. Politically, the U.S. House of Representatives discussed the matter in 2009,[19] the Government Accountability Office issued a report,[20] and a number of think tanks have reviewed the issue. A political position by the U.S. government or major funding agencies, such as the National Science Foundation (NSF), is missing, while several private companies and investors have been funding various research activities, some of high and some of more dubious quality.[21]

In Europe, Germany and the UK are most strongly investing in climate engineering research. Both countries funded field experiments on different climate engineering approaches. In the case of Germany, researchers focused on the ocean iron fertilization experiments such as LOHAFEX, while in the UK the National Environmental Research Council funded the experiment "Stratospheric Particle Injection for Climate Engineering" (SPICE). Both experiments encountered strong opposition by the public, and the SPICE field test was ultimately cancelled, though not solely due to public reaction.

Despite this, research on climate engineering is flourishing in Europe: In summer 2013, the German National Science Foundation (DFG) will launch a research program running until 2016 with an equivalent value of $6.5 million. In the UK, multiple projects are currently funded. In addition, research projects, often in the area of approximately $1 million and up, are currently funded or prepared in Finland, France, Norway, and Sweden, as well as by the European Commission. Though these sums are marginal compared to the national research budgets of these countries, it is a substantial development given that just five years ago hardly any projects existed in Europe.

While research in Europe may be more substantially funded by governmental agencies than in the United States, there are few political debates on the topic in Europe. Only the British and German parliaments and ministries have taken up the issue more substantially, though others like the Dutch are beginning to do so as well. The UK House of Commons issued a report in 2010[22] and the UK's Department for Energy and Climate Change published the government's perspective on climate engineering in February 2013.[23] These documents show the British government's view that it would be premature to consider climate engineering given the current lack of knowledge on the topic; much more research is necessary.

This position is mirrored in Germany: While the Bundestag has not yet debated the issue, the Office for Technology Assessment is currently preparing a report on the matter. In 2012, one of the opposition parties, the Social Democrats, issued a formal inquiry to the German government on the topic. The response[24] by the government—which echoes the UK position—is the only government-wide document that exists. Other than that, individual positions and perspectives have been issued by representatives of a wide range of governmental agencies, including the Federal Ministry for Research and Education, the Federal Environmental Agency, and the Planning Office of the Federal Armed Forces. A coherent government position or strategy, beyond rejecting climate engineering as replacement for mitigation or adaptation, cannot be found at present.

Although there was a joint inquiry by the U.S. House of Representatives and the UK House of Commons into the matter in 2009/2010, there is currently no transatlantic political dialogue or common understanding on climate engineering. The research communities from both sides of the Atlantic are, however, strongly connected. Indeed, the "Geoengineering Model Intercomparison Project"[25] is a joint effort largely by researchers from North America and Europe to conduct research on climate engineering. Beyond this project, given the still relatively small research community, there is a continuous exchange between the North American and the European community. This needs to be intensified, but as these two regions are only roughly 850 million people out of a global population of 7 billion, it needs to be eventually widened to include researchers from other regions as well. A starting point would be the research communities of the G20 countries.

Furthermore, to build confidence as well as increase transparency and legitimacy internationally, climate engineering research should be guided by a common set of criteria or a code of conduct agreed upon internationally. It would provide a common point of reference across borders and disciplines, for governments as well as for funding agencies. Several guidelines, such as the Oxford Principles or findings of the Asilomar conference have been suggested.[26] Though differing in details, there are great similarities in substance. These guidelines have been mostly discussed within academic circles so far; the next logical step is to identify a suitable international forum with high legitimacy, agree on the core essentials and thus provide a common, global point of reference.

The Belmont Forum, a coalition of large research funders including the United States and Canada, many European countries like France, Germany, and the UK, as well as China, Brazil, and South Africa, could be such a forum and play an important role. First, as a collection of funding agencies, it could shape climate engineering research quite easily. Second, due to its international nature, it could facilitate interlinking the research communities. Particularly the U.S. National Science Foundation, the German DFG, and the National Environment Research Council in the UK could initiate and drive jointly such a process.

The Next Decade: Research Needed for Understanding, Not Deployment

Climate change due to anthropogenic interference is continuing apace. Limiting global warming to 2°C compared to pre-industrial levels with conventional mitigation measures is becoming increasingly difficult and perhaps impossible. Climate engineering may become part of a portfolio of approaches to comprehensively address climate change by offering options to remove greenhouse gases from the atmosphere and limit global warming. However, it cannot serve as a replacement for mitigation and adaptation. Furthermore, it adds additional risks and uncertainties that need to be accounted for, but are only poorly understood so far. Considering the possibilities of misuse and risks of uncoordinated deployment and research, climate engineering requires international coordination and cooperation. Cooperation, however, is currently deficient.

Accordingly, any attempt to introduce climate engineering into climate negotiations as a response to climate change should be rejected at this stage. More research is necessary to identify which role, if any, climate engineering could play. Focus should be on risks and uncertainties and research itself needs to be better coordinated. In particular, the following recommendations emerge:

- Research on climate engineering should continue in order to help us better understand risks and uncertainties. As keeping the 2°C aim becomes ever more difficult to achieve with conventional mitigation, climate engineering may become part of a portfolio approach necessary to stabilize the climate. However, there should be no research on deployment before risks and uncertainties are more fully understood. Research on uncertainties and risks may entail field tests, but there is still much to learn from natural analogues, lab research, and computer modeling.

- Research should include the full spectrum of issues affected by climate engineering, thus including among others the political, social, and economic consequences. This should be reflected in interdisciplinary research teams providing a breadth of perspectives.

- Research should follow a common, internationally developed set of guidelines or a code of conduct. Various norms, criteria, and guidelines have already been proposed, which are similar in many respects, and can serve as a basis for such a code. Key aspects include transparency, public disclosure of results, advance notice of projects, and engaging the public beforehand.

- Members of the Belmont Forum, such as NSF, DFG, and NERC, should drive the development and dissemination of an international code of conduct on climate engineering research. The members of the Belmont Forum should abide by this code and use their soft power to propagate it further. Similarly, the Belmont Forum should be used as a platform for outreach to major research communities outside of North America and Europe.

- A knowledge repository on climate engineering research should be created; as climate change is a common concern for humankind, climate engineering and access to information should be as easy as possible for transparency reasons. Such a repository should include a registry of planned, active, and completed projects; full disclosure of methods and results; and an online library with published interpretations of results.

- American and European researchers, as well as political bodies, can play an important role in driving forward the research and the governance of research on climate engineering. Of key importance is a sober and practical approach, which firmly puts understanding risks and uncertainties into the foreground.

Notes

1 The author would like to thank Peter Irvine, Stefan Schäfer, and Mark Lawrence for many helpful comments and insights.

2 Climate Action Tracker, “Current pledges far from implementing agreed goal,” 30 November 2012, <http://www.climateactiontracker.org/>.

3 Carbon Tracker in collaboration with the Graham Research Institute, *Unburnable Carbon 2013: Wasted Capital and Stranded Assets* (London: Carbon Tracker, 2013).

4 CNA, *National Security and the Threat of Climate Change* (Alexandria, VA: CNA, 2007); UN Security Council, “Statement by the President of the Security Council”, 20 July 2011, <http://www.securitycouncilreport.org/atf/cf/%7B65BFCF9B-6D27-4E9C-8CD3-CF6E4FF96FF9%7D/CC%20SPRST%202011%205.pdf> (30 April 2013).

5 O. Edenhofer et al., “IPCC Expert Meeting on Climate engineering. Lima, Peru, 20-22 June 2011. Meeting Report,” 22 June 2011, >http://www.ipcc-wg3.de/publications/supporting-material-1/EM-GeoE-Meeting-Report-final.pdf> (19 June 2012); Wilfried Rickels et al., *Large-Scale Intentional Interventions into the Climate System? Assessing the Climate Engineering Debate. Scoping report conducted on behalf of the German Federal Ministry of Education and Research (BMBF)* (Kiel: Kiel Earth Institute, 2011); Government Accountability Office (GAO), *Climate Engineering: Technical Status, Future Directions and Potential Responses* (Washington, DC: U.S. Government Accountability Office, 2011); Royal Society, “Geo-engineering the Climate: Science, Governance and Uncertainty,” September 2009, <http://royalsociety.org/uploadedFiles/Royal_Society_Content/policy/publications/2009/8693.pdf > (30 April 2013).

6 J. Eric Bickel and Lee Lane, *An Analysis of Climate Engineering as Response to Climate Change* (Copenhagen: Copenhagen Consensus Centre, 2009).

7 Carbon Tracker in collaboration with the Graham Research Institute, *Unburnable Carbon 2013: Wasted Capital and Stranded Assets* (London: Carbon Tracker, 2013).

8 World Bank, *Economics of Adaptation to Climate Change. Synthesis Report* (Washington, DC: World Bank, 2010).

9 Wilfried Rickels et al., *Large-Scale Intentional Interventions into the Climate System? Assessing the Climate Engineering Debate. Scoping report conducted on behalf of the German Federal Ministry of Education and Research (BMBF)* (Kiel: Kiel Earth Institute, 2011).

10 Government Accountability Office (GAO), *Climate Engineering: Technical Status, Future Directions and Potential Responses* (Washington, DC: U.S. Government Accountability Office, 2011).

11 H. Schmidt et al., “Solar irradiance reduction to counteract radiative forcing from a quadrupling of CO2: Climate responses simulated by four earth system models,” *Earth System Dynamics* 3 (2012): 63-78.

12 See e.g., E. Chalecki and Lisa Ferrari, “More maple leaf, less CO2: Canada and a global geo-engineering regime,” *Canadian Foreign Policy Journal* 18:1 (2012): 120-132.

13 P. Irvine et al., “Climatic effects of surface albedo climate engineering,” *Journal of Geophysical Research* 116 (2011).

14 Cf. James Fleming, *Fixing the Sky: The Checkered History of Weather and Climate Control* (New York: Columbia University Press, 2011)

15 Achim Maas and Jürgen Scheffran, “Climate Conflicts 2.0? Climate engineering as a Challenge for International Peace and Security,” *Security and Peace* 30:4 (2012): 193-200.

16 Clive Hamilton, *Earthmasters: The Dawn of the Age of Climate Engineering* (New Haven: Yale University Press, 2013).

17 Wilfried Rickels et al., *Large-Scale Intentional Interventions into the Climate System? Assessing the Climate Engineering Debate. Scoping report conducted on behalf of the German Federal Ministry of Education*

and Research (BMBF) (Kiel: Kiel Earth Institute, 2011).

18 James Fleming, *Fixing the Sky: The Checkered History of Weather and Climate Control* (New York: Columbia University Press, 2011)

19 Bart Gordon, “Engineering the climate: Research needs and strategies for international coordination,” Report by Chairman Bart Gordon, Committee on Science and Technology, U.S. House of Representatives, October 2010, <http://www.washingtonpost.com/wp-srv/nation/pdfs/Geongineeringreport.pdf> (16 May 2013).

20 Government Accountability Office (GAO), *Climate Engineering: Technical Status, Future Directions and Potential Responses* (Washington, DC: U.S. Government Accountability Office, 2011).

21 For an overview, see Clive Hamilton, *Earthmasters. The Dawn of the Age of Climate Engineering* (New Haven: Yale University Press, 2013).

22 UK House of Commons, “The Reguliation of Geo-Engineering,” Fifth Report of Session 2009-10, March 2010, <http://www.publications.parliament.uk/pa/cm200910/cmselect/cmsctech/221/221.pdf> (16 May 2013).

23 UK Department of Energy and Climate Change, “The governments view on geo-engineering research,” 27 February 2013, <https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/120688/Government_view_on_geo-engineering_research.pdf> (16 May 2013).

24 Deutscher Bundestag, “Antwort der Bundesregierung auf die Kleine Anfrage der Abgeordneten René Röspel, Dr. Ernst Dieter Rossmann, Oliver Kaczmarek, weiterer Abgeordneter und der Fraktion der SPD,” Drucksache 17/10311, 16 July 2012, <http://dip21.bundestag.de/dip21/btd/17/103/1710311.pdf> (15 May 2013).

25 See the project description: <http://climate.envsci.rutgers.edu/GeoMIP/publications.html> (15 May 2013).

26 For an overview, see Wilfried Rickels et al., *Large-Scale Intentional Interventions into the Climate System? Assessing the Climate Engineering Debate. Scoping report conducted on behalf of the German Federal Ministry of Education and Research (BMBF)* (Kiel: Kiel Earth Institute, 2011).

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