HEARING TO REVIEW THE POTENTIAL ECONOMIC IMPACTS OF CLIMATE CHANGE ON THE FARM SECTOR

HEARING

BEFORE THE

SUBCOMMITTEE ON CONSERVATION, CREDIT, ENERGY, AND RESEARCH

OF THE

COMMITTEE ON AGRICULTURE
HOUSE OF REPRESENTATIVES

ONE HUNDRED ELEVENTH CONGRESS

FIRST SESSION

DECEMBER 2, 2009

Serial No. 111–38

Printed for the use of the Committee on Agriculture
agriculture.house.gov

U.S. GOVERNMENT PRINTING OFFICE
54–580 PDF WASHINGTON : 2010

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SUBMITTED MATERIAL

HEARING TO REVIEW THE POTENTIAL ECONOMIC IMPACTS OF CLIMATE CHANGE ON THE FARM SECTOR

WEDNESDAY, DECEMBER 2, 2009

HOUSE OF REPRESENTATIVES,
SUBCOMMITTEE ON CONSERVATION, CREDIT, ENERGY, AND RESEARCH,
COMMITTEE ON AGRICULTURE,
Washington, D.C.

The Subcommittee met, pursuant to call, at 10:00 a.m., in Room 1300 of the Longworth House Office Building, Hon. Tim Holden [Chairman of the Subcommittee] presiding.

Members present: Representatives Holden, Herseth Sandlin, Dahlkemper, Markey, Schauer, Kissell, Boccieri, Costa, Ellsworth, Walz, Kratovil, Murphy, Goodlatte, Moran, Rogers, Schmidt, Smith, Latta, Luetkemeyer, Thompson, Cassidy, and Minnick.

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OPENING STATEMENT OF HON. TIM HOLDEN, A REPRESENTATIVE IN CONGRESS FROM PENNSYLVANIA

The CHAIRMAN. This hearing of the Subcommittee on Conservation, Credit, Energy, and Research to review the potential economic impacts of climate change on the farm sector will come to order. I would like to welcome our witnesses and guests to today's hearing, the first of two hearings on the topic of climate change as it pertains to agriculture. Today, our witnesses will provide testimony on the impacts of climate change on the farm sector, and tomorrow's panel will discuss the cost and benefits of agriculture offsets. The intent of these hearings is not to cover all issues related to climate change, but to cut through the talking points and rhetoric used to distort the conversation to suit special interests.

Over the next 2 days we will hear testimony from researchers with different areas of expertise, backgrounds, and perspectives to find out what climate change and legislation related to climate change really means for agriculture. I hope they can provide a complete and realistic analysis of the two biggest areas of concerns, impacts and offsets. The Committee on Agriculture took a first step in March of this year by issuing a climate change questionnaire that was sent to over 400 agriculture-related organizations to solicit input on greenhouse gas emissions. Their responses and other related issues were further discussed at a hearing in June during the debate of the American Clean Energy and Security Act.

It became clear after these efforts that there is much interest from the agriculture community, and from Members of this Committee, in the way agriculture fits into the climate change debate. Regardless of what side of the debate we are on everyone can agree there is much more work to be done in this area. More information is needed to determine what we can be doing better. The 2007 Supreme Court decision has left us all in a state of confusion. We do not yet know the implications of what kind of domino effect this decision will have on all industries. We do know that EPA will likely take actions to regulate greenhouse gases under the Clean Air Act.

No matter what your position is on climate change, I don't believe having EPA regulating emissions on farms is the way any of us want to proceed. The successful efforts of Chairman Peterson during the debate of the climate change bill to prevent EPA regulation of greenhouse gases under the Clean Air Act ensures that there should be no cow tax or EPA regulations of agriculture. The bill passed by the House, however, is a long way from the President's desk. There is still a lot of work to do and more information to be gathered. These hearings may produce more questions than answers, but they will allow us all the opportunity to hear from the distinguished panelists who have the knowledge and expertise on these issues, the researchers, economists, educators and analysts.

I look forward to their testimony and the opportunity to listen, learn, and question those who have been doing the actual work on agriculture and climate change.

[The prepared statement of Mr. Holden follows:]

PREPARED STATEMENT OF HON. TIM HOLDEN, A REPRESENTATIVE IN CONGRESS FROM PENNSYLVANIA

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The CHAIRMAN. I now recognize the Ranking Member of the Subcommittee, the gentleman from Virginia, Mr. Goodlatte.

OPENING STATEMENT OF HON. BOB GOODLATTE, A REPRESENTATIVE IN CONGRESS FROM VIRGINIA

Mr. GOODLATTE. Thank you, Mr. Chairman. I want to thank you for holding today's hearing to review the potential economic impacts of climate change on the agriculture sector. The House has passed H.R. 2454, but by a very close margin, with the overwhelming majority on my side of the Committee, including myself, voting no. And many questions still remain on the impact that cap-and-trade will have on our economy, and this Committee should continue to intensely review how these proposals will affect farmers and ranchers, as well as consumers of agricultural products. The Senate is considering similar legislation to the American Clean Energy and Security Act or ACES, as its authors like to call it.

I have another name for this legislation, the Agriculture Can't Exist Standards. There are many studies that model the effects of cap-and-trade on our economy. I am very interested to hear from our witnesses today who will discuss their cap-and-trade analyses for the agriculture industry. Although each model uses different assumptions and has different end results, the conclusions of these studies remain the same. Cap-and-trade legislation has the potential to devastate the agriculture community with higher energy prices and lower farm income. As these higher energy prices ripple throughout the economy, producers will pay more for fertilizer, pesticides, seed, equipment, machinery, steel, and other supplies needed for their agriculture operations.

This is expected to increase operating costs, anywhere from 10–32 percent. Studies show a decrease in farm income from $5 billion to $50 billion per year. According to ERS, net farm income will be down $30 billion in 2009. Additionally, grain and meat processing and food production facilities will be hit with the same costs as producers. Rural America cannot afford the economic stifling effects of a cap-and-trade policy. Proponents of cap-and-trade may point to the agriculture offsets provision that is supposed to create potential for farm revenue, but this provision picks winners and losers by ignoring certain commodities and regions and by excluding early actors of conservation practices.

In essence, not every farmer and rancher will be able or even eligible to participate. Although we are still anxiously waiting to see USDA's regional analysis for the potential of agricultural offsets, the EPA analysis of offsets shows that farmers best and only chance to participate in an offset program would come from taking land out of production to plant trees. Congress is creating another government mandate that will result in an artificial competition between food, feed, fuel, and now carbon. This will undoubtedly change cropping patterns, which will reduce our domestic supply of agricultural products and ultimately increase commodity prices.

This policy will reduce exports and move our agriculture production overseas forcing other countries to clear land for agriculture production to meet their food, feed, and fiber needs. Mr. Chairman, you are absolutely correct when you refer to the problem we are confronting with the Environmental Protection Agency, and the possibility, in fact, right now the likelihood that they will take action absent Congressional action in this area. However, there is a simple solution that the Members of this Committee should take the lead on in pushing since Members on both sides of the aisle in large numbers opposed the cap-and-trade legislation, and that would be to simply push for legislation that restrains the authority of the EPA to take the action that they are threatening to take. That to me would be the simplest way to set the standards for the Congress in how we will proceed from here.

If were to do that, the Congress would be retaking control of this important policy area from the Environmental Protection Agency, an agency that is acting based upon a Court decision that was rendered; notwithstanding the fact that when the Clean Air Act standards were set that they are operating on had no one in the Congress, or for that matter in the EPA thinking that back in the 1970s that that would be an appropriate thing to do to regulate carbon dioxide emissions. What this all means for the American consumer is higher food costs or worse, a dependency on foreign nations for our food supply.

Mr. Chairman, I again thank you for holding the hearings this week. The impact that cap-and-trade will have on the ag sector and our economy and our very lives is extensive. We should make sure that we fully vet its impact, particularly at a time when our economy is struggling and unemployment is at 10.2 percent. It is no time to further cripple our economy with the burdens of a cap-and-tax policy. I hope that we can continue these discussions at the full Committee so that all our Members have the opportunity to review cap-and-trade policy and the effects it will have on their constituents.

[The prepared statement of Mr. Goodlatte follows:]

Prepared Statement of Hon. Bob Goodlatte, a Representative in Congress from Virginia

Mr. Chairman, thank you for holding today's hearing to review the potential economic impacts of climate change on the agriculture sector.

The House has passed H.R. 2454, but many questions still remain on the impact that cap-and-trade will have on our economy. And, this Committee should continue to intensely review how these proposals will affect farmers and ranchers, as well as consumers of agricultural products. The Senate is considering similar legislation to the American Clean Energy and Security Act or ACES as its authors like to call it. I have another name for this legislation: the Agriculture Can't Exist Standards.

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As these higher energy prices ripple throughout the economy, producers will pay more for fertilizer, pesticides, seed, equipment, machinery, steel, and other supplies needed for their agriculture operations. This is expected to increase operating costs anywhere from 10–32 percent. Studies show a decrease in farm income from $5 billion to $50 billion per year. According to ERS, net farm income will be down $30 billion in 2009. Additionally, grain and meat processing and food production facilities will be hit with the same costs as producers. Rural America cannot afford the economic-stifling effects of a cap-and-trade policy.

Proponents of cap-and-trade may point to the agriculture offsets provision that is supposed to create potential for farm revenue. But this provision picks winners and losers by ignoring certain commodities and regions, and by excluding early actors of conservation practices. In essence, not every farmer and rancher will be able or even eligible to participate.

Although we are still anxiously waiting to see USDA's regional analysis for the potential of agriculture offsets, the EPA analysis of offsets shows that farmers' best and almost only chance to participate in an offset program would come from taking land out of production to plant trees. Congress is creating another government mandate that will result in an artificial competition between food, feed, fuel, and now carbon. This will undoubtedly change cropping patterns, which will reduce our domestic supply of agricultural products and ultimately increase commodity prices. This policy will reduce exports and move our agriculture production overseas forcing other countries to clear land for agriculture production to meet their food, feed, and fiber needs.

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I hope that we can continue these discussions at the full Committee so all our Members have the opportunity to review cap-and-trade policy and the effects it will have on their constituents.

The CHAIRMAN. The chair thanks the gentleman, and asks all other Members of the Subcommittee to submit their statements for the record.

[The prepared statements of Messers. Peterson, Walz, Smith, and Latta follow:]

PREPARED STATEMENT OF HON. COLLIN C. PETERSON, A REPRESENTATIVE IN CONGRESS FROM MINNESOTA

Thank you, Chairman Holden, for holding the hearings today and tomorrow to look more closely at the impact of climate change and climate change legislation on the farm sector.

I am going to keep my remarks brief so that we can get to the substance of today's hearing. In fact, the very reason for today's hearing is to cut through all the rhetoric and talking points and focus on the reality of how agriculture is involved in climate change and proposals to regulate greenhouse gas emissions.

When it became clear that Congress was going to act on climate change legislation and that EPA was prepared to act if Congress did not, we realized that the Agriculture Committee needed to be engaged in this process or else we would be left with much of the burden and none of the potential benefits of climate change legislation. The bottom line for me was that we needed to be sure that EPA would not be coming onto farms to regulate greenhouse gas emissions. I don't want to turn around in a year or 2 and find that we're fighting an uphill battle against EPA on whatever regulatory scheme they come up with to hold agriculture responsible for greenhouse gas emissions.

H.R. 2454 is far from perfect, and more protections for the agriculture and forestry sectors are needed before I will vote for final passage of the conference report. But, everyone agreed that the changes we made for agriculture in the House-passed bill were necessary and good.

Moving forward, we are here today to listen and learn about the economic analysis that has been done on climate change and agriculture, which will help us understand what the potential impacts might be, whether we act or fail to act on climate change legislation. I look forward to learning more from our witnesses and the discussion we will have here today.

Prepared Statement of Hon. Timothy J. Walz, a Representative in Congress from Minnesota

Chairman Holden, Ranking Member Goodlatte, thank you for holding this hearing to look at the objective research surrounding the effects of climate change and climate change legislation on the agriculture sector. I further appreciate that this hearing is coupled with the hearing tomorrow to look at agriculture offset programs, for we must look at how these issues are coupled together.

Climate change is a real and serious problem, and we're simply hurting ourselves every day we don't act to change the way we emit greenhouse gas. We have an obligation to fix this problem, to set an example for the world, to strengthen our economic security and energy independence. However, we must do it wisely, it must make sense, and it must not do more harm than good.

I firmly believe our agriculture producers can and want to be a part of the solution. I understand much of the testimony today will focus on how H.R. 2454, the American Clean Energy and Security Act, will increase energy prices for farmers. However, I believe we must also focus on the cost of inaction.

Do the costs associated with H.R. 2454 outweigh the costs of inaction? The Institute for Policy Integrity at New York University's School of Law has done an analysis showing the benefits of H.R. 2454 will exceed costs by 9:1. Of course, this is looking at climate change across all sectors. What I want to know is if the agriculture economists here today have done similar studies looking at the cost of inaction on the agriculture sector and how those costs compare to the cost of H.R. 2454.

I look forward to the testimony today.

Prepared Statement of Hon. Adrian Smith, a Representative in Congress from Nebraska

Thank you, Mr. Chairman. I appreciate the Subcommittee holding this hearing to review the economic impact of climate change policy on the farming sector.

Recent efforts to reduce greenhouse gas (GHG) emissions by implementing a "cap-and-trade" system add up to a national energy tax at a time when both producers and consumers are struggling. While I support investment in clean, renewable energy, the infrastructure needed to employ this approach is not realistic. The farming sector is one of the most energy-intensive industries, both directly and indirectly. The Third District of Nebraska is one of the leading agricultural districts in the country, home to more than 30,000 farmers and ranchers who would suffer from even a slight increase in operating cost.

Assumptions about cap-and-trade's potential impact are being made on all sides of this debate. Forecasting cropland changes, weather patterns, and energy and commodity prices, while useful, is not exact. But one thing is certain: forcing a cap-and-trade mandate will create greater challenges for our rural economy. As a Member of this Subcommittee, I would like to see more thoughtful deliberation on such far-reaching policy, which is why I voted against the American Clean Energy and Security Act when it came before the House in June of this year, and more recently joined a number of my colleagues in sending a letter to the Chairmen and Ranking Members of the House Energy and Commerce, Agriculture, and Small Business Committees requesting a joint hearing to examine climate change legislation and its effects on manufacturing, agriculture, and small business in the Midwest.

Over the past decade, improved agricultural practices such as no-till cropping, targeted chemical applications through global positioning satellite technology, and methane digesters have reduced emissions from the agricultural sector. Strategies which involve a voluntary offset program could allow for farmers and ranchers to reduce emissions and recover a portion of their increased input costs. Federal policy should reward—not punish—our producers who are responsible stewards of the land.

Again, thank you, Mr. Chairman. I appreciate the opportunity to hear the testimony of these experts and look forward to moving ahead in a bipartisan, productive manner.

Prepared Statement of Hon. Robert E. Latta, a Representative in Congress from Ohio

Good Morning. Chairman Holden and Ranking Member Goodlatte.

Thank you for having this hearing today to examine Climate Change legislation and its economic impacts on the farm sector. H.R. 2454, the misleading titled

"American Clean Energy and Security Act of 2009," otherwise known as cap-and-tax was the vehicle used in the House of Representatives early this July. While narrowly passing the House by 219–212 margin, there was strong bipartisan opposition to this bill, which will be detrimental to our economy.

I represent Ohio's Fifth Congressional District, the largest agricultural and largest manufacturing district in Ohio. Recently, I sent a letter to the Chairmen and Ranking Members of the House Agriculture, Energy and Commerce, and Small Business Committees, as well as Democratic Leadership asking them to hold a joint hearing on the impact which climate change legislation will have on the agriculture, manufacturing, and small business sectors. The Midwest is dependent on agriculture, manufacturing and small businesses, and I hear daily from my constituents regarding this issue and what negative effect it will have upon them. I was joined on the letter by Republican Leader John Boehner and Republican Conference Chairman Mike Pence, both also from the Midwest, along with 29 other Members of Congress.

Unfortunately, only 0.8 percent of Ohioans are actively employed in the agriculture sector. The farmers in my district are not solely farmers; they are producers who farm full time and many of whom also have full time jobs in industries such as manufacturing. Ohio boasts over 618,000 manufacturing jobs according to most recent Bureau of Labor Statistics data. These are people who work in energy intensive industries that will be hit the hardest if this proposed climate change legislation is signed into law, or if the proposed Federal regulations are made final. These current pieces of legislation and proposed Environmental Protection Agency regulations will not only kill jobs in the United States, but will destroy the agriculture, manufacturing and small business jobs in my Congressional District and throughout the country. These are the same small businesses that make roughly 70–80 percent of all new jobs in the United States each year.

My district's main crops are corn, soybeans, and wheat. All of these crops have a significant operating cost for fuel, seed, electricity, fertilizers, and chemicals, all of which will increase heavily under current climate change legislation in the House and Senate. Operating costs amount to 71 percent for corn, 50 percent for soybeans, and 72 percent for wheat. Farmers in my district will not be able to sustain their farms and support their families with these increased costs.

According to the Heritage Foundation, farm income is expected to drop $8 billion in 2012, $25 billion in 2024 and over $50 billion in 2035 if H.R. 2454 is enacted or similar legislation. This represents decreases of 28, 60, and 94 percent, respectively. In addition, I have farmers in my district that strongly believe in domestic energy production to reduce our costs at the pump and our dependency on foreign oil, all the while helping to bring back American jobs. With gasoline and diesel prices continuing to rise, the only thing this legislation will reduce is the size of individuals' pocketbooks, especially with gasoline and diesel costs projected to be at least 58 percent higher under current climate change legislation. Under the current climate change legislation being proposed, economic impacts are severe, with job loss predicted at an astounding 1.1 million with peak unemployment projected at 2.5 million. This legislation will have an even more devastating effect by 2035, as by that time this legislation is projected to have reduced our gross domestic product by $9.6 trillion. This legislation will result in higher energy costs for consumers, particularly in areas such as mine, where coal is the primary energy source.

Over 86 percent of Ohio's electricity is generated by coal. The costs incurred from this legislation on electricity generators will be passed along to the consumers. Not only will farmers in my district, and throughout the country, be burdened with not being able to afford to operate their farms, this legislation will raise their electric rates, gasoline rates and place an even larger burden on their family. A family of four could incur costs anywhere from $1,500 to $4,300 per year. In these tough economic times, this is an unbearable cost on the taxpayer.

The Fifth District's rural community relies on eleven different electric cooperatives to supply electricity throughout the district. Rural utility companies such as the ones in Ohio are more dependent on coal for electricity generation than utilities in urban areas. According to data from the National Rural Electric Cooperative Association, eighty percent of electricity production by a rural electric co-op is generated by coal compared to fifty percent nationally.

In 2006, China surpassed the United States as the world's largest carbon dioxide emitter. According to date from the Global Carbon Project, from 2000 through 2007, global total greenhouse gas emissions increased by 26 percent. During that same period, China's carbon dioxide emissions increased 98 percent, India's increased 36 percent, while the United States' carbon dioxide emissions only increased by three percent. If the United States were to completely cease using fossil fuels, the increase from the rest of the world will replace United States' emissions in less than 8 years.

We have an Administration that has stated they do not want to burden tax increases on anyone making under $200,000 per year. However, Americans who make under this amount still use electricity and gas, they still go the service station to fill their gasoline tanks, and they purchase things that have to be manufactured, processed and transported. With each of these respective items, cap-and-trade will drive up prices.

A 2008 study by Doane Advisory Services, who is testifying today, has calculated the per-acre production cost increases under current climate change legislation. With my district's main crops being corn, soybeans, and wheat, we would see an increase in production costs of each by 27 percent, 15 percent and 27 percent, respectively. These are direct prices only, and do not take into account the high costs of transportation, manufacturing, and processing of these crops.

Just as burdensome as proposed climate change legislation will be, the 2009 United Nations' Conference on Climate Change in Copenhagen is projected to produce an agreement similar to the one passed in 1997 in Kyoto. Just like Kyoto, Copenhagen will be an agreement that will be detrimental to the U.S. economy and its energy intensive industries. This agreement will be a legally binding, comprehensive threat to America, especially detrimental to the Midwest.

Copenhagen will be a multi-nation agreement with 192 countries participating in this process, which makes the United States and its efforts to control its outcome very difficult to agree on the final terms. America will be expected to show leadership at Copenhagen and succumb to the European Union and the group of 77 developing countries to agree to a legally-binding document. The U.S. will be required to reduce their greenhouse gas emissions significantly even though countries such as China and India will not be forced to comply. The U.S. has had little if no increase in greenhouse gas emissions since 1997, yet we will be expected to further reduce ours to make up for other countries non-participation. This will do nothing but further decrease jobs, reduce our GDP, drive up the costs of energy, and increase our national debt. This agreement will force our taxpayers' hard-earned dollars to go to developing nations to develop their clean energy programs. The U.S. will be forced to redesign their energy policy, as well as help fund other countries' energy policies including sending billions of dollars every year to China.

As if U.S. Government regulation is not enough, U.S. companies and small businesses would be forced into investigations and decisions to be cast down upon them by foreign entities and governments. Just like cap-and-trade legislation, the Copenhagen Agreement will be a pure transfer of wealth not from the heart of the Midwest to the East and West Coasts, but from the entire United States to the rest of the world. The Energy Information Administration in the Department of Energy released a study which projected costs of U.S. compliance between $100 and $397 billion annually. Between legislation, regulations, and a potential treaty, American farmers, manufacturers and small businesses are facing severe consequences.

It is time for Congress to take a strong look at climate change legislation and the effects it will have on our economy, especially how hard it will affect the midwestern states that rely heavily on agriculture, manufacturing, and small businesses. I am still requesting that a joint hearing be held between the House Committees on Agriculture, Energy and Commerce, and Small Business. I do not want to see the Midwest be unfairly penalized, and we must ensure that our hard-working Americans have job security in farming and manufacturing. We need to keep American farmers feeding the world, our manufacturers in operation to keep our citizens employed by making American-made products, and our small businesses given incentives to create jobs and expand operations to new markets. I look forward to working with my colleagues on both sides of the aisle on this critically important matter.

The CHAIRMAN. And we would like to welcome our first witness, Dr. Joseph Glauber, Chief Economist, United States Department of Agriculture, Dr. Glauber, you may begin.

STATEMENT OF JOSEPH GLAUBER, PH.D., CHIEF ECONOMIST, U.S. DEPARTMENT OF AGRICULTURE, WASHINGTON, D.C.

Dr. GLAUBER. Mr. Chairman, Congressman Goodlatte, and Members of the Subcommittee, thank you for the opportunity to review the potential economic impacts of proposed climate change legislation to the farm sector. Specifically, my comments today focus on how changes in energy prices under a cap-and-trade system for greenhouse gas emissions would likely affect farmers and ranchers.

The economic impacts of climate change on the farm sector are broad, complex, and will evolve slowly over the next decades. Impacts will be influenced by the timing and the extent of climate change; the efficacy of actions to mitigate emissions and adopt changes, and the forms of actions taken within the United States and in other countries; and the extent to which mitigation within the farm sector can be compensated through greenhouse gas offsets or other mechanisms.

Our preliminary analysis of H.R. 2454, published last July, focused on the economic impacts of changes in energy prices associated with the cap imposed on domestic emissions. We have refined and expanded that analysis and my written testimony summarizes preliminary findings focusing on the effects of higher energy prices. Agricultural producers are not affected uniformly by the rise in energy prices and not all agricultural producers have the same opportunities to provide offsets. How changes in energy prices and the ability to provide offsets affect different parts of the agricultural sector relate to the relative and absolute magnitude of the changes in production costs and ability to change farming practices.

Energy-related inputs and the ability to generate and provide offsets have a different importance across the sector and impacts reflect those different roles, both by commodity and region of the country. Energy consumption in the agricultural sector can either be direct, such as gasoline, diesel, petroleum, natural gas, electricity, and energy used for operating irrigation equipment; or indirect such as the energy used to produce fertilizer. Over 2005 to 2009, using data collected by the Economic Research Service, shows that expenses from direct energy use averaged about 6.7 percent of total production expenses in this sector, while fertilizer expenses represented another 6.5 percent. With the more recent increase in energy costs, the combined share of these inputs reached nearly 15 percent in 2008.

In general, energy costs as a percent of total operating costs are highest for wheat and feed grains with energy input shares of some 50 to 60 percent of total operating cost. On a per-acre basis energy costs are generally highest for rice, corn, and cotton. Direct energy costs make up a small share of total operating costs on livestock operations comprising less than ten percent of total operating cost for dairy, hog, and cow-calf operations. However, these operations also experience energy costs indirectly through higher feed costs. Feed costs average from less than 11 percent of a cow-calf total operating cost to almost 77 percent for dairy.

Agriculture and forestry are not covered sectors under the cap-and-trade system of H.R. 2454. Therefore, producers in these sectors are not required to hold allowances for greenhouse gas emissions. Nonetheless, U.S. agriculture would be affected in a variety of ways. Energy providers' compliance with greenhouse gas emission reduction legislation will likely increase energy costs. Higher prices for fossil fuels and inputs would increase agricultural production costs, particularly for more energy intensive crops. This would in turn affect planting and production, which would affect the livestock sector through higher feed costs. Higher energy prices could also result in increased biofuel production.

Using energy price scenarios estimated by the Environmental Protection Agency and the Energy Information Administration, we found that farm level price and income effects due to higher production costs will be relatively small, particularly over the short run, that is, over the next—from 2012 to 2025, when fertilizer producers will be eligible for significant rebates under the so-called energy intensive export or the trade-affected industries. In the longer term, the energy price effects grow larger and the impact on production costs are roughly proportional in magnitude. This assumes no change in technology or production practices which could mitigate some of the impact.

Though the effects are not incorporated into the main findings of this testimony, H.R. 2454 would also provide opportunities for farmers and ranchers to receive payments for carbon offsets. Revenue from offsets for changes in tillage practices, reductions in methane and nitrous oxide emissions in tree plantings, for example, could mitigate the effects of higher energy prices for many producers. Last, H.R. 2454 could have significant land effects. Though this analysis does not include bioenergy production effects or changes in land use due to added fuel production, or carbon sequestration through afforestation, both could further affect output prices and farm income.

I will deal with this tomorrow in more depth—our analysis does include this, and I will presenting this in tomorrow's testimony. Again, thank you, Mr. Chairman, for holding these hearings on climate change. I think it is important to spend the time to understand the effects on agriculture, and I hope my testimony today and tomorrow is useful in that regard. I am certainly happy to answer any questions.

[The prepared statement of Dr. Glauber follows:]

PREPARED STATEMENT OF JOSEPH GLAUBER, PH.D., CHIEF ECONOMIST, U.S. DEPARTMENT OF AGRICULTURE, WASHINGTON, D.C.

Mr. Chairman, Members of the Subcommittee, thank you for the opportunity to review the potential economic impacts of proposed climate change legislation to the farm sector. Specifically, my comments today focus on how changes in energy prices under a cap-and-trade system for greenhouse gas (GHG) emissions would likely affect farmers and ranchers based on analyses of the American Clean Energy and Security Act of 2009 (H.R. 2454), which included a cap-and-trade system for GHG emissions. The economic impacts of climate change on the farm sector are broad, complex and will evolve slowly over the next decades. Impacts will be influenced by the timing and extent of climate change, the efficacy of actions to mitigate emissions and adapt to changes, the form of the actions taken within the United States and in other countries, and the extent to which mitigation within the farm sector can be compensated through GHG offsets or other mechanisms.

We have not been able to quantify all of these factors and their influence on the farm economy. Our preliminary analysis of H.R. 2454, published in July,[1] focused on the economic impacts of changes in energy prices associated with the cap imposed on domestic emissions.

We have refined and expanded that analysis and my comments today will summarize preliminary findings focusing on the effects of higher energy prices. The findings suggest that under the energy price scenario estimated by the Environmental Protection Agency, price and income effects due to higher production costs will be relatively small, particularly over the short run (2012–2025) when fertilizer producers will be eligible for significant rebates. Separate testimony will address the

[1] U.S. Department of Agriculture, Office of the Chief Economist and Economic Research Service. "A Preliminary Analysis of the Effects of H.R. 2454 on U.S. Agriculture" July 22, 2009. Available at *http://www.usda.gov/oce/newsroom/archives/releases/2009files/HR2454.pdf.*

role of GHG offset markets and their effects on farm income, the analysis of which suggest that the cap-and-trade as a whole likely will have a positive effect on net farm income.

Agriculture and forestry are not covered sectors under the cap-and-trade system of H.R. 2454. Therefore producers in these sectors are not required to hold allowances for GHG emissions. Nonetheless, U.S. agriculture would be affected in a variety of ways. Energy providers' compliance with GHG emissions reductions legislation will likely increase energy costs. Higher prices for fossil fuels and inputs would increase agricultural production costs, particularly for more energy-intensive crops. This would, in turn, affect plantings and production, which would affect the livestock sector through higher feed costs. Higher energy prices could also result in increased biofuel production. It is worth noting that fertilizer prices will likely show little effect until 2025 because of the H.R. 2454's provision to help energy-intensive, trade exposed industries mitigate the burden that the emissions caps would impose.

Though the effects are not incorporated into the main findings of this testimony, H.R. 2454 would also provide opportunities for farmers and ranchers to receive payments for carbon offsets. Revenue from offsets for changes in tillage practices, reductions in methane and nitrous oxide emissions, and tree plantings, for example, could mitigate the effects of higher energy prices for many producers.

Last, H.R. 2454 could have significant land use effects. Though this analysis does not include bioenergy production effects or changes in land use due to added biofuel production or carbon sequestration through afforestation, both could further affect output prices and farm income.

Energy Use by U.S. Agriculture

Agriculture is an energy intensive sector with row crop production particularly affected by energy price increases. Direct energy consumption in the agricultural sector includes use of gasoline, diesel fuel, liquid petroleum, natural gas and electricity. Indirect use involves agricultural inputs such as nitrogen and other fertilizers which have a significant energy component associated with their production. Over 2005–2008, ERS data show that expenses from direct energy use averaged about 6.7 percent of total production expenses in the sector, while fertilizer expenses represented another 6.5 percent. With the more recent increases in energy costs, the combined share of these inputs reached nearly 15 percent in 2008.

In general, energy costs as a percent of total operating costs are highest for wheat and feed grains. Based on cost of production data for 2007 and 2008, wheat, sorghum, corn, barley and oats have energy input shares between 55 and 60 percent (*table 1*). Cotton and soybeans are among the least energy intensive crops, with total energy costs representing only about 30 percent of total production costs.

A somewhat different distribution of energy costs by commodity results if looked at in terms of per-acre costs for energy-related inputs rather than shares of operating costs. Rice, corn, and cotton have the highest per-acre expenses for these inputs. Again, energy-related costs for soybean production are low among these crops.

There is also variation in the regional distribution of energy-input costs. *Figure 1* illustrates this for wheat and soybeans, two sectors at the opposite end of the energy-input share spectrum. For wheat, the regions with the largest share of input costs allocated to energy are the Fruitful Rim and the Heartland (71 percent), followed by the Prairie Gateway (69 percent).

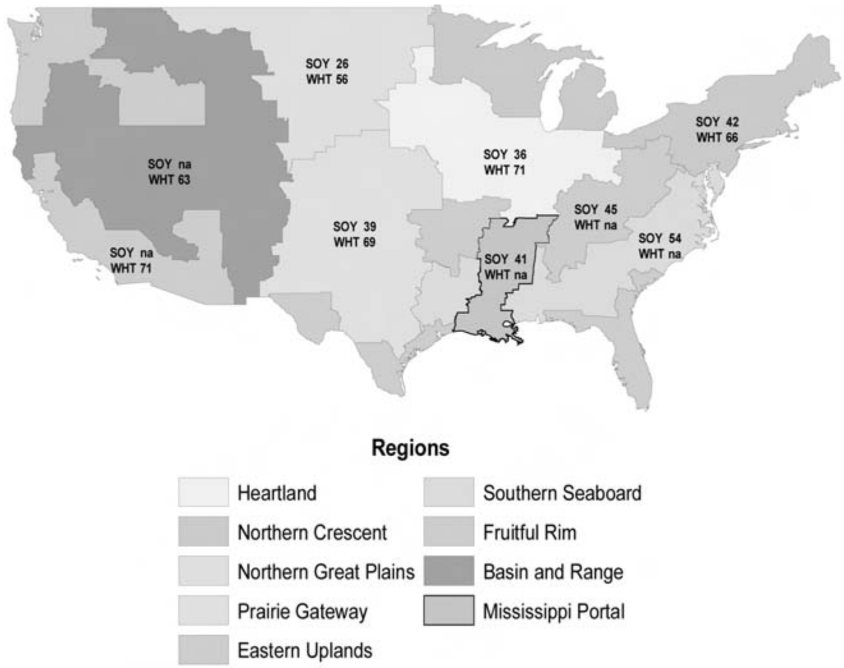
Wheat production cost relationships for the Northern Great Plains and the Prairie Gateway, where the majority of the crop is grown, present an interesting contrast in operating expenses. While the two regions have a similar share of production costs attributable to fertilizer expense in 2008 (44–45 percent), the shares of costs that are for fuel, lubrication, and electricity are much different (25 percent for the Prairie Gateway, while only 11 percent for the Northern Great Plains). This is likely due to the high level of irrigation used in the Prairie Gateway.

For soybeans, the region with the largest share of input costs allocated to energy is the Southern Seaboard (54 percent), followed by the Eastern Uplands (45 percent). The region with the largest soybean plantings is the Heartland, which has the second lowest share of energy inputs in total operating expenses, at 36 percent.

Direct energy costs make up a small share of total operating costs on livestock operations, comprising less than ten percent of total operating costs for dairy, hogs and cow-calf operations (*table 2*). However, these operations experience higher energy costs indirectly through higher feed costs. Feed costs ranged from less than 11 percent of a cow-calf operator's total operating costs to almost 77 percent for dairy.

Trends in energy-related inputs could themselves change in the future in response to climate change impacts, as shifts in temperature and precipitation alter the need for fertilizer, pesticides, and irrigation. USDA's production cost modeling framework does not reflect these future changes in agroclimatic conditions.

Figure 1. Total energy input costs as a percentage of total operating costs, 2008, by ERS Farm Resource Region (soybeans and wheat).



Effects of Higher Energy Costs on U.S. Agriculture

To represent the effects on the U.S. agricultural sector of higher energy costs resulting from the emissions cap-and-trade system in H.R. 2454, estimated energy price changes from EPA's (June 2009) and EIA's (August 2009) analyses were used to derive implications for crop-specific production costs.[2] Cost categories in the USDA–ERS cost of production framework included in this analysis were fertilizer and fuel, lube, and electricity. As shown in the previous section, these production inputs represent a significant portion of operating expenses for major field crops. We use the Food and Agricultural Policy Simulator Model (FAPSIM) to analyze the effect of H.R. 2454 on national level production costs. This model allows farmers to change acreage decisions in response to higher energy prices, but does not allow for changes in input mix. Though FAPSIM is only designed to examine short-term impacts, we extrapolate to the intermediate and long-term to make an initial assessment of how higher energy prices in those years would affect farmers if they made identical decisions to those modeled in the short term. We know this is not the case due to changes in productivity over time as well as farmers ability to adapt to higher energy prices by shifting away from energy-intensive inputs. Regional effects are discussed only for the short-term impacts.

For the short-term scenarios, agricultural sector impacts were derived for 2012–2018 based on energy price changes from the EPA and EIA analyses. While most of the direct energy price increases would be felt immediately by the agricultural sector, fertilizer costs would likely be unaffected until 2025 due to provisions in H.R. 2454 that would distribute specific quantities of emissions allowances to "energy-intensive, trade exposed entities" (EITE).[3] Additionally, EPA analysis indicates that

[2] For the June EPA H.R. 2454 analysis, scenario 2 was used. The EPA analysis of H.R. 2454 can be found at: *http://www.epa.gov/climatechange/economics/economicanalyses.html.* For the EIA analysis, the basic case was used. The EIA analysis of H.R. 2454 can be found at: *http://www.eia.doe.gov/oiaf/servicerpt/hr2454/index.html.*

[3] Under Subtitle B of Title IV, "energy-intensive, trade exposed entities" (EITE) covers industrial sectors that have: (1) an energy or greenhouse gas intensity of at least 5% and a trade intensity of at least 15%; or (2) an energy or greenhouse gas intensity of at least 20%. Without

the allocation formula would provide enough allowances to cover the increased energy costs of all presumptively eligible EITE industries. Based on these considerations, the USDA analysis assumes H.R. 2454 imposes no uncompensated costs on nitrogen fertilizer manufacturers related to increases in the price of natural gas through 2024. These allocations are terminated beginning in 2025. This reflects an assumption that enough foreign countries have adopted similar GHG controls to largely eliminate the cost advantage for foreign industries. These assumptions are consistent with the treatment of EITE industries, including nitrogen fertilizer manufactures, in the EPA analysis of H.R. 2454.

Medium-term and long-term impacts are based on EPA estimated changes in energy prices. Years covered in this analysis for these periods are 2027–2033 and 2042–2048. Since EPA results were presented in 5 year increments, results for other years covered in the analyses were derived by interpolation and extrapolation. EITE rebate scenarios are not covered for these periods since the rebates are assumed to end after 2025 in the EPA analysis. Because of the time horizons considered in the medium and long term analyses, there is much uncertainty surrounding the effects estimated here. Factors such as yield productivity, development of energy-saving technologies and weather can all have major effects on supply, demand and price outcomes, thus mitigating or exacerbating the effects estimated here.

As emission caps become more stringent over time, allowance prices and corresponding energy price impacts become larger. Results for these scenarios illustrate some of these larger impacts. *Table 3* shows selected energy-related impacts from the EPA and EIA analyses of H.R. 2454 that were used for the agricultural sector scenarios across each of the time periods. EIA results were available on an annual basis out to 2030.

Using the EPA and EIA results shown in the previously mentioned tables, changes in measures of energy-related agricultural inputs were estimated. Fuel price impacts are based on the EPA petroleum price changes and the EIA diesel fuel (transportation) price changes. Fertilizer price impacts in the EPA scenarios reflect price changes for natural gas and petroleum, while those in the EIA scenarios are based on price changes for natural gas (feedstock) and industrial distillate fuel oil.

Table 4 shows the average percent changes in the indexes of prices paid by farmers for fuels and fertilizer across the various time periods and scenarios analyzed. Reflecting the differences in the relative sizes of the EPA and EIA energy price impacts, effects on producer input prices during 2012–2018 are about twice as large for the EIA-based scenarios compared to the EPA scenarios. The exception is the net fertilizer cost increase, reflecting in part different rebate sizes and inclusion within the EIA scenario of a greater shift from coal to natural gas under H.R. 2454.

National Impacts of Higher Energy Prices

The discussion of national impacts on the agricultural sector resulting from higher energy prices associated with the proposed emissions cap-and-trade policy is divided into two parts. First, an assessment of the impacts on major field crops and the livestock sector is discussed. This is followed by a discussion of impacts of higher energy costs on production expenses for the fruit and vegetable sector. Both discussions cover multiple short-term scenarios, as well as a medium-term and a long-term scenario, as discussed above. The analysis and discussion below does not include the effects of GHG offsets or other mechanisms to compensate farmers for emissions reductions and carbon sequestration. It also does not include the effect of other countries enacting policies mitigate GHG emissions. When revenues from offsets are considered in conjunction with production costs, net farm income is expected to be positive. These effects of offsets will be discussed briefly today, and in more detail in my testimony tomorrow.

To assess impacts on major field crops and the livestock sector, changes in agricultural production costs arising from higher energy prices are used as inputs to FAPSIM. This model covers commodity markets for corn, sorghum, barley, oats, wheat, rice, upland cotton, soybeans (including product markets for soybean meal and soybean oil), cattle, hogs, broilers, turkeys, eggs, and dairy. Fruit and vegetables are not modeled in FAPSIM but are analyzed using a separate model below. FAPSIM calculates the impacts of changes in production costs on supply, demand, and prices in each of these markets over the years 2009–2018. At the aggregate

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these allocations, firms in EITE industries would incur energy-related costs that foreign competitors would avoid; hence, putting them at significant market disadvantage. The bill sets a maximum amount of allowances that can be rebated to EITE industries at, 2% for 2012 and 2013, 15% in 2014, and then declining proportionate to the cap through 2025. Beginning in 2026, the amount of allowance rebates will begin to be phased out and are expected to be eliminated by 2035. The phase-out may begin earlier or be delayed based on Presidential determination.

level, the model also computes associated changes in production expenses in the sector and net farm income. The model simulations for the different scenarios and time periods assume no changes in technology or production practices (such as fertilizer application rates) beyond those implicit in the reference scenario's trends.[4]

Short-term Scenarios—EPA and EIA Energy Prices

Higher prices for energy-related agricultural inputs (fertilizer and fuel) raise the cost of production for all major crops. *Table 5* shows the average nominal dollar impacts on variable production costs per acre for major field crops over 2012–2018. For the EPA scenario (based on energy price increases consistent with EPA's CO_2-equivalent allowance prices for 2015 and 2020), the largest changes in per-acre production costs from baseline levels are for crops that use more energy-related inputs, most notably rice, corn, and cotton. However, compared with overall crop-specific production costs, high-cost rice and cotton are relatively less affected by the energy-related input changes (each up by less than two percent), while sorghum production costs are relatively more affected at 2.2 percent. This is due to the lower energy-input share relative to production costs for rice and cotton producers (as shown earlier in *table 1*). Whether looked at on a cost per acre basis or on a cost as share of production costs basis, soybean production costs are less affected than those of most other crops.

For the EIA scenario, energy-related production cost impacts for all crops are generally on the order of twice as large as those for the EPA scenario. However, the relative impacts among the crops are similar to those identified for the EPA scenario. For both price scenarios, the EITE rebates for fertilizer producers result in a significant reduction in potential costs since most of the impacts are limited to the increase in fuel costs.

Acreage effects, without offsets, are modest (*table 6*). Under the EPA price scenario, overall acreage planted to major field crops decreases by 133,000 acres, a less than 0.1 percent change from baseline levels over 2012–2018. However, relative net returns among cropping alternatives, along with differences in producer responses to changes in economic incentives, result in varying impacts for each crop. Wheat acreage is down the most at 63,000 acres. While corn acreage also declines (less than 0.1 percent decline), its impacts are sharply reduced because of the importance of the EITE rebates in determining fertilizer costs. Also, the net shift of acres to soybean production is reduced relative to baseline levels as the relative cost advantage of the low-fertilizer input crop is diminished with the rebate.

Similarly, for the EIA scenario, a larger absolute decline in total acreage results, though still modest, with planted acreage down 354,000 acres. This represents a 0.1 percent decline in planted acreage. Wheat and corn acreage still experience the largest reductions. Again, there is a net switch in acreage to soybeans as their returns are affected the least among crops.

In general, crop production is down slightly, leading to higher prices (*table 7*). However, since production changes are small under the EITE rebates, price impacts are minimal, with no price change greater than 0.4 percent (0.2 percent and 0.4 percent are the highest price changes under the EPA and EIA scenarios, respectively). Under both scenarios, slightly higher corn prices, which are partially offset by lower soybean meal prices, lead to a a small increase in feed costs for the livestock sector (*table 8*). As a result, livestock production declines slightly. The impacts on livestock production vary across livestock species reflecting the relative shares of corn and soybean meal in the typical feed ration. Because corn is large part of their feed ration, pork and beef are affected more than poultry. Feed costs under the EIA scenario experience a larger increase than those from the EPA scenario, resulting in slightly larger livestock production declines.

Net farm income in the agricultural sector declines from the FAPSIM baseline on average by \$0.76–\$1.72 billion (0.9–2.1 percent) over 2012–2018 (*table 9*). This change is due primarily to higher production expenses, although higher cash receipts partly offset the increases in production expenses. These income effects do not reflect revenues from GHG offsets nor do they reflect the related effects of land use changes associated with GHG offsets. These effects will be examined in more detail in tomorrow's testimony.

Effects on Production Expenses for the Fruit and Vegetable Sector

Fruits and vegetables are not included in FAPSIM. Instead, data from USDA's 2007 Agricultural Resources Management Survey (ARMS) were used to estimate the effects of H.R. 2454 on the fruit and vegetable sector. Average per farm effects on

[4] A more detailed description of FAPSIM is given in Appendix A.

variable costs of production were estimated based on the increased input prices for fuels, electricity and fertilizer estimated under the FAPSIM runs described above.

Unlike for most row crops and livestock production, labor is the single largest variable cost for vegetable, melon, fruit and tree nut farms. However, the second largest expense component is fertilizer and agricultural chemicals. In 2007, fertilizer and agrichemicals accounted for about 18 percent of the variable cash expenses of vegetable and melon farms and 13 percent for fruit and tree nut farms. Motor fuels and oil used to run tractors, generators, and irrigation pumps accounted for five percent of vegetable cash costs and four percent of cash costs for fruits and tree nuts. In this analysis, per-acre fertilizer application rates are assumed to remain unchanged. Over the medium- and long-run, this is unrealistic since most growers would adjust application methods, amounts, timing, or the mix of crops produced to reduce expenses.

In addition, electricity is required by these farms to run irrigation pumps, ice makers, lights, and sorting and packing equipment in packing sheds. Although the exact share is not certain, electricity likely accounts for a significant share of the 4–5 percent of cash costs accounted for by expenditures for utilities. This analysis for the fruit and vegetable sector assumes that the entire utility expense category consists of electricity costs since there was no way to break out electric costs from telephone, water, and other utility expenses. Like fertilizer and other fuel expenses, no adjustments were assumed in electricity use; thus, the results for energy costs assumed here are likely high estimates.

Impacts of higher fertilizer, fuel, and electricity prices on variable costs within the fruit and vegetable complex are generally small in terms of percentages (*table 10*). Across the EPA and EIA short-term scenarios, impacts on costs for all fruits and vegetables were two percent or less. Over the long-term, the total impact under the EPA energy price scenarios was estimated to be 3.8 percent, or $7,747 per farm that specializes in fruits and vegetables (farm for which more than half of all sales come from fruits and vegetables).

Impacts Across Farm Types and Regions

Regional and farm type impacts are based on results from the Farm-Level Partial Budget Model. The model operates on individual farm data for farm businesses from ARMS. The model reflects historic production patterns and farm structure within each region. Any potential structural or production responses by farms are not included within the model.

The model uses results from the FAPSIM scenarios discussed earlier as inputs to derive regional and farm type impacts consistent with the national outcomes. Results can be summarized across various groupings of farms such as by resource region, commodity specialization, or farm size categories. Nonetheless, since farm business performance varies within these groupings, results do not indicate performance of individual farms within a group.

The overall impacts reported in this section can differ from those in the national farm income accounts due to a number of factors. This section reflects, in part, on farm businesses[5] so the concentration of expenses is higher than for all farms. Further, part of the differences relates to the treatment of rent—the national accounts use net rent, while rent comes directly out of net cash income at the farm level.

A simulation of how the legislation will impact agriculture by farm type reveals that some segments of agriculture will be more impacted by the legislation than others. The analysis focuses on results for 2014 and this 1 year analysis serves as an example of regional and commodity differences in the short run.

Rebates to the fertilizer industry as an EITE to compensate for higher natural gas prices significantly lessens the impact of the higher energy prices across all farm types. With EITE rebates, 2014 net cash income for all farm businesses is estimated to be 1–4 percent lower than in the 2014 baseline level compared to the 1–2 percent decline in net farm income presented in the previous section. Wheat, cotton, rice, and "other crop" producers have a decrease in net income of 2–8 percent across the EPA-based and EIA-based scenarios (*figure 2*). Except for "other livestock" producers, most other farm types have a net income decrease of around 1–3 percent. As in the previous sections, these impacts do not include revenue from GHG offsets or increased biomass production.

The impact of higher energy prices under a fertilizer rebate scenario is not evenly distributed. Other cash grains, wheat, corn, soybeans, cotton, rice, specialty crops, and hogs account for nearly 49 percent of all farms, but these farms also account for over 63 percent of the projected decrease to net cash income relative to 2014

[5] *Farm businesses* are defined as family and non-family operations that report farming as their principal occupation.

baseline levels. As was the case in analyzing farm types, net cash farm business incomes under both the EPA and the EIA-energy price scenarios are reduced across all regions. All regions can expect a decrease in net cash income, ranging from less than two percent to about seven percent (*figures 3* and *4*), with the biggest decrease in the Mississippi Portal region under the EIA scenario. Again, it is important to note that these estimated income effects do not reflect management decisions about changes in inputs, revenues from GHG offsets nor do they reflect the related effects of land use changes.

Figure 2—Reduction in farm business net cash income by farm production specialty, 2014, with EITE rebate.

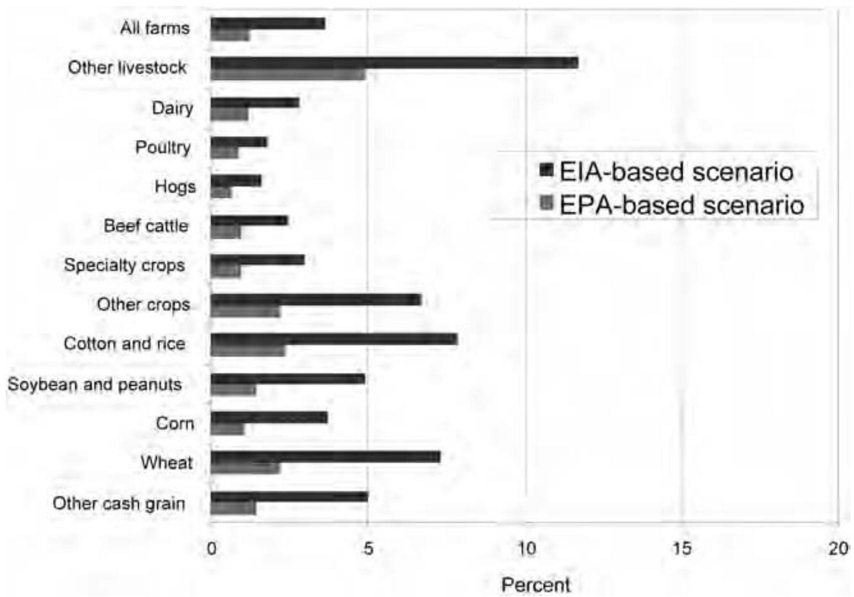

Figure 3—Reduction in farm business net cash income by resource region, EPA-based results, 2014, with EITE rebates.

Figure 4—Reduction in farm business net cash income by resource region, EIA-based results, 2014, with EITE rebates.

Medium-term and Long-term Impacts

As cap levels become more stringent over time, allowance prices and corresponding energy price impacts become larger. FAPSIM is designed to evaluate short-term impacts. It is therefore difficult to make accurate statements about the medium and longer-term. Nonetheless, to make some initial assessment of the effects of higher energy prices on agriculture beyond the initial short-term focus, the estimated impacts of energy prices for selected periods from the EPA analysis were used to look at two additional time periods using the FAPSIM framework. First a medium-term scenario was based on EPA estimated changes in energy prices for 2027 33. Then a long-term assessment was based on EPA results for 2042–2048.

The methodological approach used was similar to that used earlier. However, given the assumptions necessary to extrapolate beyond the FAPSIM time frame, these should be viewed with full acknowledgement of the limitations of this analysis. Since these two additional time periods are beyond the horizon of the FAPSIM model, results were generated within the FAPSIM time horizon based on percent changes for affected variables and then inflated to the medium- and long-term time periods based on the annual inflation rate from the EPA analysis, 1.8 percent. This implies a constant real price assumption for those two additional time periods. Additionally, no additional changes in production practices beyond those implicit in underlying trend yields between now and these time periods is assumed. While these assumptions are analytical simplifications, they provide a vehicle for simulating representative impacts were they to occur in the short run. For the medium-term and long-term periods, there are no EITE rebate simulations included as those rebates are assumed to end after 2025 in the EPA analysis. For comparison purposes, results shown in this section repeat some of the earlier short-term impacts.

This approach has limitations given the observation that energy per unit of output has drastically declined over the last several decades. These estimates are likely an upper bound on the costs because they fail to account for farmer's proven ability to innovate in response to changes in market conditions.

Table 11 presents the impacts of higher energy prices on average annual production costs in the medium and long term along with those from the short-term (no-rebate case) discussed earlier. The medium- and long-term impacts on production costs have a relatively larger impact on fertilizer intensive crops such as corn compared to less fertilizer intensive crops such as soybeans. In the long-term, corn production costs are estimated to increase by more than $25 per acre (in $2005), representing an increase of almost ten percent. In comparison, soybean production costs rise by $5.19 per acre, on average, 4.6 percent. Wheat, sorghum, barley, and oats would see increases similar to corn in percentage terms. Rice is estimated to have the largest average per-acre increase in the long term at $28.08 per acre, although its percentage increase would be less than that for wheat, corn, and the other feed grains. Likewise, cotton has a relatively high absolute increase in production costs, but this represents a smaller share of operating expenses. Soybean production costs remain the least affected.

Resulting adjustments in the agricultural sector to these higher production expenses follow the same dynamics as discussed earlier for the short-term results. Acreage shifts would lead to changes in commodity prices and adjustments through the livestock sector.

Table 12 presents the projected impacts of the higher energy costs across the different time periods for farm cash receipts, production expenses, and net farm income. In the long-term results, fuel, oil, and electricity expenses are estimated to increase, on average, 22 percent above baseline levels, while fertilizer and lime expenses are estimated to rise, on average, by almost 20 percent. While total receipts increase marginally—due to higher crop and livestock prices—they only partly offset the increase in expenses. As a result, higher energy prices associated with H.R. 2454 would lower net farm income by as much as 7.2 percent from baseline levels in the long term scenario. These results do not include the effects of GHG offsets.

Last, it is important to note that the medium to long term analyses are conservative given that energy use per unit of output has declined significantly over the past several decades. Because of this, the estimates in *table 11* are likely an upper bound estimate on the costs because they fail to account for farmers' ability to fully respond to changes in market conditions. In addition, the analysis is also conservative because it does not account for revenues provided by GHG offsets, expanded renewable energy markets, or the effects GHG offsets and biofuel production have on land use, production and prices.

In my testimony tomorrow I will address the effects of GHG offsets on the U.S. agriculture, including effects on farm income. The results are drawn from modeling results provided by EPA from an economic model, developed by Bruce McCarl at the Texas A&M University.[6] *Table 13* provides a summary of those findings on farm income. Modeling results provided by EPA show the annuity value of changes in pro-

[6] The results presented in *table 13* reflect simulation output from March 2009. A more complete description of FASOM modeling framework and a complete list of commodities can be found at: *http://agecon2.tamu.edu/people/faculty/mccarl-bruce/FASOM.html.*

ducer surplus over the entire simulation period.[7] When the effects of GHG offsets are taken into account, it is estimated that the annuity value of the change in producer surplus is expected to be almost $22 billion higher; an increase of 12 percent compared to baseline producer surplus. About 78 percent of this increase is due to higher commodity prices as a result of the afforestation of cropland, with the remainder due to GHG related payments. Almost 30 percent of the gains would occur in the Corn Belt followed by the South East region (16 percent of the gains), Great Plains region (13 percent), and South Central region (ten percent).

The producer surplus impacts exclude earnings from the sale of carbon from afforestation. The annuity value of the gross revenues associated with the sale of afforestation offsets would result in approximately $3 billion of additional farm revenue. About 90 percent of that additional revenue would be generated in four regions of the country: the Corn Belt (40 percent), Lake States (25 percent), South Central (14 percent), and Northeast (11 percent). However, part of that increase in revenue will be offset by the continued costs associated with maintaining afforestation projects.

Conclusions

Mr. Chairman, I appreciate the opportunity to discuss how a cap-and-trade system would likely affect farmers and ranchers. In today's testimony I have focused almost exclusively on how higher energy prices would affect the agriculture sector. Separate testimony will discuss the role of GHG offsets in much greater detail and how a properly designed offset program can both mitigate energy price impacts of a cap-and-trade system and provide significant benefits to farmers and ranchers. I am happy to answer any questions.

TABLES

Table 1—Energy Related Inputs Relative to Total Operating Expenses for Selected Crops, 2007–2008

Commodity	Fuel		Fertilizer	
	$/acre	Percent of operating costs	$/acre	Percent of operating costs
Corn	37.11	14.1	116.16	44.3
Soybeans	17.71	15.1	20.22	17.2
Wheat	22.51	20.6	42.60	39.0
Cotton	54.98	12.6	76.88	17.6
Rice	122.28	27.7	93.35	21.2
Sorghum	48.83	34.3	38.02	26.7
Barley	26.06	20.5	44.31	34.8
Oats	20.26	20.8	38.97	40.0
Peanuts	76.88	16.6	88.04	19.0

Source: Economic Research Service. Available at *http://www.ers.usda.gov/data/CostsandReturns/*.

Table 2—Energy Related Inputs Relative to Total Operating Expenses for Selected Livestock, 2007–2008

Commodity	Unit	Fuel		Feed	
		$/unit	Percent of operating costs	$/unit	Percent of operating costs
Milk	Per cwt sold	0.76	5.2	11.16	76.5
Hogs	Per cwt gain	1.81	3.5	29.61	57.6
Cow-calf	Per bred cow	66.42	10.1	71.52	10.8

Source: Economic Research Service.

[7] The EPA model estimates the impact on producer surplus, a concept similar to net farm income.

Table 3—Estimated Impacts of H.R. 2454 on Energy Prices

	2015	2020	2025	2030	2035	2040	2045	2050
$ per ton CO_2e (2005 $)								
Allowance price:								
EPA [1]	12.64	16.31	20.78	26.54	33.92	43.37	55.27	70.40
EIA [2]	20.96	29.95	42.80	61.16				
Percent change from baseline								
Electricity price:								
EPA	10.7	12.7	14.0	13.3	16.9	24.0	29.1	35.2
EIA	6.1	4.1	2.7	19.7				
Natural gas price:								
EPA	7.4	8.5	8.6	10.4	14.3	18.9	24.1	30.9
EIA	2.2	4.7	6.2	17.1				
Petroleum price:								
EPA	3.2	4.0	4.7	5.6	7.2	9.0	11.4	14.6
EIA	7.3	8.4	10.0	13.8				

[1] Source: EPA, June 23, 2009. The EPA analysis of H.R. 2454 can be found at: *http://www.epa.gov/climatechange/economics/economicanalyses.html.*

[2] Source: EIA, August 4, 2009. The EIA analysis of H.R. 2454 can be found at: *http://www.eia.doe.gov/oiaf/servicerpt/hr2454/index.html.*

Table 4—Prices Paid By Farmers, Energy Related Agricultural Inputs, Various Scenarios

Item	EPA short term (2012–18)	EIA short term (2012–18)	EPA medium term (2027–33)	EPA long term (2042–48)
Average annual percent change from reference scenario				
Fuel	2.6	5.3	4.6	9.3
Fertilizer	0.3	1.7	8.4	17.6

Table 5—Effects of Energy Price Increases on Nominal Per-Acre Costs of Production, 2012–2018 Averages

(Percent Change Shown in Parentheses)

Commodity	EPA price scenario	EIA price scenario
Corn	1.44 (0.4%)	4.72 (1.5%)
Sorghum	1.52 (0.9%)	3.71 (2.2%)
Barley	0.85 (0.6%)	2.41 (1.6%)
Oats	0.69 (0.6%)	1.97 (1.7%)
Wheat	0.80 (0.6%)	2.31 (1.7%)
Rice	3.74 (0.7%)	9.14 (1.7%)
Upland cotton	1.76 (0.3%)	4.56 (0.9%)
Soybeans	0.55 (0.4%)	1.43 (1.0%)

Table 6—Effects of Energy Price Increases on Planted Acres, 2012–2018 Averages

(in 1,000 Acres, Percent Change Shown in Parentheses)

Commodity	EPA price scenario	EIA price scenario
Corn	−27 (−0.0%)	−89 (−0.1%)

Table 6—Effects of Energy Price Increases on Planted Acres, 2012–2018 Averages—Continued

(in 1,000 Acres, Percent Change Shown in Parentheses)

Commodity	EPA price scenario	EIA price scenario
Sorghum	−26 (−0.3%)	−48 (−0.7%)
Barley	−2 (−0.1%)	−6 (−0.1%)
Oats	−10 (−0.3%)	−25 (−0.7%)
Wheat	−63 (−0.1%)	−176 (−0.3%)
Rice	−3 (−0.1%)	−8 (−0.3%)
Upland cotton	−7 (−0.1%)	−20 (−0.2%)
Soybeans	4 (0.0%)	19 (0.0%)
Total	−133 (−0.1%)	−354 (−0.1%)

Table 7—Effects of Energy Price Increases on Farm Level Prices, 2012–2018 Averages

(Percent Change Shown in Parentheses)

Commodity	EPA price scenario	EIA price scenario
Corn ($/bu)	0.00 (0.1%)	0.01 (0.3%)
Sorghum ($/bu)	0.01 (0.2%)	0.01 (0.4%)
Barley ($/bu)	0.00 (0.1%)	0.01 (0.3%)
Oats ($/bu)	0.00 (0.1%)	0.01 (0.4%)
Wheat ($/bu)	0.01 (0.1%)	0.02 (0.3%)
Rice ($/cwt)	0.01 (0.1%)	0.03 (0.3%)
Upland cotton (¢/lb)	0.04 (0.1%)	0.11 (0.2%)
Soybeans ($/bu)	0.00 (0.0%)	0.00 (0.0%)
Soybean meal ($/ton)	0.00 (0.0%)	0.03 (0.0%)
Soybean oil (¢/lb)	0.00 (0.0%)	0.01 (0.0%)

Table 8—Effect of Energy Price Increase on Feed Costs and Livestock Production, 2012–2018 Average

(Percent Change From Baseline)

Commodity	EPA price scenario	EIA price scenario
Beef:		
Feed costs	0.1%	0.1%
Production	−0.0%	−0.1%
Pork:		
Feed costs	0.1%	0.2%
Production	−0.0%	−0.0%
Young chickens:		
Feed costs	0.0%	0.2%
Production	−0.0%	−0.0%
Milk		

Table 8—Effect of Energy Price Increase on Feed Costs and Livestock Production, 2012–2018 Average—Continued

(Percent Change From Baseline)

Commodity	EPA price scenario	EIA price scenario
Feed costs	0.1%	0.3%
Production	−0.0%	−0.0%

Table 9—Effects of Energy Price Increase on Farm Income, 2012–2018 Average

(Billion Dollars, With Percent Change From Baseline in Parentheses)

Commodity	EPA price scenario	EIA price scenario
Cash receipts:		
Crops	0.02 (0.0%)	0.08 (0.0%)
Livestock	0.03 (0.0%)	0.12 (0.1%)
Total cash Receipts	0.05 (0.0%)	0.20 (0.1%)
Total production expenses	0.80 (0.3%)	1.91 (0.6%)
Net farm income	−0.76 (−0.9%)	−1.72 (−2.1%)

Table 10—Effects of Energy Price Increases on Per-Farm Variable Cash Production Expenses for Fruit and Vegetable Sector

Scenario	Vegetable and melons		Fruit and tree nuts		Fruits, tree nuts, and vegetables	
	Dollars	Percent	Dollars	Percent	Dollars	Percent
Short term:						
EPA, with rebate	1,275	0.44	758	0.45	909	0.44
EIA, with rebate	2,616	0.91	1,398	0.82	1,754	0.86
Medium term	6,134	2.13	2,933	1.72	3,869	1.89
Long term	12,387	4.29	5,831	3.42	7,747	3.78

Table 11—Estimated Impacts on Per-Acre Variable Costs of Production of Higher Energy Prices Under an Emissions Cap-and-Trade System

($2005/Acre, Percent Change From Baseline in Parentheses)

Crop	Short-term (with rebate)	Medium-term (no rebate)	Long-term (no rebate)
Corn	1.19 (0.4%)	12.02 (4.6%)	25.19 (9.6%)
Sorghum	1.26 (0.9%)	5.45 (3.9%)	11.30 (8.0%)
Barley	0.70 (0.6%)	5.00 (4.1%)	10.44 (8.5%)
Oats	0.57 (0.6%)	4.12 (4.4%)	8.66 (9.3%)
Wheat	0.66 (0.6%)	4.94 (4.5%)	10.34 (9.5%)
Rice	3.09 (0.7%)	13.48 (3.1%)	28.08 (6.5%)
Upland cotton	1.46 (0.3%)	7.90 (1.8%)	16.44 (3.7%)

Table 11—Estimated Impacts on Per-Acre Variable Costs of Production of Higher Energy Prices Under an Emissions Cap-and-Trade System—Continued

($2005/Acre, Percent Change From Baseline in Parentheses)

Crop	Short-term (with rebate)	Medium-term (no rebate)	Long-term (no rebate)
Soybeans	0.45 (0.4%)	2.50 (2.2%)	5.19 (4.6%)

Table 12—Estimated Impacts on Net Farm Income of Higher Energy Prices Under an Emissions Cap-and-Trade System

($2005 Billion, Percent Change From Baseline in Parentheses)

Item	Short-term	Medium-term	Long-term
Total receipts	0.0 (0.0%)	0.4 (0.2%)	0.9 (0.3%)
Total expenses	0.7 (0.3%)	2.7 (1.1%)	5.6 (2.2%)
Fuel, oil and electricity	0.7 (6.4%)	1.3 (11.1%)	2.6 (22.2%)
Fertilizer and lime	< 0.1 (0.3%)	2.0 (9.5%)	4.3 (19.9%)
Net farm income	−0.6 (−0.9%)	−2.4 (−3.5%)	−4.9 (−7.2%)

USDA data based on EPA results, selected time periods.

Table 13. Annuity Impacts on Producer Surplus/Farm Income, by Region.

Region	billion (2004) dollars annualized annuity value
Corn Belt	6.4
Great Plains (no forestry)	2.9
Lake States	1.6
Northeast	0.4
Rocky Mountains	1.5
Pacific Southwest	0.7
Pacific Northwest	0.7
South Central	2.3
Southeast	3.4
South West (no forestry)	1.9
U.S. Total	22

USDA analysis based on FASOM simulations provided by EPA.

Appendix A—The Food and Agricultural Policy Simulator (FAPSIM)

The Food and Agricultural Policy Simulator (FAPSIM) is an annual, dynamic econometric model of the U.S. agricultural sector. The model was originally developed at the U.S. Department of Agriculture during the early 1980s.[8] Since that time, FAPSIM has been continually re-specified and re-estimated to reflect changes in the structure of the U.S. food and agricultural sector. The model includes over 800 equations.

The model contains four broad types of relationships: definitional, institutional, behavioral, and temporal. Definitional equations include identities that reflect mathematical relationships that must hold among the data in the model. For example, total demand must equal total supply for a commodity at any point in time. The model constrains solutions to satisfy all identities of this type.

[8] Salathe, Larry E., Price, J. Michael, and Gadson, Kenneth E. "The Food and Agricultural Policy Simulator." *Agricultural Economics Research,* (34(2)): 1–15, 1982.

Institutional equations involve relationships between variables that reflect certain institutional arrangements in the sector. Countercyclical payment rates calculations are example of this type of relationship.

Definitional and institutional equations reflect known relationships that necessarily hold among the variables in the model. Behavioral equations are quite different because the exact relationship is not known and must be estimated. Economic theory is used to determine the types of variables to include in behavioral equations, but theory does not indicate precisely how the variables should be related to each other. Examples of behavioral relationships in FAPSIM are the acreage equations for different field crops. Economic theory indicates that production should be positively related to the price received for the commodity and negatively related to prices of inputs required in the production process. Producer net returns are used in the FAPSIM acreage equations to capture these economic effects. Additionally, net returns for other crops that compete with each other for land use are included in the acreage equations. While the model covers the U.S. agricultural sector, trade for each commodity is included through econometrically-based export equations.

For the most part, FAPSIM uses a linear relationship to approximate the general functional form for each behavioral relationship. Generally, the parameters in the linear behavioral relationships were estimated by single equation regression methods. The large size of the model precludes the use of econometric methods designed for systems of equations. Ordinary least squares were used to estimate the majority of the equations. If statistical tests indicated the presence of either autocorrelation or heteroscedasticity in the error structure of an equation, maximum likelihood methods or weighted least squares were used.

Temporal relationships are empirical equations that describe the inter-relationships between variables measured using different units of time. For example, not all of the variables in FAPSIM are measured using the same concept of a year. Commodity data are reported on a marketing year basis; budgetary data are reported on a fiscal year basis; and farm income data are reported on a calendar year basis. As a result, empirical equations are sometimes needed to establish relationships among variables in these different temporal categories. For example, cash receipts for crops are reported on a calendar year basis, but production and price information for crops are on a marketing year basis. Equations are used in FAPSIM to estimate cash receipts using information from both marketing years that overlap the calendar year.

Commodities included in FAPSIM are corn, sorghum, barley, oats, wheat, rice, soybeans, (including product markets for soybean meal and soybean oil), upland cotton, cattle, hogs, broilers, turkeys, eggs, and dairy. The dairy model contains submodels for fluid milk, evaporated and condensed milk, frozen dairy products, cheese, butter, and non-fat dry milk. Each commodity submodel contains equations to estimate production, prices, and different demand components. FAPSIM also includes submodels to estimate the value of exports, net farm income, government outlays on farm programs, retail food prices, and consumer expenditures on food. All of the submodels are linked together through the variables they share in common.

The CHAIRMAN. Thank you, Doctor. I understand the information presented today is an expanded and refined version of an earlier study done by USDA. Can you walk us through the differences in modeling assumptions and underlying input data that is used here and not in your previous examination, and why did you decide to focus on increased energy costs?

Dr. GLAUBER. Well, primarily the most significant impact, at least—this bill will affect agriculture in several ways, and if you focus on the cost side, because of the emissions caps that are in this bill that will raise energy prices. There are several analyses of what the impacts will be. EIA has put out an analysis, and there have been several private analyses as well. Those will affect energy prices. A lot depends on our assumptions in terms of what the estimated effects on fuel prices will be. We also know what the effects would be on natural gas. Natural gas can potentially affect fertilizer prices. And because of that, we can then translate that into—and what we do in our modeling is look at these increased price effects and look at what the impact will be on agricultural production.

Higher energy prices, in general, raise the cost for these producers, which cause them either to grow less of a particular crop, or switch to other crops. When you have those sorts of production impacts then prices rise partially offsetting the impact, because the higher prices will increase revenue, but it has another impact in the sense that it increases feed costs for livestock producers. Now that is all on the cost side, and I dare say that looking at some of the other studies that have been done, certainly, most people go about the modeling in a very similar way. That is they look at what the impacts on the energy prices are going to be, and then translate those into the production cost impacts.

The other side of this, though, is in part what will be discussed tomorrow, which I think is as, if not more, significant, and that is the offset side. It is significant because offsets, one, are important for reducing the cost of the cap-and-trade emissions by having offsets. It mitigates the impact on energy prices so that is important, not just for agriculture, but, obviously, for all sectors of the economy. The second thing is that offsets have a potential income source for producers although, as I mentioned in my opening statement, that will differ across regions and across commodities.

And, third, are the land use implications. If offsets are—if the practice is used to gain offset credits through afforestation, for example, that is putting agricultural land or pasture land and planting forests then obviously that is taking land out of production and has potential implications for prices that way.

The CHAIRMAN. What are your initial thoughts on the other analyses that are out there? Is there any of them that you can think that are completely off base?

Dr. GLAUBER. Well, I have—and I can't say I have seen all of them. Certainly some of my colleagues behind me—I am very familiar with the FAPRI modeling results and very familiar with the Texas A&M modeling results, and Doane's modeling results, and I would say that by and large they are very similar to the way we approached the problem. The differences, largely, are in what the assumptions are on the energy price impacts. Again, we used the Environmental Protection Agency's impacts, estimated impacts, on fuel prices like gasoline, natural gas, electricity. In this analysis, we broadened the analysis to also include EIA impacts. That was not available to us when we put out the preliminary report in July, but EIA has since come out with analyses.

But, if, for example, you consider scenarios that have far higher price impacts then those will have far larger impacts on production costs. But I would say, generally, the modeling that was used that is looking at production cost data and looking at those impacts how higher energy prices will affect production costs, I think that we pretty much share a common modeling framework there.

The CHAIRMAN. Thank you, Doctor. And, last, do you think the agriculture sector would be disproportionately affected by higher energy costs compared to other sectors?

Dr. GLAUBER. Well, there is no question that agriculture is an energy intensive sector, and in that sense they will be affected. There are other sectors, obviously, that are highly energy intensive as well. I do think the offsets provide opportunities, however, to offset the production cost increases. So, agriculture, while it will be hit by higher energy costs, I also think it has unlike a number of other—because it is an uncovered sector, it does have opportunities to provide offsets which could result in income for producers.

The CHAIRMAN. Thank you, Doctor. The chair recognizes the gentleman from Virginia, Mr. Goodlatte.

Mr. GOODLATTE. Thank you, Dr. Glauber. Those farmers and ranchers who will be able to have some of those offsets are hit or miss, right? Some will be able to take advantage but some won't?

Dr. GLAUBER. It is certainly true that a lot depends on where you are in the country, what sort of commodity you would grow, what sort of opportunities you would have that way.

Mr. GOODLATTE. So this legislation is really massive picking of winners and losers by government *fiat* as opposed to allowing farmers to fend for themselves and compete for themselves. They will be put at the mercy of this legislation depending upon what crops they grow, what area of the country they operate in, what climates they operate in, and what types of energy sources they use.

Dr. GLAUBER. Well, I would just say, and, unfortunately, just the way the testimonies are broken out here, I don't have a lot of the information on offsets in the current testimony, but in tomorrow's testimony you will see I have provided a table that shows potential offsets from a variety of agricultural practices that would be, potentially, available to not just someone using no-till, but also for livestock producers or others using—would reduce greenhouse gas emissions through reductions in methane.

Mr. GOODLATTE. These analyses you provided us are preliminary on the effects of higher energy prices. Can we expect a complete analysis on all agriculture production inputs such as pesticides, seed, equipment, machinery, steel, and other supplies needed for agricultural operations? Is USDA conducting any studies of H.R. 2454's effect on ag processors or manufacturers?

Dr. GLAUBER. We have not. Certainly as you go down or up the marketing chain one way or the other, there are a lot of energy costs imbedded in those industries and, unfortunately, we don't have a lot of data on that. USDA doesn't. Our data mainly is at the farm level.

Mr. GOODLATTE. And I am also aware that there have been requests for state by state analysis or more detailed analysis for livestock and specialty crops, so what is the status of those economic assessments?

Dr. GLAUBER. Well, we do include a number of regional breakouts here. Certainly if you are looking at production cost data in the aggregate that is available by state. That is pretty easy to put together, and we have that and we are more than happy to provide it to the Committee. We also, using the Economic Research Service, their survey data on cost production, were able to break out the energy cost by farm, various sorts of farming operations by region, not down to the state level but down to a regional level. That would give a pretty good indication for your area or anyone's, and some of that is in this material summarized in maps, *et cetera*, but we have the raw data that we certainly would be happy to provide in tabular form.

Mr. GOODLATTE. And if they have been completed, how many acres will move from crop and pasture production into forestry, and what impact will that have on grain prices?

Dr. GLAUBER. Well, there again there are a number of models out there that have looked at this issue. What I will do as a brief preview of what I am going to do tomorrow, we do look at the analysis that was provided to us from EPA that was based on the Texas A&M so-called FAPSIM model, and in that analysis, the analysis that was done back in March of 2009, they show a substantial number of acres going into forestland, some 60 million by the year 2050. Now in our own studies of sequestration, some of which were done by the Economic Research Service, you get a very different pattern over the near term. With low carbon prices you see a lot of land going into—or a lot of farmers adopting no-till practices, a number of what I would consider less disruptive practices in terms of their effect on production.

With higher carbon prices then the real issue at that point is where would the carbon come from, and is that sufficient enough to—with carbon prices say at $50 or $60 a ton, is that sufficient enough to have a producer devote land and put in a long-term set-aside by planting trees.

Mr. GOODLATTE. I take it that the long-term prognosis is that tens of millions of acres are headed into forests.

Dr. GLAUBER. Well, that is certainly the case with the EPA analysis, and they show that some——

Mr. GOODLATTE. And I take it that the incentives are not going to be there since wood is a carbon-based source of energy, the incentive is not going to be there to be able to burn those trees to use that as a source of energy in the future. They are just a carbon sink. At some point in time, we are going to have to figure out what to do with all those trees. They are going to die and release that carbon back into the atmosphere at some point.

Dr. GLAUBER. The whole idea of a carbon sink would be permanent to put that in trees.

Mr. GOODLATTE. But it is a very problematic thing for farmers to lose the productive use of their land. The last question, if I might, Mr. Chairman, will Secretary Vilsack travel to Copenhagen to represent U.S. agriculture interests during the climate change discussions, and since we are still learning so much about the effects of H.R. 2454, I am curious what his message might be on behalf of agriculture.

Dr. GLAUBER. Congressman, I can tell you that he is traveling to Copenhagen. I think what he will—I can't speak for the Secretary here, but I know that, just based on what he has said in the past, that he believes there is a real good possibility for agriculture in the climate change legislation and he will be promoting the offsets and the mechanisms that producers can potentially gain from this.

The CHAIRMAN. The chair thanks the gentleman and recognizes the gentleman from Ohio, Mr. Boccieri.

Mr. BOCCIERI. Thank you, Mr. Chairman. I had some specific questions for you, Doctor. I don't claim to be a climatologist or a scientist. In fact, I graduated with a degree in baseball and minor in economics when I was in college, but we have to pay attention to what our national security experts are suggesting. I am interested, after serving now for 15 years in the military, why the Department of Defense and why the CIA are saying that we need to elevate this from a debate on—a national debate to a matter of national security, and where, in fact, every candidate running for the highest office in this country last year suggested that this is a threat to national security. Did you take that into account in your analysis?

Dr. GLAUBER. The short answer is no. What we don't look at, and it is a legitimate issue, is what the effects of climate change itself are on agriculture. I believe that you will have the opportunity to ask one of the panelists on the next panel on that issue. But let me just say briefly, there have been a lot of studies on what the potential costs of agriculture will be or potential cost of climate change on agriculture, or global warming, as it were. And certainly if you look at in the short run, particularly, with the small increases in global temperatures of the 1° to 2° centigrade level that you can actually see growth in agriculture that is actually for things like grains, which are highly adaptable to climate. They actually do thrive and do pretty well.

But at the same time, most of these studies then show that as global warming increases that you begin to see a sharp deterioration in yields. And more disturbing is the variability, and that is what is expected. What most are showing, most of these studies show a lot of variability in climate, and we know what that does for agriculture.

Mr. BOCCIERI. I know USDA has conducted analysis of the possible effects to U.S. farmland from increasing climatic variability. Has the USDA concluded that climate change is real and that it is affecting farmlands across the international spectrum?

Dr. GLAUBER. I think certainly the USDA believes that climate change is a problem that needs to be addressed.

Mr. BOCCIERI. Well, I would like to reiterate some of the remarks some of our retired generals who have served under both Presidents, Democratics and Republicans alike, they said that climate change would provide the conditions that will extend the war on terror. It is fairly interesting that we are having this discussion because the farmer and the landowner that we are trying to protect we also have to take into account the national security aspects of this as well. I want to know, specifically, if you believe and the USDA believes that the offsets that are provided to the landowner and farmers will offset if there are marginal increases. In Ohio we have regulated utilities. And the industry is heavily regulated so any cost increases has to go before a nonpartisan board, and so I hope that those were taken into account in your study as well. But I want to know, specifically, from you if you think that the offsets will significantly reduce any of your projected increases.

Dr. GLAUBER. The answer is yes. I think offsets will certainly provide an income source for producers that will allow them to offset the impacts of——

Mr. BOCCIERI. Would that be greater? Will the income be greater than the cost?

Dr. GLAUBER. Yes, and our analysis shows that the income will be greater. I think the most important or the more important question is how the offset—how any offset provisions are set up and established and administered because the concerns that have been expressed by others about potential impacts on food prices, *et cetera*, you want to make sure you are setting up an offset program the right way.

Mr. BOCCIERI. Okay. Thank you, Mr. Chairman.

Mr. GOLDEN. I thank the gentleman, and recognizes the gentleman from Louisiana, Mr. Cassidy.

Mr. CASSIDY. Thank you. Page 18, your graph shows that the Mississippi Portal is going to be particularly affected by decreases in farm business net cash income. Why is the Louisiana, Mississippi, Arkansas, Tennessee area particularly affected?

Dr. GLAUBER. One reason is because on a per-acre basis the impacts for cotton and rice are high. As you know, they are both high input cost and they are also both energy intensive——

Mr. CASSIDY. Now this analysis, I don't mean to interrupt——

Dr. GLAUBER. No, go ahead.

Mr. CASSIDY. In this analysis, do you include aquaculture, the crawfish and cat fish farming operations?

Dr. GLAUBER. We did not explicitly analyze aquaculture. However, I can say because obviously they consume—they will be affected much like other livestock producers would be affected.

Mr. CASSIDY. Now it is my concern since those particular operations are low margin and they are facing stiff competition from countries like China, which have basically said they are not going to follow this, they are going to decrease their rate of increase sort of thing, but we can't monitor unless we pay for it, that the margins will be terribly affected. Clearly, it is going to be hard to reforest aquaculture. It is going to be more difficult to—I guess you grow cypress trees. So I guess my question is, do we know what is going to happen to their farm income and what that will do, specifically, as regards their ability to compete with their foreign competitors?

Dr. GLAUBER. Well, once again we say, and it is important to recognize that because of the provisions that would essentially give rebates to fertilizer producers that the price increases for things like nitrogen are going to be very muted through 2025, so you are talking about a pretty long way out where the price impacts, in general, from any sort of cap-and-trade system would be fairly small.

Mr. CASSIDY. But as you point out though that the costs are still not insignificant and also the transportation cost would be still unaffected by this, correct?

Dr. GLAUBER. To the extent that fuel costs were, yes.

Mr. CASSIDY. Which I gather those are fairly fuel intensive operations as well. So, okay, the intrinsic, intensive or the EITE, the energy-intensive and trade exposed industries, that presumes that other states, other nations, will actually adopt something such as cap-and-trade or a carbon tax or whatever, but the example we just used, China, they probably won't if we listen to what they are saying now. So is there a provision to extend the rebates to fertilizer producers if the energy-intensive and trade exposed industries are continually exposed?

Dr. GLAUBER. I believe the House bill has some border tax adjustments beyond the year 2030 that could potentially take that into——

Mr. CASSIDY. Border tax?

Dr. GLAUBER. Border tax adjustment.

Mr. CASSIDY. Now that sounds like a tariff.

Dr. GLAUBER. It sounds like a tariff.

Mr. CASSIDY. Now that sounds illegal according to WTO. Do we know that those provisions would pass muster with WTO?

Dr. GLAUBER. I do not. That has been—I will say that the WTO had been very concerned about that. There has been a lot of talk in the WTO recognizing that a climate treaty is likely, and the WTO has been looking at that issue and published a report just last year or earlier this year talking about the potential of border tax adjustments and how they should be treated.

Mr. CASSIDY. Frankly, if I was a crawfish farmer or a rice farmer, I may be planting cypress trees right now, which brings me to my next point. Just in the aggregate, we are talking about the offsets having an offsetting affect upon the loss in farm income, but it is important to note that there are some regions of the country which are more easily reforested and others that are less easily reforested. So, again, if we are speaking about the areas in which we are flooding fields, coastal Louisiana, for example, to grow rice, it will be more difficult to reforest those. So I just want to make the point that we do ourselves a disservice in this conversation to lump the offsets from reforestation with the net income loss from the other measures of this bill. Would you agree with that or disagree?

Dr. GLAUBER. Well, as I said earlier, there is no question that some producers are going to have greater opportunities than others to take advantage of particular offset provisions. I don't think that necessarily means that one is excluded just because one can't grow trees, for example. There are other things, changes in diets for animals, that can result in fewer greenhouse gas emissions, and those could be potential offset sources.

Mr. CASSIDY. If I could have 30 more seconds. Will you be able to provide us with something specific for the aquaculture industries in terms of the impact upon net income?

Dr. GLAUBER. I would be more than happy to do that in a follow up.

Mr. CASSIDY. That would be great. Thank you.

The CHAIRMAN. The chair thanks the gentleman and recognizes the gentlewoman from Colorado, Ms. Markey.

Ms. MARKEY. Yes, thank you, Mr. Chairman. Thank you, Dr. Glauber, for this update. I have some questions on your modeling for future energy prices. Have you analyzed whether or not a cap-and-trade system with ag offsets would actually help to stabilize energy prices for ag in the future? It looks like from *table 3* that electricity, that input cost will continue to increase. Does this take into account the increased use, whether it is nuclear or natural gas, wind, energy, on how they will stabilize our energy prices in the future, so what can you say about the future of energy costs?

And then, second, did your modeling take into consideration the cost of doing nothing, particularly given the volatile swings in energy costs that we have now? Look just last year when we were paying for $4.00 a gallon gas. Did you take into consideration what would be the increased cost for agriculture if we do nothing?

Dr. GLAUBER. Thanks. Insofar as the first question is concerned what we did is we utilized the energy price impacts that were estimated by EPA and EIA. Now both of those have specific scenarios that they considered, and I believe both of these scenarios that we looked at have a development of nuclear power and development of other renewables that will help meet these goals. In regards to your second question, no, what we considered was sort of the current environment and I assume current what we have under our baseline in terms of energy price. And we didn't look at any variability or probabilistic model there. We just considered what our estimates are for energy price increases over the next 10 years.

Ms. MARKEY. So just to be clear then, on *table 3* then according to EPA the impact on energy prices continues to really increase dramatically until 2050, which is where your modeling went up to 2050.

Dr. GLAUBER. Absolutely. They are increasing in tandem, in lock step with the allowance prices, and because allowance prices are soon to be increasing because of—allowance prices are increasing by roughly five percent per year and so because of that energy prices are increasing accordingly.

Ms. MARKEY. Thank you.

The CHAIRMAN. The chair thanks the gentlewoman and recognizes the gentleman from Ohio, Mr. Latta.

Mr. LATTA. Thanks, Mr. Chairman. Thank you very much for being with us today. If I could just go over to your *figure 3* on the graph on page 17. I am kind of interested in this. I represent, to just kind of give you an idea, northwest and north central Ohio. I represent across northern Ohio underneath Michigan. I represent about halfway down Indiana, and then I go about 140 miles east. And I look at this, and it shows only according to EPA, it says there is only one percent decline or less in income and then getting into another part of my district it says 1–2 percent. But I am kind of curious about this because all of the different figures and facts that we have examined and seen since the debate started on cap-and-tax that we are going to get hit a lot harder. And one of the figures that we saw was through the Heritage Foundation when they put together—since Ohio uses about 86 to 87 percent of all of our energy is coal-based, Indiana next door is around 94, I believe, and I believe it is 80 percent of all my rural electric co-ops in Ohio are co-generated where they get their energy from.

And when I look at these numbers especially with the—that I represent the largest ag district in Ohio, and also interestingly enough I represent the largest manufacturing district in Ohio, that farmers in this area are only going to be affected by a one percent decline or less in net cash income when we see all these other statistics showing that because of our high coal usage for energy usage on the farms we are going to be affected a lot more. So I am just kind of curious on that to begin with.

Dr. GLAUBER. Sure. One, realize that we are looking at our short-terms results, at price increases that will essentially be seen for the electricity sector and the petroleum sector. Fertilizer producers, which is a big component of your producers costs, energy-related costs, will be exempt because of the rebates provided under H.R. 2454. So in that case the main source is coming from higher fuel costs, and again based on EPA and EIA estimates, EIA being roughly or a little bit higher than EPA, in some cases about twice that, you are talking about four percent sort of increase for electricity under the EIA when petroleum prices are up around eight percent by 2020.

And so over the near term those are pretty small costs. That is an increase—again if you look at total cost of production remember that fuel costs are about 5–6 percent, so you are increasing what is an increase in energy prices on the order of 5–10 percent. Energy prices there only comprise for the total production cost of these producers in the ten percent range, 10–15 percent range, so it is small when it is worked through that way. Now if you add fertilizer, of course it roughly doubles that impact.

Mr. LATTA. Well, again, I guess when you look at different statistics because we are looking at some of the areas where we are seeing maybe an increase with fuel prices in gasoline and diesel because, of course, when these have to be refined, and I have refineries right around my district, that you are looking at in some cases about a 50 percent increase predicted into the long term. At the same time when you figure into this is that, I have like probably a lot of other folks that are on this Committee, a lot of my farmers not only farm full time but they have to work off the farm full time. When you look at the job hit on and off the farm my concern is we have a lot of farmers that rely on that off-farm income to make sure they can keep farming. When you put these two things together with the loss of income on the farm and then the question—we have been hit tremendously. According to the National Association of Manufacturers we have the ninth largest manufacturing district in the country. Now I am down to 15. I don't even want to see what the next number is going to be.

But what I am really concerned about is that we are just seeing the net cash farm income going down and with these increased costs because again we have to have both in our area for a lot of these people to survive.

Dr. GLAUBER. Well, again, insofar as agriculture is concerned where we did our estimations the energy price impacts over the short run should be small. I think that, again, over the longer run, as you say, if you look at the EPA and EIA analyses, as one goes out to 2030, for example, one begins to see price impacts, the energy price impacts out at the that level or at 2030, more in the range of 10–14 percent. If you go out to 2050, at least with the EPA analyses they are up more in the 30–35 percent range for at least natural gas and electricity. But, in the short run, particularly with the fertilizer rebates, that the impacts are—again, our estimates would show that those impacts are actually quite small.

Mr. LATTA. Mr. Chairman, if I can just ask one last question. Okay. If you go in your farthest out-years of a 30 percent increase, I guess my question is on the smaller family farms. How are they going to sustain because I am just thinking about those like my family and my wife's family, they have been on the same farm since the 1830's, and my brother-in-law's farm, my father-in-law is pretty much retired, but my nephews are looking at whether they want to farm in the future. My question is with this 30 percent, when you are looking at these cost increases, how is the smaller farmer going to survive in the future?

Dr. GLAUBER. Well, if you translated the cost, those price increases directly into the production cost for 2050, they would be large costs. Again, if you are talking about as a percent of total production cost of being some 10–15 percent and increasing 10 percent or 30 percent, you are talking three, four, five percent potential hit on production costs, which is substantial. That said, that analysis is—we are talking about something in 2050, and we know that if you look back to the 1970's and look at the current situation, we know our energy efficiency has improved dramatically over that time. So, again, one presumes—we didn't assume it in our analysis because we were conservative in that regard.

But the issue is whether or not you have switched to more energy efficient technologies and things that would lessen that impact, switch to less energy intensive crops. And then, because of the offset side of the equation there is potential for making up those costs, particularly for Ohio where there would be a lot of potential things that could be done, tillage practices, *et cetera*.

Mr. LATTA. I thank the Chairman.

The CHAIRMAN. The chair thanks the gentleman and recognizes the gentleman from Michigan, Mr. Schauer.

Mr. SCHAUER. Thank you, Mr. Chairman. Dr. Glauber, as I was looking at your testimony, I didn't find that the analysis took into account impacts of increased bioenergy production. I wonder if you could talk about that.

Dr. GLAUBER. In the analysis that was presented here, we did not. You are right. With higher energy prices that can potentially bring in more biofuel production, particularly for things like cellulosics, where I think people have talked about how the technologies there, the costs of producing cellulosic ethanol is quite high currently, but relative to higher energy prices it could potentially bring in production. And I think that some of the models that have been done show that. Now, remember, in the long run that most of our models in our baseline show higher biofuel production and because of the mandates, *et cetera*, under the Energy Act there are limits to what, for example, could potentially be produced by starch-based ethanols. But, on the cellulosic side it could potentially speed development of some of those technologies.

Mr. SCHAUER. Do you have any sense of the positive job impacts from that increased bioenergy production?

Dr. GLAUBER. I don't offhand. I can certainly—we have done studies on employment effects of biofuels, *et cetera*, and could certainly provide those.

Mr. SCHAUER. I come from the Midwest, as did the previous speaker, so I am very concerned, ultimately, about the impact on jobs. Agriculture is the second largest industrial sector in Michigan that is growing. That is a very positive sign. We have a very diverse agricultural sector as well. I wonder, you used some of the EPA's data. I want to make sure that we are looking at this in a relative and dynamic way. EPA, if we don't pass legislation, is going to be implementing carbon reductions across the economy. I wonder if you have that kind of relative comparison or whether you take that into account. Again, sort of the question is what if we do nothing given the EPA is going to be moving forward. I am not sure the public really understands that.

Dr. GLAUBER. It is a good question, and, frankly, in our baseline we did not—what our baseline assumes is sort of business as usual relative to current world, and so we haven't looked at a regulatory structure and what those potential effects would be.

Mr. SCHAUER. Candidly, I am very afraid of what would happen if the EPA goes forward, and I think that is something that we need an addendum to this report to take your best guess of what the impact would be on agriculture if the EPA went ahead on their own. I am very, very concerned about that.

Dr. GLAUBER. Well, just offhand, if I may, one of the key issues is what would happen to offsets, and if this were just in terms of the regulatory side in terms of providing restrictions and imposing costs that would ultimately be translated through the energy cost side of this. The flip side is would there be benefits on the other side, on the offset side, and I think there is where the problems would lie.

Mr. SCHAUER. And this Committee worked very hard to protect agriculture and make sure the cap-and-trade program didn't apply to farms, and we want to keep the USDA fully in its present position to oversee and support farming activity. Just also under the theme of sort of looking at this in a relative and dynamic way, we also need to take into account what some of our international competitors are doing. This is a global industry and some of our competitors are setting voluntary carbon caps. I wonder if you would take that into account in terms of looking at pricing.

Dr. GLAUBER. There again, we did not take into account what is going on internationally. I think that is an issue. It certainly affects not just the cost side of the equation. That is what competitors might be paying but it would also potentially affect the offset side. That is, if we are looking at international offsets, which is again a big part of H.R. 2454, that too would have obviously a big impact.

Mr. SCHAUER. And the gentleman from Louisiana brought up the issue of sort of border adjustments or border protections. I strongly supported that within this bill and clearly we can't allow our farmers and our economy to be at a disadvantage, because in some form or fashion there will be a reduction in greenhouse gases in this country. If our competitors are not doing likewise—that will cost us jobs—so I just wanted to editorialize on that point.

Dr. GLAUBER. And the key thing there is just to follow up as well is being able to do this in a WTO compliant way.

Mr. SCHAUER. Thank you. I yield back.

The CHAIRMAN. The chair thanks the gentleman. The chair would ask all Members to try to stay to the 5 minute rule. We have, obviously, a lot of Members with interest here, so we have a second round if anyone has further questions. I now recognize the gentleman from Pennsylvania, Mr. Thompson.

Mr. THOMPSON. Thank you, Mr. Chairman. Dr. Glauber, thank you for your testimony. I want to start with a real basic and then go to something—my next question is very specific. Recently, the term *global warming* has been widely rebranded *climate change.*

Dr. Glauber, could you please explain that phenomenon and also define *climate change.*

Dr. GLAUBER. Well, I guess I don't have great definitions for *climate change,* just in the sense that we would see significant changes in climatic patterns, things like temperature and precipitation, variability of climate and moving to where we would see distributions of temperature and precipitation that would adjust—that would change over time, either favorable or unfavorable, I would characterize.

Mr. THOMPSON. Which sounds like something we have always experienced, I would say.

Dr. GLAUBER. Yes.

Mr. THOMPSON. I promised a real specific question then. Obviously, agriculture has many different elements in that industry. I want to talk about one that is—well, just one of the elements, an important one, though, in my district and important in that it meets a strategic need in our country in terms of dairy. And I will be real specific. I am trying to look at the impact—my average dairy herd is family-owned, 85 head. They have enough acreage to grow just enough corn for most of them to feed their herd. And some of the things that they are living with are transportation cost, which for the milk—and our dairymen pay that. I think you mentioned 5–10 percent is the number I heard for an increase in cost there.

Diesel and gas prices because our equipment, that is what it runs on, whether it is tractors, generators, whatever. Again, 5–10 percent was your number. Electricity costs, the Pennsylvania Public Utility Commission looked at the Waxman-Markey bill. They estimated electricity cost in Pennsylvania going up 30 percent. Equipment cost, in terms of knowing what this would do to manufacturers in Pennsylvania, and our farmers can't afford to buy new equipment too often, but when they can it even drives up the cost to use equipment. Fertilizer costs, I think your numbers you gave, I heard in your earlier testimony, was ten percent in terms of getting as much corn production as possible to feed their herd.

The processor cost, which, unfortunately, many of those can pass along to the producer in the short run. A simple question for you. How would these dairy farmers survive under this?

Dr. GLAUBER. Well, again, I think for most of the—you are talking about dairy producers in your region, which are effectively crop producers and dairy producers.

Mr. THOMPSON. But the crops they are producing are corn to feed their cows.

Dr. GLAUBER. That is right.

Mr. THOMPSON. They are not planting trees.

Dr. GLAUBER. That is right. And so in general one can talk about the cow side of it, as it were. Essentially the big impact there is on feed. Feed is very big component of a dairy producer's cost, and to the degree that feed cost will be affected dairy producers would be affected as well. Now, again, I think on the feed side because of the rebates, *et cetera,* under this bill, at least in the short run would be small. So the impact on that side of the equation would be, and certainly our analyses of dairy production, *et cetera*, don't show very large changes in herd size or profits from that industry.

Mr. THOMPSON. Let me say though right now the average farmer is losing $100 per cow per month in terms of dairy, so I would encourage you to go back and look at the competencies of whoever is doing your numbers on terms of impact on dairy. And I realize that feed is one component, and it is important, but the numbers that you in your testimony today, in your written testimony and what you have shared, transportation cost, diesel and gas operation cost. We really didn't get into the manufacturing side or what the hell it is going to drive up the cost of equipment in terms of new milking parlors, tractors, all the things that our farmers use.

I mean feed is obviously important, but I don't think we have the luxury of this—of just looking at one element. We have to look at the whole picture. I want to move on just a little bit to—well, actually I am not going to move on at this point. Maybe we will do a second round. I would appreciate it.

The CHAIRMAN. The chair thanks the gentleman, and we will do a second round. The chair recognizes the gentleman from Maryland.

Mr. KRATOVIL. Thank you, Mr. Chairman. Thank you, Doctor, for your testimony. Your analysis distinguishes among farm types and regions. My question is does your analysis distinguish between farmers from states that are already participating in cap-and-trade programs in terms of regional programs?

Dr. GLAUBER. Well, it does in the sense that the regional cost structures are imbedded in this model, so we take into account what producers in a given region, what those current costs of production are.

Mr. KRATOVIL. And what is the impact on cost, comparatively, between states that are already participating in regional cap-and-trade programs and those that are not?

Dr. GLAUBER. There I would—just looking at the data, we don't see large discrepancies between regions, in general. Where we see the biggest impact, at least it was pointed out, in one of the earlier questions is that for those crops that are highly energy intensive that they tend to be affected.

Mr. KRATOVIL. But the argument for the increase in cost under the proposed legislation is that having a cap-and-trade program would indeed increase costs, correct?

Dr. GLAUBER. Having a cap-and-trade program, well, in the sense that it affects, yes, in the sense that it affects utility prices.

Mr. KRATOVIL. So for states that were already participating in a regional program, presumably, if that is true their costs would have already gone up?

Dr. GLAUBER. Well, under this bill I am not sure. If you look at H.R. 2454 in looking at given the specifics of what the energy price impacts are estimated by EPA and EIA, then all regions will see some increases in energy prices.

Mr. KRATOVIL. Are you aware of any study that specifically is looking at the issue of those already existing cap-and-trade programs and the impact for those states as related to other states that are not?

Dr. GLAUBER. I am not aware of any—I would be happy to get back with you on that. I am not personally aware of any. That doesn't mean that there aren't studies out there, so we will look into that.

Mr. KRATOVIL. Let me go back to sort of follow up on Mr. Schauer's question. Without specifically excluding ag from EPA regulation as was done in the energy bill, is it possible that EPA could and would, in fact, regulate ag?

Dr. GLAUBER. That is better directed at EPA.

Mr. KRATOVIL. Let me ask it this way. Without such a specific exclusion, what would prohibit EPA from doing so?

Dr. GLAUBER. Well, you are right in that sense that any regulations could be structured to affect all parties. That would be at the discretion of how EPA would interpret the legislation and Court decision.

Mr. KRATOVIL. You mentioned the cost of fertilizer. What is the percentage of fertilizer that would be imported and so would not be subject to the additional cost that you are talking about?

Dr. GLAUBER. I think currently about 50 percent—we are at about 50 percent or so imported.

Mr. KRATOVIL. And 80 percent of it would not be subject to those additional costs that we are referring to?

Dr. GLAUBER. That is right.

Mr. KRATOVIL. Having spent significant time evaluating the proposed legislation given the fact that ag currently is not subject to the cap but can, in fact, participate in the offset program, what additional amendments would you suggest that we could do to further protect ag?

Dr. GLAUBER. Well, again, in my view the single most pressing important issue in this whole debate is how the offset programs would be structured. It is a very careful balance of ensuring a program that would provide ample offset opportunities across a wide range of regions and commodities, but in a way that wouldn't have those sort of unintended consequences of extremely high consumer prices, food prices, for example.

Mr. KRATOVIL. Thank you, Doctor. I will yield back.

The CHAIRMAN. The chair thanks the gentleman and recognizes the gentleman from Alabama, Mr. Rogers.

Mr. ROGERS. Thank you, Mr. Chairman. I just want to ask two quick questions. One is a follow-up to Ms. Markey's question when you were talking about your modeling and you included development of nuclear power in that modeling. Tell me more about that. We haven't built a new nuclear facility in over 30 years in this country.

Dr. GLAUBER. Let me clarify. We don't have a nuclear industry modeled in the agricultural sector models that we are using. What I was saying is that we use the projections for the impacts on energy prices that were done by EPA and EIA, and we use those scenarios that—we took the so-called reference scenarios both by EIA and EPA that assumed that nuclear capacity would be built. I might add both of them have done analyses of if it weren't built what the effects would be. I can say at least for 2030 if one looks at allowance prices, and remember that allowance prices are a rough indicator of what the energy prices would be, under the EPA scenario some $26 under the case we were looking at, and with a modified nuclear option some $30 under EIA was more like $61 under the reference price or under the reference scenario increasing to $72, so an increase if that capacity is not built in.

Mr. ROGERS. And I think that is the more realistic projection as a practical matter. The 2030 option, even if we were to start construction on some new facilities, we would be stretching it to get to that. The only other thing I wanted to ask about was when Mr. Goodlatte was talking to you, you mentioned that—you were talking about offsets in the uncovered sector that could generate some revenue for farmers. Tell me more about what you meant about how they would generate revenue.

Dr. GLAUBER. Well, in the sense that farmers can undertake practices that they would be essentially sequestering carbon under a variety of practices. It could be something like conservation, tillage or no-tillage where you would earn "X" tons per acre for undergoing a practice. Because industries in affected sectors are going to be interested in reducing their reduction commitments, they will be willing to pay and so there would be a transfer there.

Mr. ROGERS. That is all I needed. Thank you, Mr. Chairman.

The CHAIRMAN. The chair thanks the gentleman and recognizes the gentleman from Minnesota, Mr. Walz.

Mr. WALZ. Thank you for being here, Dr. Glauber. I really appreciate it. It is important for us to keep a couple things in mind. The first thing I would says is the title of this hearing was going to be the potential economic impacts of climate change on the farm sector, not H.R. 2454 but of climate change. In this argument, if I could reduce and take care of two things that I didn't have to be concerned about, one is if I did not believe against the preponderance of every single, every single major scientific organization, that human impact is leading to climate change. If I could exclude that from my reasoning and exclude that oil is at $78 a barrel at the worse recession since the 1930s, and demand is at its lowest and it is not going to go up, then we could make some debates that there is going to be a negative economic impact on farming.

The fact of the matter is when I hear people talk about what about tillable land, what about picking winners and losers, what about flooding in Louisiana, the bill won't do that, the climate will do that. I think we need to have a honest discussion. If that is not part of what you believe then that needs to be put forward to where it is, and not go after where the data shows where EPA is at, not go after the data that shows where the projections are at based on baseline data. If you want to reject the scientific preponderance of this, that is absolutely correct. I don't think we need to pick winners and losers, and I don't think it needs to be a choice in this. I think we can exercise leadership, protect the farm economy, protect the national security, and get to the heart of that.

So my question is, coming from USDA what studies are out there to show, as I have seen some, part of the climate change is not fictional global warming for the entire globe, it is the instability of climate and unpredictability which is the farmer's worse enemy. One of the things we see is a concentration of precipitation in much larger amounts in smaller days. Have you taken that into consideration?

Dr. GLAUBER. It is not taken into account in the modeling itself, in part, because to understand that a lot of these effects are—most of these studies that you mentioned, and there has been a number of studies that conclude very similar effects on agriculture. Most of those occur out in the——

Mr. WALZ. We don't have that data, and we don't have that data from USDA. How can we make a good assumption? If the world were going to stay exactly the same as it is today, as I said, no climate change is going to be a negative effect other than the usual swings or there is no change in oil prices, we might be able to determine that. I do have a study that shows, and it was one for agriculture in Illinois alone, about a 1.2° centigrade increase in climate there will show a difference of about $9.3 billion in projected losses. Now is that a scenario that is every bit as plausible as oil prices staying stable or nothing happening? Those are things we need to look at. Another study found that the value of rain-fed non-irrigated farmland in the central United States will fall 69 percent in the next 75 years because of its ability to be able to produce.

Those are part of the equation we need to come up with and decide, and I would ask and see if, Mr. Chairman, I could submit to the record—Dr. Glauber, are you familiar with the study that came out of New York University Institute for Quality and Integrity, the *Other Side of the Coin,* that talks about and looked at these things not specifically for agriculture but the economy as a whole a 9:1 cost basis. One of the best investments we can make is to get a handle on this, control our own energy needs. Like the gentleman from Virginia said, the generals understand there is a national security need, and they project it to be a positive on the investment, a 9:1 return.

Are those the type of things that should be studied in particular and in specific towards agriculture because, if I could, I would like to submit this one to the record.

[The document referenced is located on p. 163.]

The CHAIRMAN. Without objection. And then tomorrow I am going to submit one from the University of Tennessee that does start to do this. My question is does USDA with its resources attempt to duplicate or find out what this one is the analysis of the implications of climate change and then energy legislation?

Dr. GLAUBER. Congressman, I don't want to leave you with the wrong impression. We have done work on climate change and done numerous studies over the years that have looked at the impacts of climate change on agriculture, and I would be happy to provide those.

Mr. WALZ. Is any of it positive?

Dr. GLAUBER. No. I mean in the sense—no, they all conclude very similar results, that is——

Mr. WALZ. Are my nieces and nephews going to be able to farm if we do nothing?

Dr. GLAUBER. It will depend on the crop. The more adaptable crops, there is potential—the bigger concerns are for the crops that are very specific to——

Mr. WALZ. Rice and——

Dr. GLAUBER. Or fruits and vegetables and some of the crops that have a very definite niche with ecological demands——

Mr. WALZ. Well, I look forward—I know tomorrow, and I sure don't want to steal your thunder on this, tomorrow's hearing may be a more appropriate place to talk about a little some of the positives and some of the opposites as it goes in. But I would like to say, Mr. Chairman, I believe that all of us here, it behooves us to look at evidence on all sides of this and a short term view of this, a short term view of what is going to happen, is not going to secure this nation's food, fiber, fuel and national security, and I yield back.

The CHAIRMAN. The chair thanks the gentleman and recognizes the gentleman from Nebraska, Mr. Smith.

Mr. SMITH. Thank you, Mr. Chairman, and thank you, Dr. Glauber, for your service and for your time here today. You did talk or you mentioned changing the diet, or the diet in livestock. Could you elaborate on that?

Dr. GLAUBER. Well, the numerous studies done or some studies done at least in terms of greenhouse gas emissions and whether or not under the current feed ration mix that cattle, hogs, and poultry, and looking at switches in diets to more—I believe it is more oils, is that right? Some shifts in diet, studies have been done that show that there are potential greenhouse gas reductions. Those could be, potentially under some offset program, credited. I can get you more information on that. In terms of feed rations and things like that, they are not exactly my specialty, but we certainly have information on that.

Mr. SMITH. In light of the fact that margins in livestock, in the livestock industry today are narrow to non-existent and even worse, I hope that we can have some balance there, but I appreciate that. On the transactional costs of purchasing credits, for example, what do you see as the average cost there? What would go to the brokers and certainly the traders, so to speak?

Dr. GLAUBER. I think that is a great question, and a lot will depend—I mean there are a whole host of issues when you are talking about an offset program in terms of how verifiable the offset is, how permanent it is, and to the degree that there is less reliability, then you are talking about potential discounts in the transactions. Just transaction cost themselves, those could—I would anticipate those would be pretty low just looking at other markets, contingency markets, that we see, things like the permits for acid rain and other sorts of things. I think the bigger concern is getting an offset market where you are crediting here a ton for this operation that you can verify that it actually is a ton, and it will be—you will be doing what you say you are going to be doing. And that is important not just for domestic legislation, it is also important, obviously, for international accounting.

Mr. SMITH. The gentleman from Minnesota certainly pointed out with some passion on the issue as well that there is great harm and danger looming due to climate change, and are you confident that the cap-and-trade bill would mitigate that harm?

Dr. GLAUBER. The issue, ultimately, will be what can be done internationally, clearly. I mean this is not something that one country can do in terms of global warming. I think it is important for—it speaks to the bigger issue of getting international agreement on greenhouse gas emissions.

Mr. SMITH. But you would say that we need to move forward first before other rather large emitters of carbon would participate?

Dr. GLAUBER. I think that, yes, I think that the climate bill itself, to me the key thing about the climate bill is doing it correctly in terms of things like the offset program and having that established——

Mr. SMITH. In terms of international participation?

Dr. GLAUBER. Yes, both for that and also that we ensure that we have sufficient offsets to mitigate the cost of the legislation itself. But, also in terms of, as I mentioned earlier, not causing unintended consequences of sequestering or pulling large swaths of land out of production.

Mr. SMITH. And do you believe that enactment of a cap-and-trade bill would or would not lead to higher food prices worldwide?

Dr. GLAUBER. I think, again, depending how the offset provisions are accomplished, that there is potential there for higher food prices if a lot of land is taken out of production. I think the energy cost side, again, is relatively small, ultimately.

Mr. SMITH. But do the offsets depend on taking land out of production?

Dr. GLAUBER. Not necessarily. There are other ways of acquiring carbon and again it depends on where the land is taken out of production, whether or not it is pasture land which obviously has an effect as opposed to prime corn land. So, there are real concerns there in terms of getting that part of it right, but there is obviously great potential there for the agricultural sector.

Mr. SMITH. Thank you. Thank you, Mr. Chairman.

The CHAIRMAN. I thank the gentleman and recognize the gentlewoman from Pennsylvania, Mrs. Dahlkemper.

Mrs. DAHLKEMPER. Thank you, Dr. Glauber. I want to ask if you believe that the peer reviewed economic literature regarding the impact of cap-and-trade has a generally settled opinion on the likely impacts of the legislation.

Dr. GLAUBER. I think that—well, the economic literature on cap-and-trade, there is—there are a lot of studies out there that show estimates. I certainly looked at the EIA and EPA numbers, and they are fairly consistent. EIA is a little higher in terms of their overall impacts, and I would say in terms of translating that into the impacts on agriculture. I mentioned at the outset, I think that most of the models that have been done on the agricultural side show fairly similar, if one uses the same estimated impacts on energy prices, the impacts on agriculture that these models would derive are fairly similar.

Mrs. DAHLKEMPER. And do these economic models adequately incorporate, do you think, a fair array of opinions from different climate scientists?

Dr. GLAUBER. Well, again, I want to be careful here because I don't think—most of these models have not really looked at the sort of counter-factual case of what would happen if we had large changes in the climate, what about those costs, because then you would have to look at both what the impacts of the legislation are in terms of costs and offsets on producers, but also the impact on climate itself and how that is mitigated. I think that was alluded to by the previous questioner. I think that one way or the other that has not been done, and I am not aware of any model that has looked at that whole array of issues, and it is important, as was mentioned earlier.

Mrs. DAHLKEMPER. Certainly in my region in northwestern Pennsylvania we have a grape industry that could be very much affected as well as certain nursery stock and other specialty crops. Thank you. I yield back.

The CHAIRMAN. I thank the gentlewoman and recognize the gentleman from Missouri.

Mr. LUETKEMEYER. Thank you, Mr. Chairman. I appreciate the opportunity, and thank you, Dr. Glauber, for being here today. In your testimony you start out by saying that you are reviewing the potential economic impacts of the proposed legislation on the farm sector, and the cap-and-trade legislation is based on the fact that we have man-made global warming. As a result of the revelations over the last week with regards to the U.N. Intercontinental Panel on Climate Change and how those folks have been able to skew some of the data and to withhold some of the information with regards to actual global warming trends and what have you, I am curious as to whether we are going to continue down this path or not. I have a couple quotes here just this morning from Tim Wirth, President of the U.N. Foundation, "We have to right this global warming issue. Even if the theory is wrong, we will be doing the right thing in terms of economic environmental policy." Christine Stewart, the former Canadian Minister of the Environment who led that country's delegation to Kyoto said, "No matter if the science of global warming is all phony, climate change provides the greatest opportunity to bring about justice and equality in the world."

These folks are out there with an agenda that doesn't include the facts. Based on this, what do you at the USDA, do you believe that—are you going to continue to support this position?

Dr. GLAUBER. Congressman, all I can tell you is I am asked to do analyses of what things like the legislation would have on agriculture, and I think there we try to be as objective as we can be. We try to be as transparent as we can be in terms of what the assumptions are. We look at how this legislation would affect a variety of agricultural producers and ranchers and on a regional basis. I haven't looked at the broader literature on global warming. I am aware of the controversies that have arisen over the last——

Mr. LUETKEMEYER. Excuse me, but my question is if we are aware that this is based on unsound science, it is based on a political agenda *versus* actual belief that there is man-made global warming, why are you pursuing this at all? Shouldn't you be going out here and disclosing the correct information and trying to get something done that is correct and that is going to be impactful and helpful to our farmers instead of wallowing around in something that is not right?

Dr. GLAUBER. I think the issue again for me is how would this legislation affect agriculture. I can't address this controversy. It will get resolved hopefully. I don't know what the answer is.

Mr. LUETKEMEYER. Okay. You are saying that you are going to address the impact on the farming community. One of the individuals that is going to testify shortly is Dr. Westhoff, from the University of Missouri, which happens to be in my district. He heads up or is Co-Director of Missouri's Food and Agricultural Policy Research Institute, which studies these type of things. His study, and I assume his testimony this morning will include that the costs for Missouri wheat producers are going to go up over ten percent by 2050 and over nine percent for corn producers in Missouri. How are they going to survive between now and then?

Dr. GLAUBER. Well, again, as I said in my opening comments, certainly in the short run through 2025 most of the costs that would otherwise affect wheat producers in Missouri would be things like nitrogen fertilizer costs which will be——

Mr. LUETKEMEYER. Forgive me for interrupting, but I have only a minute left here. But my question is this, and you have been asked three times now and you have never answered it, how are farmers going to exist between now and then, whenever you think the markets are going to turn or they can afford this. The gentleman from Nebraska just asked the same question as well, how are they going to be able to afford an increased cost when they are already in a negative position with their cash flow and with their income? How can they continue to absorb increased costs if they don't get to price their products, sir?

Dr. GLAUBER. If you look at the size of the energy price impacts, again you are talking about impacts that are out at 2050, and I might add our numbers aren't all that different from what we——

Mr. LUETKEMEYER. They are immediate that take place over a lot of time. They are going to be immediate with regards to the impact on the farming community from now on for the next 15, 20, 30 years. How are they going to survive between now and then?

Dr. GLAUBER. My point is they are gradual impacts. These are very gradual impacts, and for the first 12, 15 years they are very small, very small. And we are assuming—and Pat does the same thing I do when I look at these analyses. We assume essentially that the current technologies in place are going to remain in place.

Mr. LUETKEMEYER. Sir, if you have a wound and you bleed a certain level of blood all the time eventually you are going to pass out and you are going to die, and that is exactly what has happened to our farmers. They are wounded right now and they are bleeding, and they need some help, and this does not help. Thank you, Mr. Chairman.

The CHAIRMAN. The chair thanks the gentleman, and recognizes the gentleman from California, Mr. Costa.

Mr. COSTA. Have you had time to check out the differential as it relates to energy costs as it relates to specialty crops? It seems to me there is a limited evaluation in the analysis that you provided on the impacts of specialty crops in comparison to other—the program crops that we see in other parts of the country. Obviously, I am speaking California specific where we have the largest, in terms of farm gate agricultural production, approximately $37 billion last year, in almost 300+ specialty crops. And, of course, we have high energy costs there as you know as we look at alternatives. Could you please respond?

Dr. GLAUBER. You are right in the sense that, frankly, we don't have the detailed cost of production data that we would like to have on fruits and vegetables that we have on our row crops. Most of the row crops and livestock, things like cow-calf operators, hog operations, and dairy, we do periodic surveys where we take very detailed—collect very detailed data on cost of production. That is one of the reasons we are able to do the sort of simulations, *et cetera*, that we do. For fruits and vegetables, what we do is we have an annual survey that surveys farms across the U.S., including fruit and livestock—or, excuse me, fruit and vegetable producers. And the analysis that we did there or that we presented in this report breaks out those producers in the aggregate, again showing fairly small cost as affects total production costs, largely because labor is such a large—such a big individual component for fruits and vegetables.

Mr. COSTA. Well, labor is a big estimate, and we will get to that in a moment, but you indicate in your testimony, and correct me if I am wrong, I noted $7,747 increase in energy costs for fruit and vegetable farms.

Dr. GLAUBER. On average.

Mr. COSTA. Right. This is an annual increase?

Dr. GLAUBER. This would be the increase for that year relative to the baseline in the year, yes. It is looking over the average for 2012 to 2018 looking at the average annual increase.

Mr. COSTA. Well, given the horrific challenges U.S. agriculture is facing and in California, I can tell you it is just difficult, and then I am going to ask you the next question. Do these numbers take into account the notion that in places that I am talking about 99 percent of our agriculture is irrigated and agriculture depends upon irrigation. It adds to those energy costs.

Dr. GLAUBER. Two things. One is my colleague corrects me that that was the long run impact that is out—closer to 2040, 2050, that $7,000 number. But you are right, the energy costs are imbedded in things like irrigation. We do take that into account in terms of the potential increase, and when we were doing the analysis we also looked at surcharges on electricity prices and natural gas prices that are used for irrigation.

Mr. COSTA. And when did this—dairies as well are very energy intensive, and while the example that my colleague talked about from his constituent, or smaller dairies, with dairies in California that average 600 cows or 1,000 cows milking, those are much larger dairies, I can tell you they are energy intensive.

Dr. GLAUBER. You are right. Obviously, when you are looking at any producer, it is hard to—we tend to look at just the nature of it. We have to do averages so——

Mr. COSTA. I know, but these numbers are somewhat false. You are not taking into account the other larger problem. I voted against cap-and-trade because I just don't think it works for some of the same reasons that was mentioned here earlier. But that aside in the drought conditions that we are transporting water at enormous cost, have you taken any snapshot to look into the impact that droughts are having in certain key areas of the country, especially the regulatory drought that we have in California?

Dr. GLAUBER. In the sense that the cost of production data was based on 2007, it does not reflect the more recent increases due to the regulatory——

Mr. COSTA. Then a lot of this information then is no longer valid in terms of our current——

Dr. GLAUBER. Well, it may not be valid for a specific——

Mr. COSTA. I mean this drought has lasted 3 years and in other parts of the Southwest, and God forbid it lasts a fourth year, but it seems to me you need to go back and update your information at the very least if this is going to be of any value to us.

Dr. GLAUBER. Well, again, Congressman, I would be happy to look at some follow-up and get back to you on it.

Mr. COSTA. All right. We will follow up. Thank you very much.

The CHAIRMAN. The chair thanks the gentleman and recognizes the gentleman from Kansas.

Mr. MORAN. Mr. Chairman, thank you. Dr. Glauber, thank you for the opportunity to question you today. And again I apologize for the last time we were together in this room in which I didn't give you a chance to respond to my question. I even heard from your predecessor that I was rude to you, so again I apologize for my manners.

Dr. GLAUBER. That is quite all right.

Mr. MORAN. It was unbecoming of me and hopefully out of character. I would say that the legislation passed by the House of Representatives now a few weeks ago in my mind remains the most damaging piece of legislation ever passed by the House of Representatives during my time in Congress, as far as it affects agriculture. And I indicated that in this Committee and I indicated that on the House floor and urged my Agriculture colleagues to oppose that legislation despite the efforts by this Committee to refocus some of the jurisdiction of the issue from the EPA to the Department of Agriculture.

One of the things that I think we have not talked about, and I am interested in knowing whether your study has considered at least this theory of mine, and that is while agriculture producers will not move their operations abroad due to increasing cost, the land is here in the United States, farming will continue as long as it is conceivably profitable, but I have a great concern about agricultural processors. It seems to me that with increasing costs caused by cap-and-trade, and other issues, agriculture processors can move their operations abroad which then not only has an employment consequence to the United States but has a cost effect upon agriculture producers. The farmer ultimately is damaged by the industry that he or she deals with being countries away around the globe as compared to down the road.

And, again, my premise is based upon the belief that the increased cost to agriculture processors whether it is an ethanol plant or a processing facility, a chemical company, a livestock processor, a packing plant, we have to have real concern that that sector of the agriculture economy departs this country as it becomes less and less competitive in a global economy. Any comments or response to my thoughts?

Dr. GLAUBER. Congressman, frankly, we haven't looked at the processing sector. One of the difficulties is we just don't have cost data on it, and I know just in speaking to some of the people that have come through my office, and I presume have also been up to see you too, are processors who are concerned about this aspect. Again, a lot will depend on what the individual price impacts are on these individual firms. Again, in the near term it is less of an issue. Over the longer run, the bigger issue is going to be on efficiencies and things like that. But you are right. For some processing firms, they may be very energy intensive, and those will take—just like in agriculture there will be differential——

Mr. MORAN. Would it be safe to assume that refining capacity, if it moves abroad, is more expensive, the end product is more expensive to agricultural and other consumers in the United States? And my assumption is that it is better to have the packing plant down the road buying your cattle than in South America. That has to have a price consequence, a cost consequence upon the actual farmer or stockman in the United States, true?

Dr. GLAUBER. Yes. There is no question. If there is added cost at the processing level that has some effect both in terms on the retail side and also on the other side on the purchasing side.

Mr. MORAN. Thank you, Dr. Glauber.

Dr. GLAUBER. Thank you.

Mr. MORAN. Thank you, Mr. Chairman.

The CHAIRMAN. The chair thanks the gentleman. Doctor, you have been very generous with your time, but I believe Mr. Thompson had a follow-up comment or question.

Mr. THOMPSON. Just real quickly. First of all, let me in the spirit of apology, let me apologize for questioning the competence of the folks who have done the analysis on dairy farming. Let me encourage them to go back to the books and look at the statistics you shared today in terms of diesel, gas, and electricity cost and all those things that, frankly, farmers have to figure out how to write the check out for on a monthly basis, because it is all part of the picture, and they are drowning, they are dying today. As my colleague from Missouri talked about, in general about farmers, the dairy farmers are really taking it hard.

Just briefly, natural gas is the cleanest fossil fuel, and we certainly have vast amounts of on tap resources right here on and off shore in the Outer Continental Shelf. Natural gas, we have already established, is also a necessity in running our nation's farms. In my view, if this debate is really about curbing our carbon emissions and we really wish to protect our farms and food supplies then natural gas should be encouraged. Natural gas to me is a bridge that buys us time until we have significant amounts of renewable energy and proper infrastructure in place. Not only will natural gas be a cleaner fuel and one that we can control the price of here at home, natural gas production will create a enormous number of skilled, good paying jobs.

I know the Marcellus Shale that is in part of my district and New York and Ohio and West Virginia that created, I believe, somewhere around 28,000 jobs in 2008. Dr. Glauber, you discussed H.R. 2454 will necessarily increase energy costs in the agriculture sector and how the legislation attempts to lessen the burden. My question is why bother capping natural gas and offering all these offsets when we have huge amounts of natural gas that can be easily developed and in quantity. The Marcellus Shale plate alone is the single largest plate of natural gas in the world, and that is in addition to everything else we have on the continent and the Outer Continental Shelf, and also it is just clean, good clean energy.

Dr. GLAUBER. Well, there are a lot of advantages for natural gas and certainly in terms of pollutants, *et cetera*. However, on a greenhouse gas side, they do have substantial greenhouse gas emissions, and that is, at least in theory, why they were addressed specifically in the legislation. I would agree with you in many of the points you made insofar as, one, natural gas, we know a lot of producers use it already as a direct fuel cost for pumping for irrigation, *et cetera*, and there are a lot of advantages of natural gas. And certainly when we saw the increases in the prices over the last few years those producers had to make some pretty quick adjustments.

Mr. THOMPSON. I yield back.

The CHAIRMAN. I thank the gentleman. The gentleman from Louisiana, a follow-up question?

Mr. CASSIDY. First a comment based on what you just said. Actually, you could probably show that natural gas has a lower carbon footprint than corn-based ethanol, and I think that would be fairly easily shown. But as I looked at your testimony on page 23, yes, page 23, and again I am looking at rice—energy inputs relative to total operating expenses for selected crops. Rice takes it on the chin. I think rice, if you add the cost of fuel and fertilizer, is the highest priced of any other among all the crops.

Dr. GLAUBER. Absolutely, per acre. You are absolutely right.

Mr. CASSIDY. Now really this kind of extends my argument regarding aquaculture to rice. Will they be able to compete absent WTO-defined tariffs with foreign importers if they have such an energy-intensive process?

Dr. GLAUBER. Well, the flip side of it is looking at it on a percent of operating cost and there rice is not quite as high as some of the other commodities, but still quite high, in general. I think that a key for rice will be, potentially, whatever offsets can be generated on rice production by tillage practices, *et cetera*.

Mr. CASSIDY. Now my next question is knowing that they flood, is there going to be some sort of carbon offset for flooding? They don't till *per se.*

Dr. GLAUBER. My colleague here who knows a lot about offsets says that there are potentials on nutrient management, and what I would like to do is follow up with you with a more detailed response.

Mr. CASSIDY. My next question is that clearly the Achilles' heel behind this whole theory of this bill is the carbon leakage of energy intensive industries to other nationals, the Caribbean, China, India, *et cetera*, who just said they are not going to comply with this. So what about carbon leakage of our fertilizer? We are already importing some percentage you mentioned. Frankly, I can see a business plan you would not expand here. You would expand elsewhere because in 15 years this subsidy goes away and you would be at a competitive cost advantage by carbon leakage of the fertilizer manufacturers.

Dr. GLAUBER. Well, again, with rebates that will take you through 2025, thereabouts, you are right. At that point, natural gas prices, if that is phased out, there are issues then about competition with foreign producers, and a lot will depend there in terms of what is done internationally.

Mr. CASSIDY. So we know that it is the global emissions of carbon that is important, not just that which is produced in the United States. If we have carbon leakage of these energy intensive industries then we are probably net going to be no better off, maybe worse, assuming they have lower environmental protections. My next question is the EITE, does that totally hold the producer harmless? For example, they are going to buy natural gas to make their fertilizer, but that natural gas price is already inflated because there is going to be someone else who is having to pay for emissions and tacking that on to the cost of the natural gas. And so there are several areas in the production line where the natural gas price will be elevated. Is the producer of the fertilizer totally held harmless or is it only for that which they themselves would be penalized for emitting?

Dr. GLAUBER. My understanding is that they will be exempt from the additional surcharge that would be implied by the allowance price for carbon.

Mr. CASSIDY. And is that the well head to their product going out the door, or is it just for the natural gas coming in to their product going out the door?

Dr. GLAUBER. I think it is as a feedstock that that price will be——

Mr. CASSIDY. From the well head?

Dr. GLAUBER. Yes.

Mr. CASSIDY. So then the cost of that offset passes all the way down to the producer, the refiner, and then the intermediary, the pipeline guy, and then the fertilizer manufacturer itself?

Dr. GLAUBER. Yes. That is my understanding. Now the other thing too is that don't forget because natural gas prices are going up for others, those who aren't protected, they are actually the demand. Demand would be affected a bit for natural gas prices, so if you take out the allowance price the price could be slightly smaller than it would have been otherwise. But again that is very conjectural.

Mr. CASSIDY. One more thing. The industrial-owned rural utilities, they are going to be subject to both the renewable energy standard and they are going to be subject to their emissions standard. Many of them in the Southeast have limited access to renewable energy sources, but they are also going to have the carbon exemptions, and since they are investor-owned, they will not have the same for whatever megawatts exemption. What is going to be—did you break out the impact of investor owned utilities *versus* the municipalities or the co-ops as regard to what is going to happen to the rural people in their districts?

Dr. GLAUBER. We did not, Congressman, but let me get back to you on that as a follow up.

Mr. CASSIDY. It seems like that could be a significant difference.

Dr. GLAUBER. I would be happy to look at it.

Mr. CASSIDY. Thank you very much. I yield back. Thank you.

The CHAIRMAN. The chair thanks the gentleman. Dr. Glauber, thank you very much. You have been more than generous with your time, so thank you very much.

Dr. GLAUBER. And we will see you tomorrow.

The CHAIRMAN. See you tomorrow. We now would like to welcome our second panel. I would like to yield to the gentleman from Missouri for an introduction of one of our panelists.

Mr. LUETKEMEYER. Thank you, Mr. Chairman. As I get settled in, it is my privilege this morning to introduce to the Subcommittee, Dr. Pat Westhoff. He is Co-Director of the Food and Agricultural Policy Research Institute there at the University of Missouri. It is called FAPRI, an acronym. He is a Research Associate Professor in Agriculture Economics. FAPRI conducts some of the most respected objective agricultural research in the world. I am proud to represent this institution in Congress. Dr. Westhoff is a native of Manchester, Iowa, and he joined FAPRI in 1996.

Prior to joining FAPRI Missouri, he served 4 years as the Chief Economist for the Democratic staff of the United States Senate Committee on Agriculture, Nutrition, and Forestry. From 1983 to 1992 he worked at the Iowa State University Center for Agricultural and Rural Development for FAPRI at Iowa State. He obtained his Ph.D. in agricultural economics from Iowa State University. We don't hold that against him. He is now at MU. We beat them in football this year so we are okay with that, right, Doc? Through the hard work of Dr. Westhoff and Dr. William Meyers, FAPRI has gained the respect of the agricultural industry from the much anticipated yearly baseline projection to the analysis conducted for Congress and outreach with farmers and agricultural organizations. FAPRI serves as a valuable asset for this industry helping both producers and policy makers develop smart decisions about the future of agriculture in Missouri, and throughout this nation.

They are basically the Bible when it comes to agriculture in our state. Through fantastic research, we rely on them tremendously for their input and data that they come up with. Pat himself has been a tremendous asset to my district and to the American agricultural industry. I greatly appreciate his being here today and look forward to his testimony. Welcome.

The CHAIRMAN. The chair thanks the gentleman. We also would like to welcome Dr. Joe L. Outlaw, Professor and Extension Economist—Farm Management and Policy, Department of Agricultural Economics, Texas A&M University; Dr. John M. Antle, Professor of Agricultural Economics and Economics, Montana State University; Dr. Judith Capper, Assistant Professor of Dairy Science, Department of Animal Sciences, Washington State University; Mr. Richard Pottorff, Chief Economist, Doane Advisory Services, St. Louis, Missouri. Dr. Outlaw, you may begin when you are ready.

STATEMENT OF JOE L. OUTLAW, PH.D., CO-DIRECTOR, AGRICULTURAL AND FOOD POLICY CENTER; PROFESSOR AND EXTENSION ECONOMIST—FARM MANAGEMENT AND POLICY, DEPARTMENT OF AGRICULTURAL ECONOMICS, TEXAS A&M UNIVERSITY, COLLEGE STATION, TX

Dr. OUTLAW. Mr. Chairman and Members of the Committee, thank you for the opportunity to testify on behalf of the Agricultural and Food Policy Center at Texas A&M University on our research regarding the potential economic impacts of climate change on the farm sector. For more than 25 years we have worked with the Agriculture Committees in the U.S. Senate and House of Representatives providing Members and Committee staff objective research regarding the potential affects of agricultural policy changes on our database of U.S. representative farms.

My testimony today summarizes the results of an analysis request from Senator Saxby Chamblis to analyze the impacts of the cap-and-trade provisions of the American Clean Energy and Security Act of 2009 on the farm sector. Our analysis, which I have provided for the record,* assessed the impacts of H.R. 2454 by including: the anticipated energy related cost increases directly experienced by agricultural produces for inputs such as fuel and electricity and indirectly experienced, such as higher chemical prices resulting from higher energy prices; the expected commodity price changes resulting from producers switching among agricultural commodities; afforestation of land previously employed in agricultural commodity production; and the estimated benefits to agricultural producers from selling carbon credits.

AFPC currently does not maintain sector level economic models with the amount of detail required to develop estimates of all the impacts listed above along with their feedback effects. Therefore, we utilized the EPA estimated energy price changes, as well as estimates of carbon and agricultural commodity prices from McCarl's FASOM–GHG model to evaluate the farm level effects of H.R. 2454. The results of this analysis are dependent on the estimated outcomes contained in the EPA analysis of H.R. 2454. As additional sector level analyses are conducted and estimates are refined, AFPC will update the farm level analysis.

AFPC has a history of maintaining a unique dataset of representative crop, livestock, and dairy farms and utilizing them to evaluate the economic impacts of agricultural policy changes. This analysis was conducted over the 2007–2016 planning horizon using FLIPSIM, our risk-based whole farm simulation model. The data described 98 farming operations in the nation's major production regions came from producer panel interviews to gather, develop, and validate the economic and production information required to describe and simulate representative crop, livestock, and dairy farms.

In our report we analyzed three scenarios relative to our baseline. Today these results are going to focus on the cap-and-trade with ag carbon credits scenario. Mr. Chairman, we have been doing policy analysis for the Congress for nearly 30 years and we have never had to make this many assumptions just to complete an analysis. Cropland requirements for carbon dioxide sequestration specify that land must be engaged in a minimum or no-till cropping program. Extension budgets from different states were used to determine changes in input and overhead costs typically experienced in converting from conventional tillage practices to no-till farming. Methane digesters may be beneficial to some confinement dairies, allowing them to generate electricity and reduce greenhouse gases.

This study assumed a dairy size of 500 cows or more is necessary to make erecting a methane digester a viable economic option, which eliminates—we had 16 of 22 farms that would be able to do this. For this study, AFPC's representative cattle ranches and rice farms were the only two categories of farms that were assumed not

*The document referred to is located on p. 216.

to participate in carbon sequestration activities. In terms of measuring performance, our report had five different measures. We have used average ending cash reserves in 2016 to highlight as the most appropriate measure to evaluate this type of long-run decision. In other words, will the farm be better off or worse off at the end of the period based on cash on hand at the end of the year?

Table 2 provides a summary of the farms with higher and lower, relative to the baseline, average ending cash reserves in 2016. Twenty-seven out of 98 representative farms are expected to be better off at the end of the period in terms of their ending cash reserves. Most of the feedgrain/oilseed farms located in or near the Corn Belt and wheat farms located in the Great Plains, have higher average ending cash reserves under this scenario. Eight wheat farms are better off under this scenario, while one cotton and no rice farms or cattle ranches are better off. One dairy is better off because it produces and sells surplus corn and soybeans which are projected to see higher prices as a result of this program.

While a few farms would be as well off as under the baseline with only slightly higher carbon prices each year, there are also several farms that would need carbon prices of $80 per ton per year or more to make them as well off as under the baseline. I would like to finish with a few points. These results are entirely dependent on the EPA analysis, however, we were only able to analyze the very beginning of the cap-and-trade implementation through 2016. Based on the projected carbon prices after 2025, producers would be much better off waiting for higher carbon prices to sell carbon credits.

We based many of our assumptions regarding how the cap-and-trade program in H.R. 2454 would work on the Chicago Climate Exchange which may or may not be accurate. Mr. Chairman, that completes my statement.

[The prepared statement of Dr. Outlaw follows:]

PREPARED STATEMENT OF JOE L. OUTLAW, PH.D., CO-DIRECTOR, AGRICULTURAL AND FOOD POLICY CENTER; PROFESSOR AND EXTENSION ECONOMIST—FARM MANAGEMENT AND POLICY, DEPARTMENT OF AGRICULTURAL ECONOMICS, TEXAS A&M UNIVERSITY, COLLEGE STATION, TX

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My testimony today summarizes the results of an analysis request from Senator Saxby Chamblis to analyze the impacts of the CAP and Trade Provisions of "The American Clean Energy and Security Act of 2009" (H.R. 2454) on the farm sector. Our analysis, which I have provided for the record, is entitled "Economic Implications of the EPA Analysis of the CAP and Trade Provisions of H.R. 2454 for U.S. Representative Farms". Our report assessed the impacts of H.R. 2454 by including:

- The anticipated energy related cost increases directly experienced by agricultural producers for inputs such as fuel and electricity and indirectly experienced, such as, higher chemical prices resulting from higher energy prices.
- The expected commodity price changes resulting from producers switching among agricultural commodities and afforestation of land previously employed in agricultural commodity production.
- The estimated benefits to agricultural producers from selling carbon credits.

AFPC currently does not maintain sector level economic models with the amount of detail required to develop estimates of all of the impacts listed above along with their feedback effects. Therefore, we utilized the EPA estimated energy price changes, as well as, estimates of carbon and agricultural commodity prices from McCarl's FASOM–GHG model to evaluate the farm level impacts of H.R. 2454.

The results of this analysis are dependent on the estimated outcomes contained in the EPA analysis of H.R. 2454. As additional sector level analyses are conducted and estimates are refined, AFPC will update the farm level analysis.

AFPC has a 26 year history of maintaining a unique dataset of representative crop, livestock and dairy farms and utilizing them to evaluate the economic impacts of agricultural policy changes. This analysis was conducted over the 2007–2016 planning horizon using FLIPSIM, AFPC's risk-based whole farm simulation model. Data to simulate 98 farming operations in the nation's major production regions come from producer panel interviews to gather, develop, and validate the economic and production information required to describe and simulate representative crop, livestock, and dairy farms. The FLIPSIM policy simulation model incorporates the historical risk faced by farmers for prices and production.

Scenarios Analyzed

- Baseline—Projected prices, policy variables, and input inflation rates from the Food and Agricultural Policy Research Institute (FAPRI) January 2009 Baseline.
- Cap & Trade without Ag Carbon Credits—Assumes H.R. 2454 becomes effective in 2010. Imposes EPA commodity price forecasts along with estimated energy cost inflation on representative farm inputs.
- Cap & Trade with Ag Carbon Credits—Assumes H.R. 2454 becomes effective in 2010. Imposes EPA commodity price forecasts along with estimated energy cost inflation on farm inputs, converts farms to no-till production (if applicable) and/or installs a methane digester on dairies over 500 head and sells carbon credits at EPA estimated market prices.
- Cap & Trade with Ag Carbon Credits and Saturation—Assumes no-till farmland reaches carbon saturation in 2014. This scenario represents the loss of revenues that will be experienced by farms at some point due to carbon saturation of the soil. This scenario is not relevant for the analysis of methane digesters on the dairies since saturation is not an issue.

This testimony will focus on the Cap & Trade with Ag Carbon Credits scenario.

Assumptions

Mr. Chairman, we have been doing policy analyses for the Congress for nearly 30 years and we have never had to make this many assumptions—just to complete our analysis.

Cropland requirements for carbon dioxide sequestration specify that land must be engaged in a minimum or no-till cropping program. Higher fuel and input costs have driven the majority of the AFPC representative crop farms to participate in some form of reduced tillage; however, very few are truly no-till operations.

Extension budgets from different states were used to determine changes in input and overhead costs typically experienced in converting from conventional tillage practices to no-till farming. All AFPC farms with the potential to sequester carbon dioxide (based on Conservation tillage soil offset map available from the Chicago Climate Exchange) were converted to no-till operations using their respective state Extension budgets as a template. Crop yields were not changed when the switch to no-till was made.

Methane digesters may be beneficial to some confinement dairies, allowing them to generate electricity and reduce greenhouse gases (GHG). The destruction of GHGs makes the dairies eligible to receive carbon credits for their efforts. This study assumed a dairy size of 500 cows or more is necessary to make erecting a methane digester a viable economic option. Sixteen of 22 AFPC representative dairies have sufficient cow numbers to justify a digester based on this assumption

For this study, AFPC's representative cattle ranches and rice farms were the only two categories of farms that were assumed not to participate in carbon sequestration activities. In order to participate in the grassland or pastureland carbon sequestration, the ranches would need to reduce their stocking rates substantially which would have substantially changed the economics of the ranches. Therefore, we assumed they would likely not participate for the purposes of this study. We are unaware of any carbon sequestration protocol in effect for rice farms therefore we assumed they would be unable to participate.

Commodity Prices, Inflation Rates, and Interest Rates Assumed in the Analysis

We developed annual estimates of commodity prices and inflation rates by interpolating between the 5 year time periods and alternative carbon price scenarios, and applying the percentage changes in the estimated economic variables from the EPA scenario estimates and EPA Baseline to the January 2009 FAPRI Baseline.

The estimated gross and net-to-farmer carbon prices per ton utilized in this study are summarized in *Table 1.* AFPC assumed that a fee structure similar to that used by the Chicago Climate Exchange (CCX) would likely be utilized under H.R. 2454.

Table 1. Gross and Net-to-Farmer Carbon Prices Utilized in Representative Farm Analysis, 2010 to 2016.[1]

Year	2010	2011	2012	2013	2014	2015	2016
Gross ($/ton)	8.97	9.704	10.438	11.172	11.906	12.64	13.374
Net-to-farmer ($/ton)	7.75	8.41	9.07	9.73	10.40	11.06	11.72

[1] These prices were derived from EPA estimates for 2015 and 2020 and extrapolated and interpolated to provide annual estimates.

Measures of Economic Performance

Five alternative measures of economic performance are provided for each of the farms. These are:

- Average Annual Total Cash Receipts—Average annual cash receipts in 2010–2016 from all sources, including market sales, carbon credit payments, counter-cyclical/ACRE, direct payments, marketing loan gains/loan deficiency payments, crop insurance indemnities, and other farm related receipts.
- Average Annual Total Cash Costs—Average annual cash costs in 2010–2016 from all sources including variable, overhead, and interest expenses.
- Average Annual Net Cash Farm Income—Equals average annual total cash receipts minus average annual cash expenses in 2010–2016. Net cash farm income is used to pay family living expenses, principal payments, income taxes, self employment taxes, and machinery replacement costs.
- Average Ending Cash Reserves in 2016—Equals total cash on hand at the end of the year in 2016. Ending cash equals beginning cash reserves plus net cash farm income and interest earned on cash reserves less principal payments, Federal taxes (income and self employment), state income taxes, family living withdrawals, and actual machinery replacement costs (not depreciation).
- Average Ending Real Net Worth—Real Equity (inflation adjusted) at the end of the year in 2016. Equals total assets including land minus total debt from all sources.

Results

Average ending cash reserves in 2016 will be highlighted as the most appropriate measure to evaluate this type of long-run decision. In other words, will the farm be better off or worse off at the end of the period based on cash on hand at the end of the year?

Table 2 provides a summary of the farms with higher and lower (relative to the Baseline) average ending cash reserves in 2016. Twenty-seven out of 98 representative farms are expected to be better off at the end of the period in terms of their ending cash reserves.

Table 2. Representative Farms by Type That Have Higher or Lower Ending Cash Reserves for the Cap & Trade With Ag Carbon Credits Scenario Relative to the Baseline.

Farm Type	Higher	Lower	Total
Feedgrain/Oilseed	17	8	25
Wheat	8	3	11
Cotton	1	13	14
Rice	0	14	14
Cattle Ranches	0	12	12
Total	27	71	98

Results show that all of the crop farms and dairies are expected to realize slightly higher average annual cash receipts under the Cap & Trade scenarios due to slightly higher crop and milk prices resulting from instituting cap-and-trade. The lone exception is the 12 cattle ranches that realize slightly lower receipts due to lower calf prices. As one would expect, the Cap & Trade with Ag Carbon Credits scenario results in slightly higher cash receipts than the Baseline. The amount of the carbon credits is relatively small with many farms averaging less than $10,000 per year higher receipts.

Costs differ from the Baseline and Cap & Trade with Ag Carbon Credits due to imposition of higher input costs and expenses incurred for conversion to no-till on farms eligible for carbon credits and construction of methane digesters on eligible dairy farms.

Most of the feedgrain/oilseed farms located in or near the Corn Belt and wheat farms located in the Great Plains, have higher average ending cash reserves under the Cap & Trade with Ag Carbon Credits scenarios. In addition, all but a few of the feedgrain/oilseed farms end the analysis period with higher cash reserves. Eight wheat farms are better off under the Cap & Trade with Ag Carbon Credits scenario, while one cotton and no rice farms or cattle ranches are better off. One dairy (WID145) is better off because it produces and sells surplus corn and soybeans which are projected to see higher prices as a result of cap-and-trade.

The average level of carbon prices necessary for the farms to be as well off as under the Baseline were estimated for farms who would be worse off under the Cap & Trade with Ag Carbon Credits scenario. Given the assumptions in this study, for some farms such as rice and the cattle ranches, no level of carbon prices would make them as well off as the Baseline. While a few farms would be as well off as the Baseline with only slightly higher carbon prices each year, there are also several farms that would need carbon prices of $80 per ton per year or more to make them as well off as the Baseline.

I would like to finish with a few points:

- These results are entirely dependent on the EPA analysis, however, we were only able to analyze the very beginning of Cap & Trade implementation through 2016.
- Based on the projected carbon prices after 2025, producers would be much better off waiting for higher carbon prices.
- We based many of our assumptions regarding how the Cap & Trade program in H.R. 2454 would work on the Chicago Climate Exchange which may or may not be accurate.

Mr. Chairman, that completes my statement.

The CHAIRMAN. Thank you, Dr. Outlaw. Dr. Westhoff.

STATEMENT OF PATRICK WESTHOFF, PH.D., CO-DIRECTOR, FOOD AND AGRICULTURAL POLICY RESEARCH INSTITUTE; RESEARCH ASSOCIATE PROFESSOR, DEPARTMENT OF AGRICULTURAL ECONOMICS, UNIVERSITY OF MISSOURI-COLUMBIA, COLUMBIA, MO

Dr. WESTHOFF. Thank you, Mr. Chairman, for the opportunity to speak with you and other Members of the Subcommittee, and thanks to Congressman Luetkemeyer for the very kind introduction. My name is Pat Westhoff, and I am the Co-Director of the Food and Agricultural Policy Research Institute at the University of Missouri. Today, I will discuss some of the reasons why there is so much uncertainty about the impacts of climate change legislation on the farm sector. As you know, legislation approved by the House would create a cap-and-trade system. And as Dr. Glauber talked about earlier, the Energy Information Administration has estimated possible impacts of the legislation on energy markets and the general economy.

Translating these estimated changes in energy costs to changes in farm production expenses is not as easy as one might think. Given the EIA's basic estimates of the House bill's impact on energy cost, we estimate that operating costs for corn producers would increase by about 1.8 percent in 2020 compared to levels that would have prevailed in a reference scenario. Operating costs would increase by two percent for wheat, 2.2 percent for soybeans, and 2.3 percent for cotton. Using the EIA's energy cost estimates for 2030, we estimate that nominal corn operating expenses would increase by 5.7 percent relative to a reference scenario. Soybean costs would increase a little bit less while the proportional increase in wheat and cotton cost would be actually larger than those for corn.

Other estimates of energy costs would, of course, lead to different estimates of crop production cost impacts. In addition to its basic scenario, EIA has examined a number of other scenarios for how the House-passed bill would impact energy markets. Because these different scenarios result in different estimates of fuel costs, they result in different estimates of farm production expenses as well. In 2020, corn operating expenses increased by just .9 percent in one of those EIA scenarios, but as much as 2.5 percent in another one of those scenarios. In 2030, the corresponding changes ran from as little as 2.3 percent to as much as 8.4 percent, so just making the point again there is great uncertainly what the production cost impacts might be because of so much uncertainty of what the impacts might be on energy costs.

I want to focus most of my remaining remarks on possible impacts on crop production patterns because I don't think those have gotten enough attention so far. There are several reasons why crop production patterns could shift in response to climate change legislation. First, rising input costs could cause some shifts away from crops that experience the largest increases in production expenses. Second, the opportunity to earn offset income could encourage landowners to reduce the amount of land used to produce current crops and expand the area devoted to forestry or the production of energy crops, as we have heard about today already.

If relatively little land shifts from cropland to forestry uses, climate change legislation may have only very small effects on crop production and crop prices, but if more significant amounts of cropland shift to forestry uses, the result would be larger production in crop production. This in turn would result in higher crop prices that would increase market revenue for farmers who continue to grow traditional crops. This increase in market revenues could offset some or even all of the increase that might occur in crop operating expenses. If large shifts in acreage do occur, they would have impacts that go far beyond possible effects on crop producer receipts. Higher crop prices would increase feed costs for the livestock industry. These higher feed costs, in turn, would result in reduced production and higher prices for meat and dairy products. Consumer food prices would increase.

Higher crop prices would reduce the quantity of agricultural products exported by the United States. Forestry uses of land result in different patterns of rural employment and economic activity that result from current crop production patterns. Finally, it is important to distinguish the effects that result when one country changes its policies from effects that result when all countries change policy simultaneously. For example, much of the analysis conducted so far assumes that U.S. firms will be able to purchase large amounts of offsets from other countries for practices that reduce emissions or sequester carbon. Similar policies in other countries could increase competition for such offsets. This would tend to increase allowance prices, resulting in higher domestic energy prices and more demand for domestic offsets.

In summary, there are five things we think we know and do not know. Number one, the House-passed legislation would raise energy costs, and this would translate into higher farm production expenses; two, just how large the increase in production costs would be is unknown. Alternative sets of reasonable assumptions result in very different estimates of crop production cost impacts; number three, the ability to earn offset income by changing production practices or planting trees or energy crops could have major impacts on agricultural production, commodity prices, farm income, consumer food costs, and rural communities; four, the greater the shift in acreage away from production of traditional crops to trees or energy crops, the larger the potential impact on crop production and prices. Resulting increases in revenues may offset some or even all of the increase in production expenses for crop producers, and, finally, unilateral U.S. changes in climate policy could have very different impacts than if there is a multilateral agreement to reduce greenhouse gas emissions. Again, thank you very much, Mr. Chairman, for your interest in our work.

[The prepared statement of Dr. Westhoff follows:]

PREPARED STATEMENT OF PATRICK WESTHOFF, PH.D., CO-DIRECTOR, FOOD AND AGRICULTURAL POLICY RESEARCH INSTITUTE; RESEARCH ASSOCIATE PROFESSOR, DEPARTMENT OF AGRICULTURAL ECONOMICS, UNIVERSITY OF MISSOURI-COLUMBIA, COLUMBIA, MO

Thank you, Mr. Chairman, for the opportunity to speak with you and other Members of the Subcommittee. My name is Pat Westhoff, and I am a Co-Director of the Food and Agricultural Policy Research Institute at the University of Missouri (FAPRI–MU). For the last 25 years, our mission has been to provide objective analysis of issues related to agricultural markets and policy.

Our institute is examining some of the possible impacts of climate change legislation on markets for agricultural products, farm income, and consumer food prices. So far, the research has raised many questions and provided few definitive answers.

Today, I will discuss some of the reasons why there is so much uncertainty about the impacts of climate change legislation on the farm sector. Consistent with FAPRI's mission, I will neither endorse nor oppose particular policy proposals, but hope to provide information that will be useful as you consider issues related to climate change.

Legislation approved by the House (H.R. 2454) would create a cap-and-trade system. Such a policy would raise farm production expenses by increasing energy costs to users of fossil fuels. It would also encourage activities that reduce greenhouse gas emissions and sequester carbon. Some of these activities could have important impacts on agricultural production, which in turn would affect farm commodity prices.

Production cost impacts

The Energy Information Administration (EIA) has estimated possible impacts of the legislation on energy markets and the general economy. In its "basic" scenario, EIA estimates that the House-passed bill would raise the nominal cost of diesel fuel by about eight percent in 2020 from reference scenario levels. Electricity costs would increase by about four percent, and industrial users would pay 14 percent more for natural gas.

Translating these estimated changes in energy costs to changes in farm production expenses is not as easy as one might think. Consider the case of fertilizer. Nitrogen fertilizer is produced in a very energy-intensive process that uses large quantities of natural gas. One might therefore expect that nitrogen fertilizer costs would increase in line with the estimated increase in natural gas costs.

The story is more complex. First, much of the nitrogen fertilizer used in the United States is imported, and foreign fertilizer producers would not necessarily experience the same change in production costs as domestic manufacturers. Second, the House-passed legislation includes provisions to provide free emission allowances to energy-intensive, trade-exposed (EITE) industries, including the nitrogen fertilizer industry. This could hold down costs to nitrogen fertilizer producers, at least until EITE allowances are phased down beginning in 2025. Third, even if the result is a significant increase in fertilizer prices, farmers could reduce their fertilizer usage, thus limiting increases in expenditures.

FAPRI–MU has prepared preliminary estimates of impacts on farm production expenses that try to consider all of these concerns. Given EIA's basic estimates of the House bill's impact on energy costs, we estimate that operating costs for corn producers would increase by about 1.8 percent in 2020 compared to levels that would have prevailed in a reference scenario. Operating costs would increase by 2.0 percent for wheat, 2.2 percent for soybeans, and 2.3 percent for cotton.

These estimates of production cost impacts all depend on a particular set of EIA estimates of energy cost impacts for one particular year. As the cap on greenhouse gas emissions is reduced over time, EIA estimates that energy costs would increase by even larger proportions. In 2030, for example EIA's basic scenario estimates that the House-passed bill would raise nominal diesel fuel costs by 15 percent, electricity costs by 22 percent, and industrial natural gas costs by 26 percent. Furthermore, the scheduled phase-down of free EITE allowances means that nitrogen fertilizer producers would be less insulated from increases in natural gas costs.

Using EIA's energy cost estimates for 2030, we estimate that nominal corn operating expenses would increase by 5.7 percent relative to a reference scenario. Because soybean production uses little nitrogen fertilizer, soybean costs would increase less (4.9 percent), while the proportional increase in wheat (6.3 percent) and cotton (6.4 percent) costs would actually be proportionally larger than the increase for corn.

Other estimates of energy costs would, of course, lead to different estimates of crop production cost impacts. In addition to its basic scenario, EIA has examined a number of other scenarios for how the House-passed bill could impact energy markets. For example, in its "high offsets" scenario, EIA considers what might happen if it is very easy to find ways to reduce greenhouse gas emissions and sequester carbon. This would substantially reduce the cost of emission allowances and result in significantly lower energy costs.

In contrast, EIA's "high cost" scenario assumes that it is not as easy to reduce emissions in electric utilities as in the basic scenario, in part because it proves more difficult to expand production of nuclear energy. This raises the estimated costs of emission allowances and the costs to users of fossil fuels.

Because these different scenarios result in different estimates of fuel costs, they result in different estimates of farm operating expenses. In 2020, corn operating expenses increase by just 0.9 percent in the high offset scenario, but by 2.5 percent in the high cost scenario. In 2030, the corresponding changes are 2.3 percent in the high offset scenario and 8.4 percent in the high cost scenario (*Table 1*).

Other institutions have also estimated impacts of the House legislation on energy costs. For example, CRA International estimates were used in earlier FAPRI–MU analysis of possible impacts on Missouri crop production expenses. In that analysis (FAPRI–MU Report #05–09), Missouri dryland corn operating costs increased by 3.2 percent in 2020 and 3.8 percent in 2030.

The earlier analysis did not consider impacts of EITE provisions, thus explaining its larger estimate of 2020 production cost impacts. However, in 2030, EIA's basic and high cost scenarios result in larger impacts on energy costs than estimated by CRA. It should not be surprising, therefore, that the estimated impacts on 2030 national corn operating costs under EIA's basic and high costs scenarios are larger than the previous FAPRI–MU estimate of increases in 2030 Missouri dryland corn operating costs.

Table 1. Estimates of Changes in Nominal Farm Operating Costs Resulting From H.R. 2454

	EIA basic scenario	EIA high offset scenario	EIA high cost scenario
*Nominal energy cost impacts**			
Diesel fuel			
2020	8.3%	4.6%	9.0%
2030	15.0%	8.0%	17.5%
Electricity			
2020	3.8%	3.6%	5.4%
2030	22.3%	11.8%	32.7%
Industrial natural gas			
2020	14.4%	8.3%	20.2%
2030	25.9%	10.2%	39.9%

Table 1. Estimates of Changes in Nominal Farm Operating Costs Resulting From H.R. 2454—Continued

	EIA basic scenario	EIA high offset scenario	EIA high cost scenario
Crop operating cost impacts			
Corn			
2020	1.8%	0.9%	2.5%
2030	5.7%	2.3%	8.4%
Soybeans			
2020	2.2%	1.3%	2.6%
2030	4.9%	2.5%	6.3%
Wheat			
2020	2.0%	1.0%	2.8%
2030	6.3%	2.6%	9.2%
Upland cotton			
2020	2.3%	1.4%	2.9%
2030	6.4%	3.1%	8.8%

* Calculations based on EIA reported nominal energy cost data. Note that inflation-corrected real price changes generally would be slightly smaller, as EIA estimates that the scenarios would result in slightly higher rates of overall price inflation in the economy.

The EIA scenarios are briefly described in the text. The full EIA analysis is available at *http://www.eia.doe.gov/oiaf/servicerpt/hr2454/index.html.*

The key point is that there is great uncertainty about the magnitude of the impact on farm production expenses, primarily because of great uncertainty about the magnitude of impacts on energy costs. If it is relatively easy for electric utilities and others to reduce greenhouse gas emissions and sequester carbon, allowance prices will be relatively low, increases in energy costs will be modest, and impacts on farm production expenses will be fairly small. If it proves much more difficult to reduce emissions and sequester carbon, allowance prices will be much higher, as will energy costs and farm production expenses.

Shifts in production patterns

In addition to its effect on production expenses, climate change legislation could have many other important effects on the farm sector. For example, others will speak to you tomorrow about the opportunities for farmers to earn income by selling offsets for activities that reduce emissions or sequester carbon. I want to focus most of my remaining remarks on possible impacts on crop production patterns.

There are several reasons why crop production patterns could shift in response to climate change legislation.

First, rising input costs could cause some shifts away from crops that experience the largest increases in production expenses. Unless changes in production expenses are larger than in the scenarios we have examined so far, we do not expect this effect to cause large reductions in overall U.S. crop production. As a result, we do not expect the increase in production expenses to translate into very large increases in prices for corn, wheat, soybeans, cotton, and other crops.

Second, the opportunity to earn offset income could encourage landowners to reduce the amount of land used to produce current crops and expand the area devoted to forestry or the production of energy crops. Analysis conducted for the Environmental Protection Agency using the FASOM model suggests that climate change legislation could lead to tens of millions of acres shifting from crop and pasture uses to forestry. Analysis conducted at the University of Tennessee suggests that there could be a large expansion in production of energy crops such as switchgrass.

We have begun to do some work looking at the possible impacts on the farm sector that might result if some land shifts to forestry uses in response to climate change legislation. As the work is ongoing, it would be premature to cite specific estimates, but it could be useful to discuss some early lessons that appear likely to hold even after we refine the analysis.

(1) If relatively little land shifts from cropland to forestry uses, climate change legislation may have only small effects on crop production and prices. If crop prices are largely unchanged, producers who face higher production expenses are likely to experience a reduction in income, unless they can earn money by selling offsets for practices like conversion to no-till farming methods.

(2) If more significant amounts of cropland shift to forestry uses, the result would be a larger reduction in crop production. This, in turn, would result in higher crop prices that would increase market revenue for farmers who continue to grow traditional crops. This increase in market revenues could offset some or all of the increase in crop operating expenses.

(3) If very large amounts of land shift to forestry uses, as suggested in the FASOM analysis, the reduction in crop production could cause very significant increases in crop prices. The resulting increase in market revenue could well exceed any increase in crop operating costs. In such a case, net revenue over operating costs could exceed reference scenario levels, even for producers who do not directly earn any offset income.

If large shifts in acreage do indeed occur, they would have impacts that go far beyond possible effects on crop producer receipts. Higher crop prices would increase feed costs for the livestock industry. These higher feed costs, in turn, would result in reduced production and higher prices of meat and dairy products. Consumer food prices would increase, not just for products made from grains and vegetable oils, but also for beef, pork, poultry and milk. All else equal, higher crop prices would reduce the quantity of agricultural products exported by the United States. Forestry uses of land result in different patterns of rural employment and economic activity than result from current crop production patterns.

If climate change legislation increases the demand for land to sequester carbon in trees, prices for crop and pasture land are likely to be bid higher. This would benefit current landowners, but could make it more difficult for new and established producers who rent land or who were looking to buy additional land to grow traditional crops.

In addition to possible impacts on crop supplies, climate change legislation could have complex effects on the demand for agricultural products. Higher energy costs would make it more expensive to process and transport food, likely increasing the gap between farm and consumer food prices. The demand for biofuels could be affected both by the opportunity to earn offset income and by changes in fossil fuel prices. Effects of climate change legislation on the macroeconomy could have an impact on domestic food demand. Export demand facing U.S. agriculture could be affected both by the legislation's impacts on the global economy and by the opportunity of foreign producers to earn offset income by changing production practices to reduce emissions and sequester carbon.

From bills to regulation

Any analysis being done today about the impacts of climate change legislation will be built on a series of assumptions about how the rest of the policy process will unfold. Final legislation may differ in important ways from the House-passed bill. Many important decisions would need to be made in writing rules to implement any legislation that is finally approved. It is inevitable that many of the policy assumptions underlying analysis today will differ in important ways from final implementation of compromise legislation. Just to take one critical example, impacts of climate change legislation on the farm sector will look very different if implementing rules make it very easy to earn offset income by planting trees than if it is difficult.

Climate change and international efforts

The discussion so far has not focused on climate change itself, primarily because I am not an expert on climate change and its potential impacts on agricultural production. It has been argued that the proposed legislation would have only modest impacts on the world's climate over the next few decades. If instead the climate effects are large, they might have important impacts on agricultural production and prices.

When examining trade agreements, it is important to distinguish effects that result when one country changes its policies from effects that result when all countries change policies simultaneously. A similar point is relevant here: it is important to be clear whether one is reporting changes that result only from proposed U.S. climate change legislation, or changes that might result if there is a global agreement. The discussion here has focused on U.S. legislation only, but it could matter tremendously what actions other countries are also taking to address climate change.

For example, much of the analysis conducted so far assumes that the U.S. firms will be able to purchase large amounts of offsets from other countries for practices that reduce emissions or sequester carbon. Similar policies in other countries could increase competition for such offsets. This would tend to increase allowance prices, resulting in higher domestic energy costs and more demand for domestic offsets.

Summary

There is considerable uncertainty over the possible impacts of climate change legislation on the U.S. agricultural sector. Here is a brief summary of what we think we know and what we do not:

(1) The House-passed legislation would raise energy costs, and this would translate into higher farm production expenses.

(2) Just how large the increases in production costs would be is unknown. Alternative sets of reasonable assumptions result in very different estimates of production cost impacts.

(3) The ability to earn offset income by changing production practices or planting trees or energy crops could have major impacts on agricultural production, commodity prices, farm income, consumer food costs, and rural communities.

(4) The greater the shift in acreage away from production of traditional crops to trees or energy crops, the larger the potential impact on crop production and prices. Resulting increases in revenues may offset some or all of the increase in production expenses for crop producers.

(5) Unilateral U.S. changes in climate policy could have very different impacts than if there is a multilateral agreement to reduce greenhouse gas emissions.

Thank you for your interest in our work.

The CHAIRMAN. Thank you, Doctor. Dr. Antle.

STATEMENT OF JOHN M. ANTLE, PH.D., PROFESSOR OF AGRICULTURAL ECONOMICS AND ECONOMICS, MONTANA STATE UNIVERSITY; COURTESY PROFESSOR OF AGRICULTURAL AND RESOURCE ECONOMICS, OREGON STATE UNIVERSITY; UNIVERSITY FELLOW, RESOURCES FOR THE FUTURE, BOZEMAN, MT

Dr. ANTLE. Mr. Chairman and Members of the Subcommittee, thank you for this opportunity to appear today and testify about the potential impacts of climate change and greenhouse gas mitigation on the farm sector and the food industry. My name is John Antle. I am a Professor of Agricultural Economics and Economics at Montana State University in Bozeman, Montana. The following are the main points I would like to emphasize. First, agriculture and the food system are likely to be impacted substantially by climate change and by policies designed to mitigate the effects of greenhouse gas emissions. While these sectors are dynamic and have demonstrated capability to adapt to change, the economic impacts of climate change on agriculture and the food system more broadly are likely to be substantial.

There are many important unanswered questions about the ability of agriculture and the food system to adapt to climate change, including the effects of policies designed to reduce greenhouse gas emissions as my colleagues have been pointing out. Second, studies of climate change impacts have likely underestimated the impacts of climate change on agriculture and the food industry, and have underestimated the importance of possible adaptations and mitigating effects of climate change. Climate impact assessments of agriculture have been limited in scope and relevance because of limitations of the data and the models used. Moreover, studies have not measured the cost of adaptation or accounted for possible changes in climate extremes.

For example, studies of production agriculture have not adequately accounted for impacts of pests and diseases on crops, and have not adequately addressed impacts on important climate sensitive sectors such as specialty crops, horticulture, livestock, poultry, and rangelands. The impacts of climate change on transportation infrastructure and the food processing industry, and the effects of greenhouse gas mitigation policies also have not been studied adequately. Third, there is a need for a comprehensive assessment of the effects of existing and likely future policies on agricultural adaptation. Many existing policies are likely to affect the ability of U.S. agriculture and the food sector to adapt to climate change, and in my written testimony I provide further discussion of these issues.

Finally, there is a potential important role for the public sector to facilitate agricultural adaptation to climate change. The substantial role that the public sector has played in making investments that led to the success of U.S. agriculture in the 20th Century raises a number of questions about the appropriate policies in the context of climate change. A key question for policy is whether climate change justifies an expanded role in these areas or whether markets can stimulate adequate responses to the adjustments that will be required as the climate changes.

Again, thank you, Mr. Chairman and Members for this opportunity to participate in this panel. I will be happy to respond to your questions. I will just conclude by noting that in addition to my written testimony, this is related to some work that I have been carrying out with an organization here in Washington, D.C., Resources for the Future on climate adaptation. I think some of that other work might be of interest to the Committee. Thank you very much.

[The prepared statement of Dr. Antle follows:]

PREPARED STATEMENT OF JOHN M. ANTLE, PH.D., PROFESSOR OF AGRICULTURAL ECONOMICS AND ECONOMICS, MONTANA STATE UNIVERSITY; COURTESY PROFESSOR OF AGRICULTURAL AND RESOURCE ECONOMICS, OREGON STATE UNIVERSITY; UNIVERSITY FELLOW, RESOURCES FOR THE FUTURE, BOZEMAN, MT

Mr. Chairman and Members of the Subcommittee, thank you for this opportunity to appear today to testify about the potential impacts of climate change on the farm sector. My name is John M. Antle and I am a Professor of Agricultural Economics and Economics at Montana State University in Bozeman, Montana. I also am a Courtesy Professor of Agricultural and Resource Economics at Oregon State University, and a University Fellow at Resources for the Future in Washington, D.C. I was first involved with research on the economic impacts of climate change while serving as a Senior Economist for the President's Council of Economic Advisers in 1990, and since then have conducted research on climate change impacts and greenhouse gas mitigation in the United States and in other regions of the world. I have also served as a Lead Author and Contributing Author to the Third and Fourth Assessment Reports published by the Intergovernmental Panel on Climate Change.

My testimony today is a brief summary of a longer publication that may be of interest to this Committee, available on the world-wide web (*www.rff.org/News/Features/Pages/Climate-Change-Forcing-Farmers-to-Adapt.aspx*). That study reviews recent research on economic impacts of climate change, and discusses implications for U.S. agriculture's potential to adapt to climate change. That report was prepared for a research program at Resources for the Future—a nonpartisan research organization in Washington, D.C.—on adaptation to climate change in agriculture and other sectors of the U.S. economy (*http://www.rfforg/News/ClimateAdaptation/Pages/domestic__home.aspx*).

The following are the main points I would like to emphasize:

- **Agriculture and the food system are likely to be impacted substantially by climate change and by policies designed to mitigate the effects of greenhouse gas emissions.** While these sectors are dynamic and have demonstrated capability to adapt to change, the economic impacts of climate change on agriculture and the food system are likely to be substantial. There are many important unanswered questions about the ability of agriculture and the food system to adapt to climate change. There are also important, unresolved questions about the effects of policies designed to reduce greenhouse gas emissions.

- **Studies of CC impacts have likely underestimated the impacts of climate change on agriculture and the food industry, and thus have underestimated the importance of possible adaptations in mitigating the effects of climate change.** Climate impact assessments of agriculture have been limited in scope and relevance because of limitations of the data and models used. For example, studies of production agriculture have not adequately accounted for impacts of pests and diseases on crops, and have not adequately addressed impacts on important climate-sensitive sectors such as specialty crops, horticulture, livestock, poultry and rangelands. The impacts of climate change on transportation infrastructure and the food processing industry, and the effects of greenhouse gas mitigation policies, also have not been studied adequately.
- **There is a need for a comprehensive assessment of the effects of existing and likely future policies on agricultural adaptation to climate change.** Many existing policies are likely to affect the ability of U.S. agriculture and food sector to adapt to climate change. These include:
  - *Agricultural subsidy and trade policies* which reduce flexibility and have unintended consequences for global markets.
  - *Production and income insurance policies and disaster assistance.* While providing some protection against climate variability and extreme events, to some extent these policies also may reduce the incentive for farmers and ranchers to take adaptive actions.
  - *Policies encouraging soil and water conservation and provision of ecosystem services.* These policies protect water quality and enhance ecosystem services such as wildlife habitat, but also may reduce flexibility to respond to climate change by reducing the ability to adapt land use and to respond to extreme events.
  - *Environmental policies and agricultural land use regulation,* such as regulations for location and disposal of waste from confined animal production facilities, are likely to affect the costs of adaptation.
  - *Tax policies* affect agriculture in many ways, and could be used to facilitate adaptation, for example, through favorable treatment of capital depreciation and investments needed to offset greenhouse gas emissions.
  - *Energy policies and greenhouse gas mitigation policies* are likely to have many impacts on agriculture as a consumer and as a producer of energy. Development of new bioenergy production systems and greenhouse gas offset policies may benefit agriculture and facilitate adaptation. The increased cost of fossil fuels associated with greenhouse gas mitigation policies will adversely affect incomes of farmers in the near term, in the longer term it will have the benefit of encouraging adaptation.
- **There is a potentially important role for the public sector to facilitate agricultural adaptation to climate change.** The substantial role that the public sector has played in making the complementary investments that led to the success of U.S. agriculture in the 20th century raises a number of questions about appropriate policies in the context of climate change. A key question for policy is whether climate change justifies an expanded role in these areas or whether markets can stimulate adequate responses to the adjustments that will be required as the climate changes. Examples of areas for public activity may be:
  - Estimation of adaptation costs and reassessment of impacts.
  - Breeding climate-resilient crop and livestock varieties.
  - Adaptation of confined livestock and poultry production to climate change and extremes, and development of resilient livestock waste management technologies.
  - Impact of climate change on insect pests, weeds and diseases and their management.
  - Effects of adaptation strategies on ecosystem services associated with agricultural lands.
  - Public information on long-term climate trends.
  - Assessing implications of energy policies and greenhouse gas mitigation policies for agriculture and the food sector.

Adaptation and Impact Assessment

Agricultural production and productivity depend on the genetic characteristics of crops and livestock, soils, climate, and the availability of needed nutrients and energy. Researchers use crop and livestock growth simulation models to analyze the possible impacts of climate change and increases in atmospheric carbon dioxide (CO_2) concentrations (known as *CO_2 fertilization*) on crop and livestock productivity. Temperature and precipitation, key drivers of agricultural production, operate on the highly site-specific and time-specific basis of the microclimate in which a plant or animal is located. Aspects of agriculture and food system impacted by climate change include:

- Soil and water resources.
- Crop, livestock and poultry productivity.
- Farm structure, income and financial condition.
- Waste management for confined animal production facilities.
- Ecosystem services from agricultural landscapes.
- Food quality and safety.
- Market infrastructure.
- Food processing and distribution.

Several methodologies have been used to estimate possible impacts of climate change on agriculture. Most studies use *integrated assessment* models, which combine process-based crop and livestock models that simulate the impacts of climate change on productivity with economic models that simulate the impacts of productivity changes on land use, crop management, and farm income. Some studies instead use statistical models based on historical data to estimate effects of temperature and rainfall on economic outcomes, and then use these models to simulate future impacts of climate change. Some of these integrated assessment models also link the farm management outcomes to environmental impact models to investigate impacts such as those on water use and quality, soil erosion, terrestrial carbon stocks, and biodiversity. The data presented here are derived from the recent U.S. assessment of climate change impacts on agriculture (Reilly *et al.* 2003), which used an integrated assessment model.

Research suggests that in highly productive regions, such as the U.S. Corn Belt, the most profitable production system may not change much; however, in transitional areas, such as the zone between the Corn Belt and the Wheat Belt, substantial shifts may occur in crop and livestock mix, in productivity, and in profitability. Such changes may be positive if, for example, higher temperatures in the northern Great Plains were accompanied by increased precipitation, so that corn and soybeans could replace the wheat and pasture that presently predominate. Such changes also could be negative if, for example, already marginal crop and pastureland in the southern Great Plains and southeast became warmer and drier. In addition to changes in temperature and precipitation, another key factor in agricultural productivity is the effect of elevated levels of atmospheric CO_2 on crop yields. Some studies suggest that higher CO_2 levels could increase the productivity of small-grain crops, hay, and pasture grasses by 50 percent or more in some areas (and much less so for corn), although these effects are likely to be constrained by other factors, such as water and soil nutrients. However, elevated CO_2 could also increase weed growth, and these adverse effects of climate change have not been incorporated into impact assessments.

According to the U.S. assessment study, the aggregate economic impacts of climate change on U.S. agriculture are estimated to be very small, on the order of a few billion dollars (compared to a total U.S. consumer and producer value of $1.2 trillion). This positive outcome is due to positive benefits to consumers that outweigh negative impacts on producers. Impacts on producers differ regionally, and the regional distribution of producer losses tends to mirror the productivity impacts, with the Corn Belt, Northeast, South, and Southwest having the largest losses and the northern areas gaining. The overall producer impacts are estimated to range from −4 to −13 percent of producer returns, depending on which climate model is used. Some statistical modeling studies have produced estimates of much smaller impacts on U.S. agriculture. For example, the study by Deschenes and Greenstone (2007) finds positive impacts on the order of 3–6 percent of the value of agricultural land and cannot reject the hypothesis of a zero effect.

Limitations of Integrated Assessment and Statistical Models

There are a number of significant limitations to integrated assessment models, as well as the statistical models, as discussed in detail in Antle (2009). One critical limitation of these modeling studies is the difficulty in quantifying the costs of adaptation. Whereas these studies have attempted to quantify the impacts of climate change on physical quantities of production and their economic value, few, if any, studies have attempted to quantify the costs of adapting to climate change. These costs would include adaptations to production agriculture, including additional research and development of crop and animal varieties, and changes in or relocation of capital investments such as crop storage infrastructure, confined animal facilities and waste management investments. If the rate of climate change were relatively high, implying that the costs of adaptation were also relatively high, then the net benefits of adaptation would also be lower, and less adaptation would occur. Consequently, contrary to many economists' arguments that adaptation is likely to offset much of the adverse impacts of climate change, it may be that if the costs of adaptation are high, the impact estimates assuming little adaptation may be closer to actual outcomes than the estimates that ignore adaptation costs.

In addition to their inherent model limitations, the impact assessments cited above do not consider many of the potential impacts of climate change on the food transportation, processing, and distribution sectors mentioned above. In particular, none of the impact assessments has considered the costs of relocating input distribution systems, crop storage and processing, or animal production, waste management, slaughter and processing facilities. Only recently have some studies begun to assess impacts of proposed GHG mitigation policies on production agriculture or on input production and distribution, output transport, or food processing and distribution systems. Recent experience with higher fossil fuel costs suggests that these impacts may be more important for farmers and food consumers than the impacts of climate on productivity. Thus, by largely ignoring possible impacts of future climate change mitigation policies, the impact assessments carried out thus far may have missed some of the most important long-term implications of climate change.

Policy Issues

The evidence on likely impacts of climate change on agriculture and the food sector suggest two aspects of policy that need to be evaluated. First, many existing policies affect agriculture and the food sector, and many of these policies are likely to affect adaptation. Climate change is not likely to be the focus of many of these policies, but it does make sense for policy design to take adaptation into consideration. Second, there may be a role for public policy in facilitating adaptation of agriculture and the food sector.

Policy Design and Adaptation

As yet there has not been any systematic effort to evaluate the effects of these existing policies on adaptation. Some examples of existing policies and their possible effects on adaptation are described here.

Agricultural subsidy and trade policies. Agricultural subsidy programs for major commodity crops such as wheat, corn, rice, and cotton, as well as trade policies such as the import quota on sugar, were established in the 1930s and continue today. The structure of these programs has changed over time, but a common feature is that they reduce flexibility by encouraging farmers to grow subsidized crops rather than adapting to changing conditions, including climate. In addition, because the United States produces a large share of many of these commodities, these policies have the unintended consequence of distorting global markets and discouraging an efficient allocation of resources in other parts of the world.

Production and income insurance policies and disaster assistance. There is a long history of both private and public crop and insurance schemes for agriculture and disaster relief programs. The most recent farm policy legislation, enacted in 2008, continued existing crop insurance subsidies, introduced a new revenue insurance program, and established a permanent disaster assistance program. These types of publicly subsidized crop and income insurance could be one way to address increasing climate variability and climate extremes associate with climate change. Whether this is an appropriate policy response to climate change is an open question that deserves further study. In any case, it is clear that public subsidies for crop or revenue insurance and disaster assistance, like other types of agricultural subsidies, will have the effect of reducing the incentive for farmers and ranchers to avoid adverse impacts of climate change through adaptation.

Soil and water conservation policies and ecosystem services. Over time U.S. agricultural policies have shifted from commodity subsidies towards a variety of policies that provide subsidies to encourage protection of soil and water resources and the provision of ecosystem services. For example, the Conservation Reserve Program, established in 1986 legislation, has led to more than 30 million acres of land being taken out of crop production and put into grass and tree cover through cost-sharing of conservation investments and long-term contracts providing payments to maintain conserving practices. While these policies protect surface water quality from soil erosion and chemical runoff, and enhance a number of ecosystem services such as wildlife habitat, they also reduce flexibility to respond to changes in climate over time, by reducing the ability to adapt land use, and also reduce the ability to respond to extreme events. For example, according to CRP rules farmers are not allowed to use CRP lands for grazing or to harvest grasses as animal feed. As a result, when severe droughts reduce availability of livestock feed in pasture and rangeland farmers are not allowed to use CRP lands for livestock, even though in many places this could be done on a temporary basis without substantially impacting environmental benefits of the CRP. In some cases the Secretary of Agriculture can waive these rules to allow grazing. Changes in program design, such as more flexibility in administrative rules, and better targeting of the policies towards lands with high environmental value, could facilitate adaptation.

Environmental Policies and Agricultural Land Use. Many environmental policies affect agricultural land use and management. Policies governing the management and disposal of animal waster from confined animal feeding operations are an important example that has clear implications for adaptation. Both state and Federal laws regulate the choice of sites and management of these facilities. Changes in average climate and climate extremes are likely to impact the viability of these operations in some locations, for example where waste ponds become vulnerable to extreme rainfall events and floods. Environmental regulations raise the cost of re-locating facilities and thus have the unintended consequence of discouraging spatial adaptation. Including benefits of climate adaptation in regulatory design could lead to policies that achieve the dual goals of environmental protection under current climate and the need for adaptation to future climate.

Tax Policies. A wide array of tax policies affect agriculture, including the taxation of income and the depreciation of assets. Tax rules could be utilized to facilitate adaptation in a variety of ways, for example, by accelerating the depreciation of assets, and by encouraging investments that reduce greenhouse base emissions. However, creating such policies for climate adaptation alone may prove difficult to implement, since many other types of economic and technological changes may also lead to capital obsolescence and it may not be desirable to give favorable tax treatment in all such cases.

Energy Policies. The increasing public interest in developing domestic sources of non-fossil based energy, including biofuels, has already resulted in significant policy developments, such as subsidies for corn ethanol, and is likely to have important implications for both food and fuels prices and for adaptation. Further developments in biofuels could further change the way land is used for food and fuel production and have implications for adaptation, and will be impacted by related energy policies, such as requirements for use of renewable energy. Development of other types of energy technologies, such as the use of animal waste for energy production, may have important impacts on the adaptability of these systems and the way they are regulated (see the preceding discussion of environmental regulation).

Greenhouse Gas Mitigation Policies. Policies that constrain greenhouse gas emissions have the potential to affect agricultural operations as both emitters and as suppliers of offsets to emissions, depending on how such policies are designed and implemented. For example, recent legislative proposals have imposed some limits on the use of offsets, but also have excluded agricultural operations from emissions caps. Moreover, because agriculture and the food system are relatively intensive fossil fuel users, any policy that effectively raises the cost of fossil fuels will have potentially important impacts on these industries.

Policies to Facilitate Adaptation

The record shows that U.S. agriculture's success in the 20th century was dependent on complementary investments in physical and human capital and agricultural research and extension, many of them publicly funded through institutions such as the land grant universities. Moreover, complementary policies have fostered the conservation of natural resources and the adoption of more sustainable management practices. This experience suggests that that the U.S. agricultural sector is capable of adapting to a wide range of conditions and adopting new technologies as they become available. As long as the rate of climate change is relatively slow and predictable, we can expect the same to be true with future climate change. However, important questions remain about how effectively the sector could adapt to rapid changes in average climate or increases in extreme events.

The substantial role that the public sector has played in facilitating agricultural development raises a number of questions about appropriate policies in the context of climate change. The justification for public funding of infrastructure, research, and information systems was based on economies of scale as well as the public good aspect of basic research needed to develop agricultural technologies. Although a substantial public role remains in infrastructure, research, and outreach, it has diminished over time as private institutions have become increasingly capable of providing these services. A key question for policy is whether climate change justifies an expanded role in these areas or whether markets can stimulate adequate responses to the adjustments that will be required as the climate changes. Some examples of the key questions about adaptation and a possible role for public sector involvement follow:

- *Estimation of adaptation costs and reassessment of impacts.* As noted above, the impact assessments carried out thus far have largely ignored the costs of adaptation for the agricultural production sector and for the broader food industry. Besides biasing the conclusions of the impact assessments, data on costs of alternative adaptation strategies are needed to inform both private and public decision makers. Costs should be evaluated under alternative scenarios for the rate of climate change, climate variability, and the occurrence of extreme events. Thus far, most of the research effort has been devoted to the impact on grain crops. Much more research on impacts and costs of adaptation in other agricultural systems is needed, particularly for livestock and other economically important products, such as vegetable and fruit crops.
- *Identifying adaptation strategies and supporting basic research needed for development of adaptation technologies.*
  - Basic crop and animal research on vulnerability to extremes.
  - Breeding resilient crops and livestock varieties.
  - Research on effects of climate change on pests and diseases and their management.
  - Development of more resilient livestock waste management technologies, incorporation into biofuels production.
- *Identifying and estimating the vulnerability of ecosystem services to climate change and adaptive responses.* Agricultural land-use practices are known to have important impacts on the provision of ecosystem services. As yet, the impacts of climate change on ecosystem services have not been quantified systematically on a regional or national basis. Research is needed to evaluate the effects of alternative adaptation strategies on ecosystem services.
- *Provision of public information about long-term climate trends and their economic implications.* There is a great deal of public information available on short-term weather forecasts, but there may be a need for more public awareness of long-term climate trends and forecasts. This information is a public good that may need to be supported with public funds.
- *Implications of climate change and mitigation policies for agriculture and the food sector.* As yet, virtually no research has been done on identifying and quantifying potential impacts or adaptation strategies for the food sector. Included in such an analysis would be costs of adapting the food distribution system to a warmer climate and potential impacts on the prevalence and control of foodborne pathogens. The dependence of this sector on fossil fuel-based energy also suggests that GHG mitigation policies could have substantial impacts on the national and global food system as it presently operates. As yet, none of these issues has been addressed in impact assessment studies.

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The CHAIRMAN. Thank you, Doctor. Dr. Capper.

STATEMENT OF JUDITH "JUDE" L. CAPPER, B.S.C., PH.D., ASSISTANT PROFESSOR OF DAIRY SCIENCE, DEPARTMENT OF ANIMAL SCIENCES, WASHINGTON STATE UNIVERSITY, PULLMAN, WA

Dr. CAPPER. Thank you very much. Mr. Chairman and the Members of the Subcommittee, it is a pleasure to be here. Obviously, I am from England but I have worked at Washington State University for the past 7 months. I would like to start by making it clear that our model is an environmental impact model as opposed to an economic model *per se,* but having said that as stated in my testimony carbon is the intrinsic fundamental unit of energy use. Therefore, if we want to make improvements both in economic sustainability and environmental sustainability, we have to look at carbon as the intrinsic unit of that. Based on that, there is an interesting link between economics and environmental impact, and the work that I am going to present to you shows that if we improve environmental impact by improving productivity then we also improve the economic prospects for the farming sector.

So, as you can see, on the graphs here we have an issue in that at present offset programs do not take into account productivity as a means to reduce environmental impacts. This is, in part, because the environmental impact programs to date have concentrated on a process basis per cow, per animal, per farm. If we do that, as you can see on the right, the carbon footprint per cow has doubled over the last 65 years between 1944 and 2007, but again this is on a per head basis. If we look at it on an output basis as an industry that is meant to produce food, produce dairy, per gallon of milk or per pound of milk the dairy industry has made huge strides.

In the U.S. we have cut the carbon footprint of a gallon of milk by ⅔ between 1944 and 2007. This means that as a total dairy industry we have cut our total carbon footprint over those years by 41 percent, which is a huge achievement and something that we should be very, very proud of. As I say, this is basically due to huge improvements in productivity. We have a four-fold increase in milk yield per cow between 1944 and 2007. That means compared to 1944, back then we produced 53 billion kilos of milk per year using almost 26 million dairy cows. Now due to improvements in nutrition/genetics management, we make 84 billion kilos of milk using only 9.2 million animals per year.

What that means is we have a huge improvement in environmental impact. We use 21 percent of the animals, 23 percent of the feed, 35 percent of the water, and only ten percent of the land per gallon or pound of milk now than we did 65 years ago. What this also has is obvious economic consequences to the producer. Less feed, less land, less water, less fertilizers, all has huge economic consequences. I would like to point out that this also has an impact on the beef industry if we go from a pasture-based beef system to a corn-based beef system. We have a huge improvement in growth rates and the animals are grown over about 200 fewer days.

That means with corn-based it yields more production, a more efficient system. We use about a third of the total energy to produce that beef. We have a third of total methane emissions and we cut land use by a fraction of 13, so again less resources, a beneficial environmental impact, and a beneficial effect on economics. Finally, this isn't confined just to farm level. If we look at the transportation sector here we have an example which we presented last month to the Cornell nutrition conference comparing buying eggs from a local farm, a farmer's market, and a grocery store. Because of the huge productivity of the food transport system in the states, we can cut our fuel use from 9 liters per dozen eggs if we buy individually per farm to only .03 liters per dozen eggs from a grocery store.

So in summary, productivity is extremely important to cut both environmental impact and to improve economic sustainability. Thank you, and I will be very happy to answer any questions.

[The prepared statement of Dr. Capper follows:]

PREPARED STATEMENT OF JUDITH "JUDE" L. CAPPER, B.S.C., PH.D., ASSISTANT PROFESSOR OF DAIRY SCIENCE, DEPARTMENT OF ANIMAL SCIENCES, WASHINGTON STATE UNIVERSITY, PULLMAN, WA

Summary

The purpose of U.S. animal agriculture is to produce high quality meat, milk and eggs for human consumption. The environmental impact of livestock production must therefore be assessed on a whole-system basis and expressed per unit of food produced. Improving productivity (output per unit of resource input) is a key factor in reducing the environmental impact of livestock production. Systems that allow for increased milk yield per cow, improved growth rate per beef steer or greater quantities of food product to be moved using a single vehicle allow for considerable reductions in resource use, greenhouse gas emissions and economic cost per unit of food produced. Management practices and systems that intuitively appear to be environmentally and economically beneficial should therefore be subjected to scientific assessment in order to correctly assess their potential for mitigating the environmental impact of livestock production.

Introduction

All food production systems have an impact upon the environment, regardless of how and where the food is produced. The environmental impacts of agricultural practices are increasingly well-known, not only to food producers but also to policymakers, retailers and consumers. Increased public awareness of these issues underlines the critical need to adopt livestock production systems that reduce the environmental impact of agricultural production. This can be achieved through the use of management practices and technologies that encourage environmental stewardship at the farm-level, as well as improving transportation operations to reduce the eventual environmental and economic cost to the consumer. In the following testimony I will discuss the potential for improved productivity to mitigate the environmental impact of animal agriculture.

Low-Input Production Systems Are, By Definition, Low-Output Production Systems

The dichotomous challenge of producing more food from a dwindling resource base often leads to the suggestion that adopting low-input production systems is the key to sustainable agriculture. However, this defies a fundamental principle of physics, the First Law of Thermodynamics which states that 'energy can neither be created nor destroyed, it can only change form'. Carbon is the key unit of currency of energy use of living organisms. Just as we balance our checkbook every month, energy (carbon) inputs and outputs must be balanced against each other. By definition, a low-input production system is a low-output system. Within livestock production systems, low-output systems are characterized by reduced productivity over a fixed time period. The following examples will discuss the effects of improved productivity manifested as increases in milk yield per day (dairy production), growth rate (beef production) and transportation carrying capacity (egg production).

Environmental Assessment Must Be Assessed Per Unit of Food Produced

The purpose of any livestock production system is to provide sufficient safe, nutritious, affordable meat, milk or eggs to fulfill market demand. In contrast to more uniform manufacturing industries, livestock production occurs within myriad different systems that range from extensive to intensive; small-scale to large-scale and independently owned and managed to contracted production. Environmental impact has previously been assessed per acre, per animal or per facility. Although this may provide an indication of the impact of animal production on a specific geographic region, this fails to consider the true aim of the system—to produce food.

When assessing environmental impact, it is therefore essential to express impact per functional unit of food, *e.g.,* resource use and waste output per lb, kg or gallon of product (Schau and Fet, 2008). Thus, greenhouse gas (GHG) emissions should not be simply assessed as per animal or per facility but based on system productivity using a lifecycle assessment (LCA) approach. Prescribed by the EPA, LCA incorporates all inputs and outputs within food production and allows valid comparisons to be made between systems. For example, it is intuitively obvious that a 50 cow dairy will have lower annual methane emissions compared to a 500 cow dairy. However, the 500 cow dairy will produce more milk both per facility (as a consequence of the increased number of animals) but also, according to a recent USDA–NAHMS report (USDA, 2007) an extra 1,152 kg milk per cow annually. Greater productivity is associated with both physical and financial economies of scale, but also with a reduction in environmental impact through the 'dilution of maintenance' effect (Bauman *et al.,* 1985).

The 'Dilution of Maintenance' Effect

All animals require a daily amount of maintenance nutrients to maintain weight, bodily functions and health. This 'fixed cost' must be met before production (growth, pregnancy or lactation) can occur and is fulfilled by primary (feed, water) and secondary (cropland, fertilizer, fossil fuels) resource inputs. It is also associated with a proportion of the animal's daily waste and GHG output. To use dairy cows as an example, 'dilution of maintenance' occurs when output (milk yield per cow) is increased, thus diluting the maintenance cost over more units of production and improving efficiency. This effect is not simply confined to lactating cows: the national herd also contains a considerable number of non-productive animals (non-lactating cows, replacement heifers and bulls) that serve to maintain the dairy herd infrastructure and require maintenance nutrients. Improving productivity thus improves efficiency and reduces the total population size required to produce a set amount of milk. Consequently it reduces both resource use and GHG emissions per unit of milk produced.

Improving Productivity (Milk Yield) Reduces the Dairy Industry's Environmental Impact

The effect of improved productivity on the environmental impact of producing a set quantity of milk is perhaps best illustrated by comparing U.S. dairy production in 1944 compared to 2007 (Capper *et al.,* 2009b). The agrarian vision of U.S. dairy farming involves cows grazing on pasture with a gable-roofed red barn in the background—a traditional low-input system. By contrast, the image of modern dairy production propounded by anti-animal agriculture activists is synonymous with "filthy and disease-ridden conditions" and "industrialized warehouse-like facilities that significantly increase GHG emissions per animal" (Koneswaran and Nierenberg, 2008). It is indeed true that modern dairy cows produce more GHG emissions than their historical counterparts. *Figure 1* shows that daily GHG emissions per cow (expressed in CO_2-equivalents, the standard measure for expressing carbon emissions) have increased considerably over the past 65 years. The average dairy cow now produces 27.8 kg of CO_2-equivalents per day compared to 13.5 kg CO_2-equivalents per day in 1944 (Capper *et al.,* 2009b). However, expressing results on a 'per cow' basis fails to consider system productivity. When analyzed using LCA on a whole-system basis, GHG emissions per kg of milk produced have declined from 3.7 kg in 1944 to 1.4 kg in 2007, a 63% reduction. This has been achieved through considerable improvements in productivity conferred by advances in animal nutrition, genetics, welfare and management. Annual milk yield per cow more than quadrupled between 1944 (2,074 kg) and 2007 (9,193 kg), allowing 59% more milk (84.2 billion kg vs. 53.0 billion kg) to be produced using 64% fewer lactating cows (9.2 million *versus* 25.6 million).

The resource use and waste output per unit of milk for 1944 and 2007 production systems are shown in *Figure 2.* The 4.4-fold increase in productivity (milk yield per cow) drove a 79% decrease in total animals (lactating and dry cows, heifers, mature and adolescent bulls) required to produce 1 billion kg of milk. Feed and water use were reduced by 77% and 65% respectively. The total land required for milk production in 2007 was reduced by 90% compared to 1944, due to both improved crop yields and the shift from feeding pasture to nutritionally-balanced diets based on silage, hay and concentrate feeds. Manure output from the modern system was 76% lower than from the 1944 system, contributing to the aforementioned 63% decrease in the carbon footprint per unit of milk. In consequence, the carbon footprint of the entire dairy industry was reduced by 41% by the adoption of technologies and modern management practices that improved productivity between 1944 and 2007.

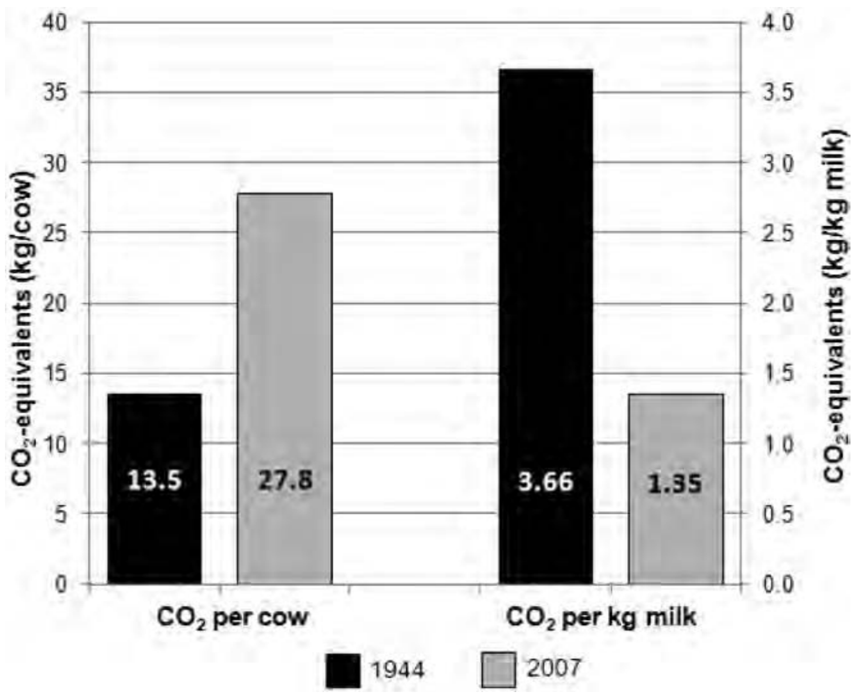

Figure 1. Carbon Footprint per Cow and per Kilogram of Milk for 1944 and 2007 U.S. Dairy Production Systems (Capper *et al.,* 2009).

The U.S. dairy industry has led the major global dairy regions in terms of productivity since 1960 (FAO, 2009). The average U.S. dairy cow produced 9,219 kg milk per year in 2007. By contrast, the average annual yield for the top six milk-producing counties in Europe was 6,362 kg milk per year, while annual production in New Zealand and Canada averaged 3,801 kg milk/cow and 8,188 kg milk/cow respectively (FAO, 2009). On a comparative basis, this meant that for every one dairy animal in the USA in 2007, Canada required 1.1 animals, Europe required 1.4 animals and New Zealand required 2.4 animals to maintain a similar milk supply (*Figure 3,* Capper *et al.,* 2009a). This clearly demonstrates the important of improving productivity in reducing the number of dairy animals required to produce a set amount of milk, therefore reducing total resources and GHG emissions associated with milk production.

Within any milk production system, a relatively minor increase in productivity will have a major environmental mitigation effect. Simply increasing the average U.S. dairy cow's daily milk yield from 29.5 kg to 34 kg would reduce the dairy population required to fulfill the market demand for milk by 12% (Capper *et al.*, 2008). This would reduce the GHG emissions per billion kg of cheese by 1,173,000 metric tonnes—equivalent to taking ~246,900 cars off the road or planting 184 million trees. This improvement in productivity would also equate to a significant improvement in economic sustainability for the producer. Fetrow (1999) discusses a similar improvement in productivity conferred by the use of the technology recombinant bovine somatotropin (rbST) and concludes that a 50% return on investment can be gained. Furthermore, as noted by Alvarez *et al.* (2008), improvements in productivity are intrinsically linked to economic and labor efficiencies.

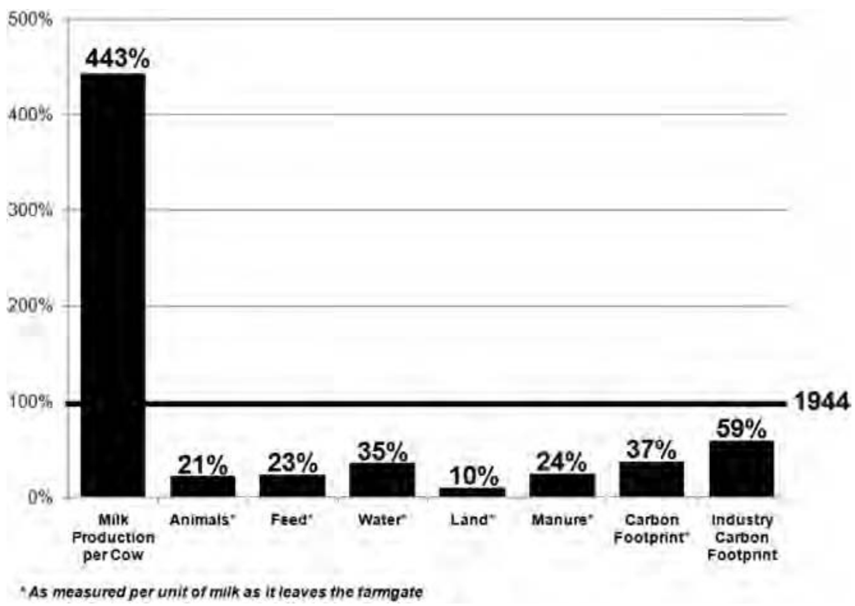

Figure 2. 2007 U.S. Milk Production, Resource Use and Emissions Expressed as a Percentage of the 1944 Production System (Adapted from Capper *et al.,* 2009).

Improving Productivity (Growth Rate) Reduces the Environmental Impact of Beef Production

Mirroring improvements in dairy productivity over time, the average beef-carcass yield per animal has increased over the past 30 years from 266 kg in 1975 compared to 351 kg in 2007 (USDA, 1976; USDA/NASS, 2008). It appears that slaughter weight has reached a plateau beyond which the processor is unwilling to venture. However, improving productivity by increasing growth rate confers considerable potential as a mechanism to reduce the environmental impact of beef production. As previously described, all animals have a basic requirement for daily maintenance nutrients to maintain health and body tissues. As growth rate increases, fewer days are required to grow the animal to slaughter weight, thus saving maintenance nutrients and associated resource inputs.

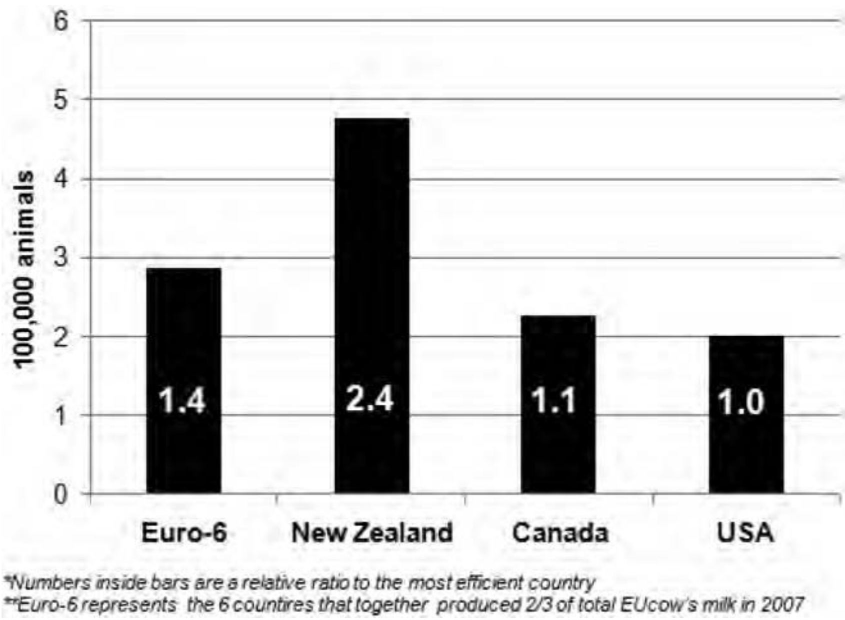

Figure 3. Dairy Animals (Cows, Heifers and Bulls) Required to Produce One Billion kg of Milk in 2007 (Capper *et al.,* 2009a).

According to Capper *et al.* (2009a) finishing beef steers on pasture takes 438 days, compared to 237 days to finish identical animals on corn-based diets. This is due to the lower growth rate conferred by pasture-based diets. In combination with increased daily GHG emissions and energy use by animals fed pasture-based diets, the extra 201 days of maintenance nutrients results in a threefold increase in total energy use and methane emissions to finish the pasture-fed steer. To supply the extra maintenance nutrients required, 13× more land is required to finish a pasture-fed beef steer than a corn-fed steer. These results are in agreement with modeling simulations of beef production systems published by researchers at Iowa State University (Lawrence and Ibarburu, 2007), and with the suggestion by Avery and Avery (2007) that pharmaceutical technologies used to improve growth rate in beef animals have positive environmental and economic effects. Furthermore, Acevedo *et al.* (2006) analyzed the economic implications of differing productivity in conventional (grain-fed), grass-fed and organic beef production systems and concluded that the conventional system, with its high growth rate, was the most economically-beneficial to the producer.

Productivity Plays a Key Role in Reducing the Environmental Impact of Food Transportation

Transportation represents a relatively minor component of the total environmental impact of food animal production with the major component occurring during the on-farm production phase (Berlin, 2002; Steinfeld *et al.*, 2006). Nonetheless, the productivity (in this situation defined as the quantity of food product moved over a specific distance) of the transport system has a major effect upon the total environmental impact attributed to transportation. In response to the current tendency to use 'food miles' as an indicator of environmental impact, three scenarios were developed by Capper *et al.* (2009a) to model the transport of a dozen eggs from the point of production to the consumers' home. The three scenarios were as follows: (1) the local chain grocery store supplied by a production facility with eggs traveling a total distance of 805 mi; (2) a farmer's market supplied by a source much closer than the grocery store's source; (total distance traveled 186 mi) or (3) directly from a local poultry farm (total distance traveled 54 mi). Intuitively it would seem that buying eggs directly from a local poultry farm would be the situation with the lowest environmental impact. However, the grocery store eggs, which traveled the furthest distance, were shown to have lowest fuel consumption per dozen eggs (0.56 liters), buying eggs from the local farm had the highest fuel use (9.12 liters per dozen eggs) and the farmer's market eggs were intermediate between the other two scenarios. The high energy efficiency of the grocery store system can be attributed to its reliance on tractor-trailers that have a capacity of 23,400 dozen eggs—a huge increase in productivity compared to the other two scenarios. Again, it is clear that productivity has a significant impact, not simply upon resource use and consequent environmental impact; but, given the current financial situation, on the economic sustainability of the food transport system.

Conclusion

The global population is predicted to increase to 9.5 billion people in the year 2050 (U.S. Census Bureau, 2008). Total food requirements will increase by 100% (Tilman *et al.*, 2002) as a function of both the 50% increase in population and the additional global demand for animal protein as people in developing countries become more affluent (Keyzer *et al.*, 2005). The resources available for agricultural production are likely to decrease concurrently with population growth due to competition for land and water and depletion of fossil fuel reserves. To continue to produce sufficient milk, meat and eggs for future domestic and export markets in an environmentally and economically sustainable manner it is essential to examine the entire food production system and to make judgments based on productivity, expressed per unit of food. There can be no doubt that improving productivity, whether as part of on-farm production or further down the transportation chain has a considerable effect upon total environmental and economic impact.

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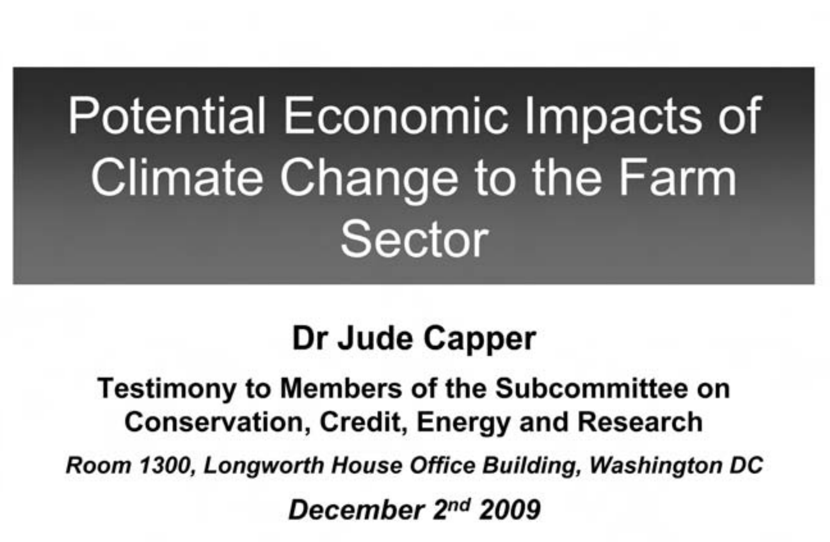
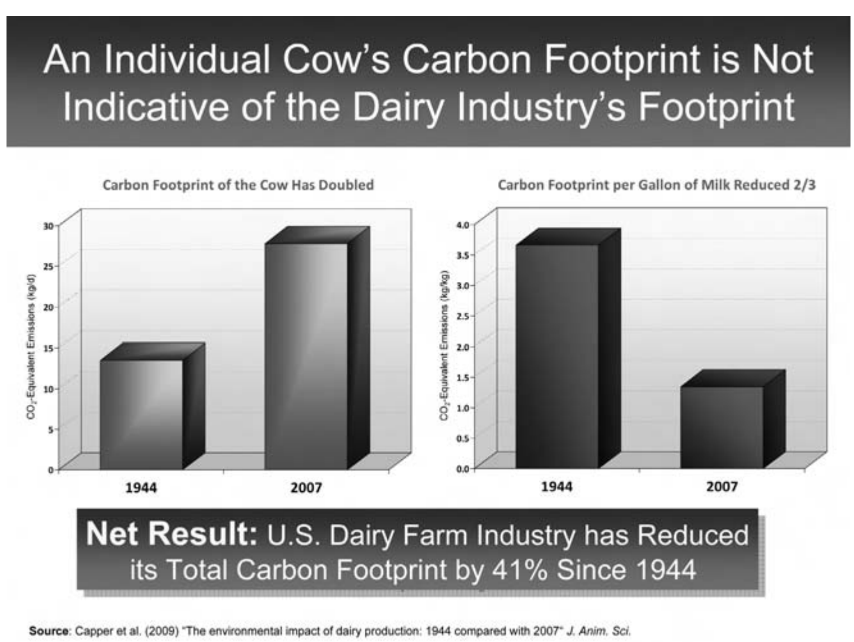
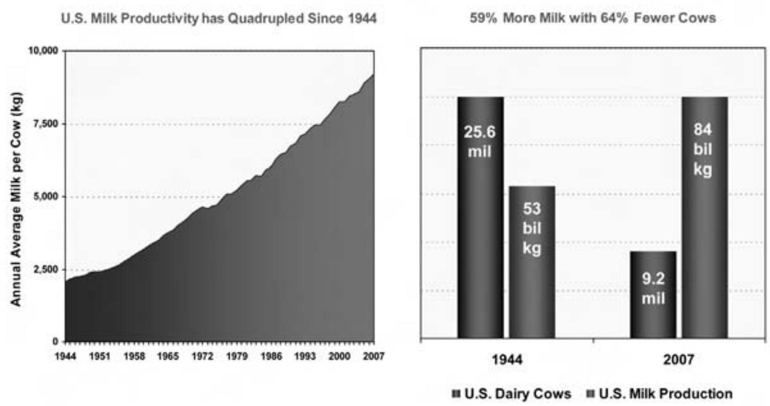
ATTACHMENT


Potential Economic Impacts of Climate Change to the Farm Sector
Dr Jude Capper
Testimony to Members of the Subcommittee on Conservation, Credit, Energy and Research
Room 1300, Longworth House Office Building, Washington DC
December 2nd 2009

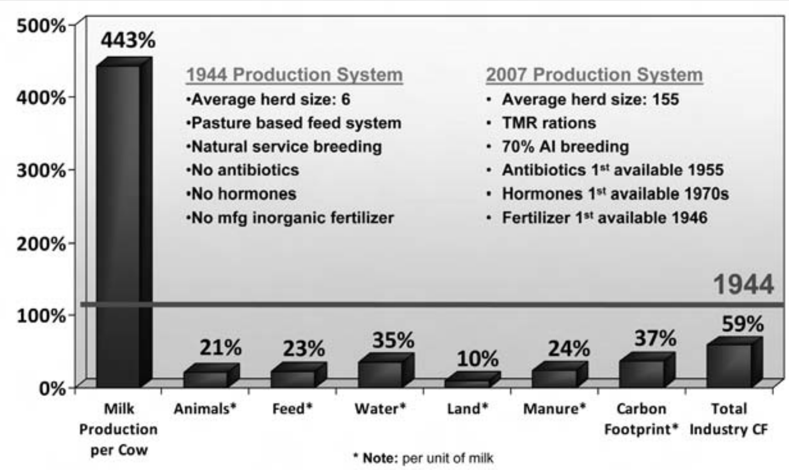

An Individual Cow's Carbon Footprint is Not Indicative of the Dairy Industry's Footprint
Carbon Footprint of the Cow Has Doubled
CO2-Equivalent Emissions (kg/d)
0
5
10
15
20
25
30
1944
2007
Carbon Footprint per Gallon of Milk Reduced 2/3
CO2-Equivalent Emissions (kg/kg)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
1944
2007
Net Result: U.S. Dairy Farm Industry has Reduced its Total Carbon Footprint by 41% Since 1944
Source: Capper et al. (2009) "The environmental impact of dairy production: 1944 compared with 2007" J. Anim. Sci.

Improved Productivity is Key to Reducing Environmental Impact

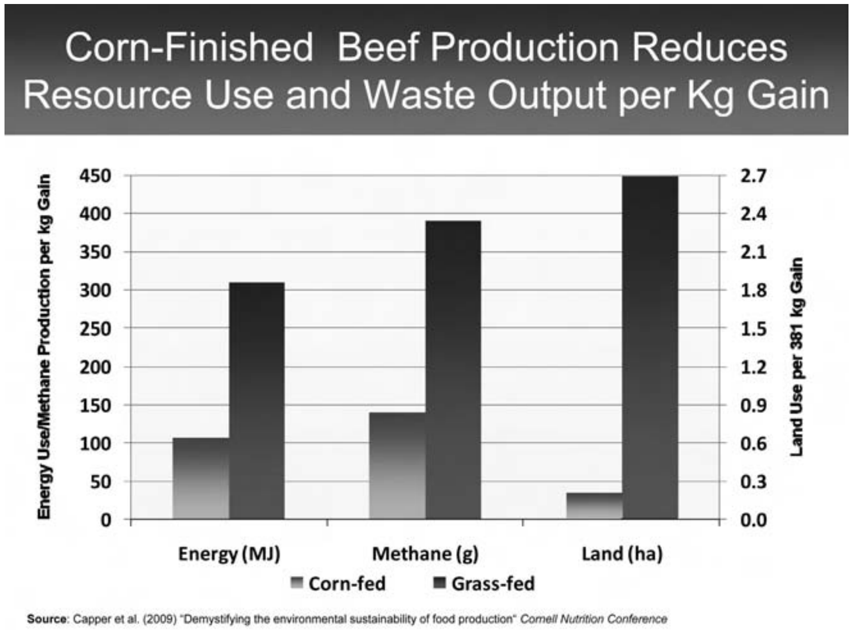


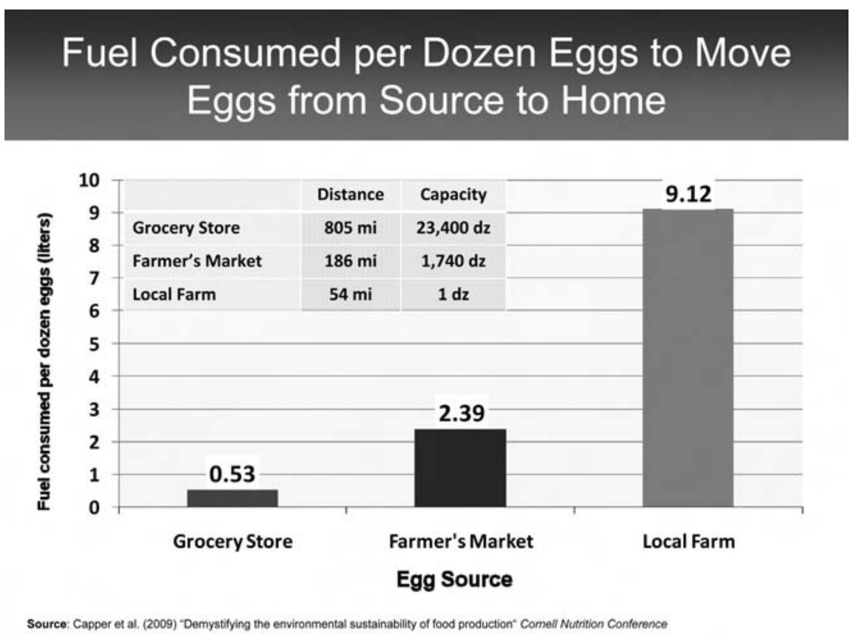
Source: USDA-NASS (2009) http://www.nass.usda.gov/Data_and_Statistics/Quick_Stats/ Last accessed, 8/14/09

Environmental Impact of U.S. Milk Production Considerably Reduced Since 1944



Source: Capper et al. (2009) "The environmental impact of dairy production: 1944 compared with 2007" *J. Anim. Sci.*


Corn-Finished Beef Production Reduces Resource Use and Waste Output per Kg Gain
Energy Use/Methane Production per kg Gain
450
400
350
300
250
200
150
100
50
0
Land Use per 381 kg Gain
2.7
2.4
2.1
1.8
1.5
1.2
0.9
0.6
0.3
0.0
Energy (MJ)
Methane (g)
Land (ha)
Corn-fed
Grass-fed
Source: Capper et al. (2009) "Demystifying the environmental sustainability of food production" Cornell Nutrition Conference


Fuel Consumed per Dozen Eggs to Move Eggs from Source to Home
Fuel consumed per dozen eggs (liters)
10
9
8
7
6
5
4
3
2
1
0
Distance
Capacity
Grocery Store
805 mi
23,400 dz
Farmer's Market
186 mi
1,740 dz
Local Farm
54 mi
1 dz
0.53
2.39
9.12
Grocery Store
Farmer's Market
Local Farm
Egg Source
Source: Capper et al. (2009) "Demystifying the environmental sustainability of food production" Cornell Nutrition Conference

The CHAIRMAN. Thank you, Dr. Capper. Mr. Pottorff.

STATEMENT OF RICHARD C. POTTORFF, CHIEF ECONOMIST, DOANE ADVISORY SERVICES, ROCHESTER, MN

Mr. POTTORFF. Good afternoon. Thank you for the invitation to participate in today's hearing. My name is Richard Pottorff and I am Chief Economist for Doane Advisory Services. The focus of our study was on the cost of production. We didn't look at potential revenue gain from the sale of carbon offsets or the impacts that may result from land moving out of crop production that was not considered. Nor were costs for transporting goods to and from farms, possible increases in the cost of food or feed processing distribution, or other off-farm costs evaluated.

Several studies, including those from government sources, showed the adoption of a climate change bill being considered in the spring of 2008 would result in higher energy prices. Energy prices are a major factor in the cost of producing crops. Production costs are impacted directly raising the cost of diesel fuel, gasoline, propane, electricity, and all the other things that farmers use to produce and harvest crops and store them. Production costs are also impacted indirectly. Natural gas is a critical factor in the production of nitrogen fertilizers which is a key crop nutrient. To meet the objectives of this study, we first estimated the relationships between the energy prices and the various components of production, per acre production costs.

The per acre production costs were based on USDA's cost and return budgets at the national level for the eight major crops. The data were extended using USDA's forecast for 2008, 2009, and then using the energy price forecast provided by EPA and the Energy Information Administration. We projected those production costs out through 2020. The alternative scenarios were then looked at to evaluate what the changes in energy prices would have on the cost of producing the major crops. The alternative scenarios were based on the productions from the Environmental Protection Agency's analysis of the Lieberman-Warner Climate Security Act of 2008.

The alternative scenarios used in this study covered a wide range of possible impacts on energy prices. One scenario included in the EPA study assumed that substantial growth in nuclear power and biofuels would mitigate the impact on energy prices. Under this scenario, natural gas prices were up 35 percent in 2020 compared to the baseline and crude oil prices were 27 percent higher. A second scenario was developed based on assumptions that nuclear power and biomass power production did not exceed the growth in the baseline scenario by 2020. In this scenario, natural gas prices were up 50 percent compared to those in the baseline and crude oil prices were up by 37 percent.

The third alternative used for the evaluation assumed that the nuclear power and the biomass production did not exceed the baseline levels, and that carbon capture and sequestration technology did not become commercially available until after 2020. Natural gas prices and crude oil prices were up by 71 percent and 52 percent, respectively, using this set of assumptions. The higher energy cost boosted crop production costs on a per acre basis by a range from $40 to $79 for corn, $11 to $20 an acre for soybeans, $25 to

$48 an acre for cotton, $80 to $153 an acre for rice, and $16 to $32 for wheat. Added together, these increased production costs in 2020 ranged from a range of $6 billion on the low side to $12 billion on the high side compared to the baseline.

A subsequent study evaluating the impact of higher energy prices on the U.S. livestock sector was undertaken. Using these same three scenarios, and assuming that the higher cost of producing crops was passed along as higher feed cost for livestock producers, livestock production cost for dairy, hogs, and cattle would increase by a total of $2.5 billion to $5 billion by 2020 compared to the baseline. Our studies were completed using energy price forecasts based on the Lieberman-Warner bill that was considered in the spring of 2008.

Government agencies have produced new reports with very different results based on the Waxman-Markey bill that passed the House of Representatives. The new EPA study showed dramatically different impacts on energy prices. The most recent study show natural gas prices up only modestly by 2020, even as caps are put on greenhouse gas emission. The determination of the level of the increase in energy prices as a result of climate change legislation is critical in determining the impact on farmers' crop production cost. Last year's EPA study showed big increases in energy prices and this year's study show very modest increases.

Other studies show significantly larger energy price impacts. Assumptions about these energy shifts, such as shifting from coal to natural gas for electricity generation, assumptions about the expansion in nuclear energy, or the assumptions about the gains in energy use technologies will all have huge implications on the estimates of cost of producing the crops for America's crop producers. Thank you.

[The prepared statement of Mr. Pottorff follows:]

PREPARED STATEMENT OF RICHARD C. POTTORFF, CHIEF ECONOMIST, DOANE ADVISORY SERVICES, ROCHESTER, MN

Good morning. Thank you for the invitation to participate in today's hearing. My name is Richard Pottorff and I am Chief Economist for Doane Advisory Services. Doane is an information company that provides economic information, analysis and forecasts to the agriculture industry. The company is headquartered in St. Louis, Missouri, and is a part of Vance Publishing Company.

About 18 months ago, we were commissioned to conduct a study designed to measure the impact that proposed climate change legislation would have on production costs for U.S. crop producers. The study, titled "*An Analysis of the Relationship Between Energy Prices and Crop Production Costs*", was completed in May of 2008. The focus of the study was on costs of production. Potential revenue gains from the sale of carbon offsets or the impacts that may result from land moving out of crop production were not considered. Nor were costs for transporting goods to and from farms, possible increases in costs of food or feed processing, distribution, or other off-farm costs evaluated.

Several studies, including those from government sources, showed that adoption of the climate change bill being considered in the spring of 2008 would result in higher energy prices. Energy prices are a major factor in the cost of producing crops. Production costs are impacted directly, raising expenditures for diesel fuel, gasoline, electricity, propane, and natural gas used by farmers to produce and harvest crops. Production costs are also boosted indirectly. Natural gas is a critical factor in the production of nitrogen fertilizers—a key crop nutrient.

To meet the objectives of the study, we first estimated the relationship between energy prices and the various components of per acre crop production costs. Production costs vary significantly from region to region, and even from farm to farm. The per acre production costs were based on USDA Costs and Return budgets at the national level. The data were extended for 2008 and 2009 using USDA forecasts, and the production costs were projected through 2020 based on the estimated relationships between production costs and energy prices. Energy price forecasts used came from USDA and the Energy Information Administration. Once this "baseline" was established, we evaluated the energy price impacts under various scenarios using the statistical relationships. Alternative scenarios were based on projections from the Environmental Protection Agency's analysis of the Lieberman-Warner Climate Security Act of 2008.

The alternative scenarios used in this study covered a wide range of possible impacts on energy prices. One scenario included in the EPA study assumed substantial growth in nuclear power and widespread international action. Under this scenario, natural gas prices were up 35 percent in 2020 compared to the baseline and crude oil prices were 27 percent higher. A second scenario was developed based on assumptions that nuclear power and biomass power production did not exceed growth outlined in the baseline scenario by 2020. In this scenario, natural gas prices were up 50 percent compared to those in the baseline and crude oil prices were 37 percent higher. The third alternative used for evaluation assumed nuclear power and biomass production do not exceed baseline levels and carbon capture and sequestration technology does not become commercially available until after 2020. Natural gas prices and crude oil prices go up by 71 percent and 52 percent, respectively, under this set of assumptions.

These higher energy costs boosted crop production costs on a per acre basis from $40 to $79 for corn, $11 to $20 for soybeans, $25 to $48 for cotton, $80 to $153 for rice, and $16 to $32 for wheat. Added together, the increased production costs in 2020 range from $6 billion to $8 billion compared to the baseline, depending on which scenario evolves.

Change in Costs From the Baseline

Crops	EPA Scenario 2 $/acre	EPA Scenario 6 $/acre	EPA Scenario 7 $/acre
Corn	40.35	55.25	78.90
Soybeans	10.52	14.03	20.41
Wheat	16.33	22.87	31.87
Cotton	24.86	33.77	48.06
Rice	79.50	107.70	153.24
Sorghum	22.23	30.58	43.56
Barley	13.35	18.16	25.87
Oats	21.86	30.65	43.93

A subsequent study evaluating the impact of higher energy prices on the U.S. livestock sector was undertaken. Using the same three scenarios, and assuming that the higher costs for producing crops were passed along as higher feed costs for livestock producers, livestock production costs for dairy, hogs, and cattle would increase by a total $2.5 billion and $3.5 billion in 2020 compared to the baseline.

Our studies were completed using energy price forecasts based on the Lieberman-Warner bill that was under consideration in the spring of 2008. Government agencies have produced new reports with very different results based on the Waxman-Markey bill that passed the House of Representatives. The new EPA studies show dramatically different impacts on energy prices. The more recent studies show natural gas prices up only modestly by 2020, even as caps are put on greenhouse gas emissions.

This determination of the level of increase in energy prices as a result of climate change legislation is critical in determining the impact on farmer's crop production costs. Last year's EPA studies showed big increases in energy prices in stark contrast to this year's results. Other studies show significantly larger energy price impacts. As an example, the midpoint of the high and low scenarios by the National Association of Manufactures is near a 40 percent increase in natural gas prices in 2020. Assumptions about energy shifts, such as shifting from coal to natural gas, assumptions about the expansion of nuclear energy, and assumptions about gains in energy use efficiencies will have huge implications for the estimates of changes in production costs for America's crop producers.

The CHAIRMAN. Thank you, sir. Dr. Westhoff, we are all aware of what the FAPSIM model shows, and the fact that EPA utilized it in their analysis or determining the impacts of H.R. 2454, but do you believe that such land shifts are likely to happen, and what would carbon prices need to be for a land to move out of crop production into trees?

Dr. WESTHOFF. Well, I very deliberately highlighted that as a major source of uncertainty that we are trying to conduct ourselves right now. I will say that my own personal impression is that the kind of shifts talked about in the EPA analysis do seem to be on the high side today. But, I also can't pretend we fully had a chance to look at all the possible stories that might unfold as people respond to, the possibility for any large amounts of money from carbon offsets. We have started to look at some other scenarios that look at more modest changes and shifts in acreage that might occur, and we find that the sort of qualitative results I talked about this morning hold even if the shifts in acreage are not anywhere nearly as large as in the analysis done for EPA.

The CHAIRMAN. Thank you. Dr. Capper, your testimony was very interesting, Mr. Goodlatte and I, think it is very helpful to a hearing we are going to be having next week, so thank you so much for that. But what is your sense of the economics of methane digesters in dairy and beef operations and what will it take for more digesters to be installed?

Dr. CAPPER. I think that is a great question. I think the main issue we have with the methane digesters are that they are not a size neutral technology so they may be ideal, for example, on a farm with 1,000 cows or 2,000 cows, but on a farm with 50 cows at the moment, the economics aren't there to make them economically viable.

The CHAIRMAN. So the economics where the Ranking Member and I come from, the Midatlantic and the Northeast, probably would not be economically viable.

Dr. CAPPER. Absolutely. Yes, absolutely.

The CHAIRMAN. Mr. Pottorff, is your organization currently working to update the 2008 study?

Mr. POTTORFF. We are not at the moment. We haven't been commissioned to do that.

The CHAIRMAN. Thank you. The chair recognizes the Ranking Member, the gentleman from Virginia, Mr. Goodlatte.

Mr. GOODLATTE. Thank you, Mr. Chairman. Dr. Capper, I want to join the Chairman in commending you for the interesting information you have provided us. What policies can Congress pursue that will achieve the goal of reduction in greenhouse gases without disrupting farm input costs and farm income?

Dr. CAPPER. As I said in my testimony productivity appears to be absolutely key. If we can improve milk yield per cow, for example, we count the number of animals——

Mr. GOODLATTE. What can Congress do about that?

Dr. CAPPER. So, therefore, we need to keep in place the tools and the management practices that allow us to do that whether that——

Mr. GOODLATTE. Those are mostly developed in the private sector, are they not?

Dr. CAPPER. Absolutely. Yes, they are.

Mr. GOODLATTE. And could there be significant GHG reductions just from additional research and development?

Dr. CAPPER. Absolutely there could. That is important, but again we have to consider productivity as the main factor.

Mr. GOODLATTE. But the research that we do provide some assistance for could help to increase productivity?

Dr. CAPPER. Of course. Yes. Absolutely. Absolutely.

Mr. GOODLATTE. So that type of approach as opposed to the sale of credits and so on might bear more effect on productivity than a cap-and-trade arrangement.

Dr. CAPPER. Yes. Absolutely.

Mr. GOODLATTE. What do you believe the environmental impact would be of shifting more agriculture production overseas? If a farmer can't comply with cap-and-trade requirements and the cost of doing business rises. If it is found to be cheaper to distributors and food processors, and so on, to import more food, would that not have the effect of actually increasing greenhouse gas emissions; since American producers are generally more efficient, as you demonstrated in your chart, than the impact of shifting the production to other places and the transportation costs of transporting those agricultural products further and further away from the end consumers?

Dr. CAPPER. Yes. Absolutely. Transportation is a fairly minor component compared to what comes from the cow, but there is absolutely not doubt that as a U.S. dairy industry we are highly efficient and we have a really low environmental impact compared to other countries, again, as in the testimony.

Mr. GOODLATTE. Thank you. Dr. Outlaw, you mentioned in your testimony that not all of the representative farms that you discussed could participate in offset projects. Did any of these representative farms have higher cash reserves at the end of the period?

Dr. OUTLAW. Yes. There were a number of them that would see benefits from higher prices. That is the question that Pat was asked earlier. If there are land shifts to afforestation, for example, then some of the cropland will go out and prices will rise, and that is driving more the results in than the carbon part of our analysis. The actual selling carbon offsets performed—only averaged a little over $10,000 per farm per year. So most of the ones that were better off were because of price impacts.

Mr. GOODLATTE. And that, of course, is borne by the consumer, is that not correct?

Dr. OUTLAW. Absolutely.

Mr. GOODLATTE. So, as with so many other aspects of cap-and-trade, whether it is a utility company or some other entity, some of the ability to sustain this is by their ability to transfer those costs to others and ultimately that burden can fall on the consumer.

Dr. OUTLAW. Correct. And the ranches that we analyzed, we didn't assume they were eligible, which at some locations they would very well be, but we didn't assume for this analysis but they are made much worse off because of the higher feed costs.

Mr. GOODLATTE. Did any of the representative farms that did have offset projects end up with lower cash reserves?

Dr. OUTLAW. Yes. Yes, they did.

Mr. GOODLATTE. Can you explain that?

Dr. OUTLAW. Well, in a lot of cases, for example, in the dairies our assumption was 500 cows or more to put in a methane digester, but not in all cases is that a financially sound move. They were actually well worse off by trying to sell program credits by doing this and selling electricity than they would have been otherwise.

Mr. GOODLATTE. And finally to Dr. Westhoff, your testimony gives several scenarios that there is a shift of crop acres to trees. If there is a large shift as expected by the EPA, how will this change the structure of agriculture? Could this drive farmers and ranchers out of business?

Dr. WESTHOFF. Well, you definitely have impacts that will be worldwide in their nature. I mean we would be talking about shifting a lot of agricultural production out of the U.S., which would have impacts on everything from the farmer to the processor to the consumer. We do think it would have impacts on things like rental rates that farmers have to pay for land and the cost of land itself. If you are a landowner, this might be a very good thing. For someone who has to rent land for a living, it might not be such a good thing.

Mr. GOODLATTE. And from a homeland security perspective since that has been raised at this hearing earlier it would make us more dependent on foreign sources of food, would it not?

Dr. WESTHOFF. It would mean that we would have less exports and that is certainly true.

Mr. GOODLATTE. Thank you, Mr. Chairman.

The CHAIRMAN. The chair thanks the gentleman and recognizes the gentlewoman from South Dakota.

Ms. HERSETH SANDLIN. Thank you, Mr. Chairman. I thank you and the Ranking Member for this hearing and the witnesses for their testimony. Dr. Antle, I would like to pose my questions to you and then the other witnesses can certainly add their perspectives. As it relates to your testimony with regard to the way that a robust public investment in agriculture in the 20th century led to such great advancements in agriculture and technology. I know some of the questioning here today, particularly of Dr. Glauber, focused on the state of the climate science, what the best approach to addressing greenhouse gas emissions would be in terms of a policy matter of cap-and-trade *versus* some other system. But, separate from that if we just accept that there have been climate changes regardless of what has caused it, and its impacts on agriculture, in your opinion what is the best role for the public sector in facilitating agricultural development in the transition to a new energy economy? Where can Federal resources best be targeted to provide the greatest benefit to help agriculture adapt to changes in climate?

Dr. ANTLE. Well, thank you for that question. Good question. I think perhaps like my colleague has suggested increasing investments in productivity are important, but I would point out that an important *caveat* there is that just raising productivity doesn't reduce emissions. It reduces emissions per unit of output but of course not overall emissions, and hence the idea of cap-and-trade type policy. But to better facilitate adaptation, we need to do a better job of understanding the range of possible impacts, hence in my testimony some of the comments about, for example, looking in more detail at the potential impacts of extreme climate events, for example, and how that would impact agriculture, and then also, really, how agriculture is going to be organized spatially. If we do see continuing changes in climate like we have been seeing agriculture is, in a sense, going to move around, and there are potentially important questions about how that will happen.

For example, the livestock industry. Relocating livestock, confined animal production, could be a real challenge given the regulatory environment we have and other issues. So, we need to look more broadly. The studies that have been done so far have really focused on grain production and sort of major commodity production, and that is largely because that is where we have models to simulate effects of climate. But a lot of other areas of agriculture are, of course, just as important.

And another thing that the studies have tended to over emphasize are costs of adaptation. When you look at these studies what you see is that in fact there has been a lot of emphasis on what are the benefits of adaptation with very little attention to what are the potential costs of adaptation, and that, of course, tends to bias the results. So, we need to think more carefully about where we think agriculture is headed in the future, impacts on the various parts of agriculture, not just grain crop production, and how research could help mitigate the impacts and facilitate the adaptations.

Ms. HERSETH SANDLIN. I appreciate that response. Any thoughts as it relates to domestic biofuels production? I understand the focus on grain because the models are there, but it is also because grain production, at least for grain-based ethanol production. What about, for example, some of the research that maybe you are doing, that folks at South Dakota State University are doing as it relates to cover crops in addition to other farming practices, or the investments that we have made in the past as it relates to providing the foundation for seed technology that, again, goes not just to productivity but perhaps meeting our domestic biofuels needs as well.

Dr. ANTLE. Definitely, there are a lot of opportunities there also with confined animal, waste management. USDA has some real breakthroughs there, so, yes, I think there are a lot of opportunities.

Ms. HERSETH SANDLIN. Well, I appreciate your focus on what is going to happen spatially. I found your written testimony very interesting as it relates to what may happen to the Corn Belt *versus* Northern Great Plains and, again, how that affects both grain production as well as livestock production. Any other witnesses—my time is up, and I know we have votes, so if any of you want to respond to those questions if you could do so in a written submission, I would appreciate it. Thank you, Mr. Chairman.

The CHAIRMAN. The chair thanks the gentlewoman. The gentleman from Pennsylvania.

Mr. THOMPSON. Thank you, Mr. Chairman, and I thank the panel for your testimony. Dr. Westhoff, you talked about, in your testimony and your remarks, about crop production patterns, and it was referenced early we certainly have concerns about food security in the future. I think that is a huge risk for us to be depending on other countries for our food supply. In your remarks with the potential for shifting certain crops and agricultural commodities, are there certain crops or commodities you see that are more at risk based on what information we have now to shifting to offshore or overseas?

Dr. WESTHOFF. There is lots of uncertainty here as has kind of been my theme, I guess, all morning here is there is lots of uncertainty about the effects we are likely to see. I do think, as Dr. Glauber talked about this morning, crops like rice, for example, is one where it is hard to see many positives that might come from the legislation's impacts. That may be one where reduced exports would be even more likely in future commodities. I do want to stress that even though we are talking about lower levels of U.S. production going overseas is a possibility here, I don't think we are likely to talk about a scenario where the U.S. becomes an importer of those products. Reduced exports is the most likely outcome.

Mr. THOMPSON. Okay. Thank you. Dr. Antle, you noted in your remarks that the market changes in responding to climate change. I was wondering are there any, based on your experience, any examples of potential market changes that could occur that you can give as an example?

Dr. ANTLE. In response to climate?

Mr. THOMPSON. Yes, please.

Dr. ANTLE. Sure. And some of them have been described here already, but the modeling studies, for example, suggest that green production might—corn, soybean production might move west and north, so that would have production impacts, and would impact market distribution systems, for example. You could also—and then further south you go typically the more adverse impacts are—what the current studies tend to show is that in the U.S. some areas benefits and some areas are harmed, and on net the impacts are fairly small. So that kind of shifting of comparative advantage would certainly have market impacts, you can imagine.

Mr. THOMPSON. Thanks. And then my final question, Dr. Capper, the information provided was very interesting in terms of dairy in terms of the increase in productivity since 1944. If I read that correctly, 443 percent increase in productivity, more efficiency. Just very simply my question is given those huge leaps, what—two questions, I guess, two-part question. What were the motivating forces to have that happen and then what is the potential for giving that growth, significant growth, so far, what is the future for—potential for future productivity increases?

Dr. CAPPER. Okay. So the advances that we have made to date have been huge, and they were basically economically based. It became more economically sound to have cows that gave more milk via nutrition/genetics management, and so on. The average animal now gives about 22,000 pounds of milk per year. The record cow has given about 40,000 pounds of milk per year and there are herds with an average of over 30,000 pounds of milk per year, so we still have a huge way to go in improving productivity that way and improving economics of the environment as well.

Mr. THOMPSON. Okay. Thank you. Thank you, Mr. Chairman.

The CHAIRMAN. I thank the gentleman. The gentleman from Minnesota.

Mr. WALZ. Thank you, Mr. Chairman, and thank you all for taking the time to testify. I really appreciate the different takes on this. Just a couple questions. I was referencing before the study that came out of New York University more integrated than this. I think maybe we make a mistake. Obviously, we are concerned.

This is the Agriculture Committee. It is our Committee of jurisdiction, but to look at one sector and silo it away from the overall impacts and how they are all going to tie together, is a mistake, and I know all of you are looking in that direction too.

I just wanted to focus on a couple of things. Again, Dr. Antle, you probably hit it more where I was coming from on this. The cost of doing nothing and the cost of allowing climate change as it exists to go forward, that has to be factored in. That has to be laid on the table as we look forward. I think one of the things I am coming to, and there is a University of Tennessee study, and maybe you guys can help me as peer review type of things, of starting to show the positive impacts of this and into the numbers of $364 billion above letting the EPA do this, potentials that are there.

So, the question is, can we do this type of legislation right if it is coupled with an energy policy that includes nuclear power which I agree has to be a part of this? Can we make this broader where we start to get energy security on this, we start to transfer, and we don't harm the agricultural markets? Do you feel from your expert opinion that the potential there lies to do this if we do this right, or is the cap-and-trade exactly the wrong way to go? And, Dr. Capper, I find it interesting you said most of the productivity improvements were done in the private sector and you all said at state universities. I say that because Dr. Borglum is from the University of Minnesota and Texas A&M from the Green Revolution and other things that come out of it. And I also say that because when I request money for Aphid control research at the University of Minnesota that is of course an earmark that isn't for bid.

Now are we counterproductive in everything we are doing? To you I want to ask, what we want is this. We want stability in our agricultural markets. We want stability in our energy markets. We want the ability to control human emissions of greenhouse gases if we believe that that is important. In your expert opinion, can that be done? Each of you, can it be done? The question basically is should we throw the cap-and-trade side of things out and is there a different way to do it, or in your opinion is it important to look at this? And I say that because what is hanging over this is all of us know one of two things. It is either the climate change itself is going to make these things known to us and we are going to find out, or EPA is going to do it one way or another or maybe both. So my question is, is this the right approach in your opinion, cap-and-trade?

Dr. OUTLAW. To be honest with you, Congressman, I really hadn't thought about it in that regard. Most of our work is on a request basis where we are requested to do certain things. Could it be done? Absolutely, it could be done. The question that I have as an economist is what is the economic cost on the players that are affected and are there ways to mitigate those costs or not, and, if not, maybe another approach. So my answer is not really an answer. It is more of a question.

Mr. WALZ. No, and I appreciate that because it is complex and I appreciate all of you thinking at it from those different angles.

Dr. WESTHOFF. FAPRI does not endorse or oppose legislation, but I will say that I think it is appropriate to ask the question: what are the consequences of doing nothing. In my own written testimony I do mention the fact that it is important to distinguish the impacts of U.S. legislation by itself and what that might do incrementally to climate change *versus* the impacts of other countries likewise agreeing to something.

Dr. ANTLE. Congressman, it is important for us to do something if we think this is a serious problem, and we all know there are a number of different ways to create incentives for not only agriculture but the rest of our economy to respond to do something different. We have to change. If we are going to solve this problem of climate change and energy consumption, we have to do things differently. So, yes, there may be some impacts on agriculture and there may be some impacts on you and me, but that is the price we have to pay for changing if we think it is important to change.

Dr. CAPPER. Again, I agree. I think it is something we should change and that we can change, and the only thing we have to take into account is we have a growing population. We have to use more food and we have less resources and what is the best way that we can possibly do that economically and environmentally.

Mr. POTTORFF. Yes, sir. I think that there have been some public studies out that show the potential yield implications of doing nothing are extreme, 40, 50 percent declines in yield production. Meanwhile, we are talking about needing to increase food production by 50 percent by 2050 or even more. And so I think that we need to take some action. What action we take is hard to say. I just want to suggest that we want to be careful when we do this so that we don't hamstring American farmers and that we don't hamstring our fertilizer industry. Over the last decade, we have seen 25 ammonium-producing fertilizer plants close, and we have out-sourced basically our nitrogen fertilizer applications, and that is why I was so concentrated on natural gas because it does have such a big impact on the fertilizer industry.

Mr. WALZ. Thank you all.

The CHAIRMAN. The chair thanks the gentleman, and the chair thanks our witnesses for their testimony today. Unfortunately, we are going to have to run. There are five votes on the House floor. Under the rules of the Committee, the record of today's hearing will remain open for 10 calendar days to receive additional material and supplementary written responses from the witnesses to any question posed by a Member. The hearing of the Subcommittee on Conservation, Credit, Energy, and Research is adjourned.

[Whereupon, at 12:34 p.m., the Subcommittee was adjourned.]

[Material submitted for inclusion in the record follows:]

SUBMITTED STATEMENT BY FORD B. WEST, PRESIDENT, THE FERTILIZER INSTITUTE

December 4, 2009

Hon. TIM HOLDEN,
Chairman,
Subcommittee on Conservation, Credit, Energy, and Research,
Committee on Agriculture,
Washington, D.C.

Dear Chairman Holden,

The Fertilizer Institute (TFI) respectfully submits this letter for the record in response to statements that were made during the Dec. 2 Subcommittee hearing that was held to examine the potential economic impacts of climate change policy on the agricultural sector.

During the hearing, U.S. Department of Agriculture Chief Economist Joseph Glauber comprehensively reviewed the potential economic impacts of climate change on the farm sector. On page six and seven of his written testimony, Dr. Glauber states:

> "While most of the direct energy price increases would be felt immediately by the agricultural sector, fertilizer costs would likely be unaffected until 2025 due to a provision in H.R. 2454 that would distribute specific quantities of emissions allowances to 'energy-intensive, trade exposed entities' (EITE). Additionally, EPA analysis indicates that the allocation formula would provide enough allowances to cover the increased energy costs of all presumptively eligible EITE industries. Based on these considerations, the USDA analysis assumes H.R. 2454 imposes no uncompensated costs on nitrogen fertilizer manufacturers related to the increases in the price of natural gas through 2024."

TFI would like to make you aware of several factors that dispute Dr. Glauber's statements regarding the potential impacts of climate change policy on fertilizer costs. First, nitrogenous fertilizer manufacturing is listed as a covered sector in the Environmental Protection Agency's (EPA) analysis of presumptively eligible sectors, which may receive allowance rebates under Subtitle B of Title IV in the House-passed climate bill H.R. 2454. However, phosphatic fertilizer manufacturing, potash mining and phosphate rock mining, all of which are industrial sectors that encompass two of the primary fertilizer nutrients (phosphorous and potassium) are not listed as eligible sectors. Given this circumstance, it is not wise to assume that fertilizer costs, which can be responsible for 19–44 percent of total operating expenses depending on the crop, would likely be unaffected by the legislation until 2025.

Second, it is currently impossible for anyone, including EPA and Dr. Glauber to predict exactly how many free emission allowances nitrogen fertilizer manufacturers will receive under Subtitle B of Title IV in H.R. 2454. All of the trade vulnerable industries will be seeking free emission allowances from a limited and defined pool and that pool will shrink each year. Emissions that aren't covered by free allowances would need to be covered by purchased allowances.

Furthermore, Sec. 763., Title IV (page 1088) of H.R. 2454 states that the purpose of the emission allowance rebate program is "to provide a rebate to the owners and operators of entities in domestic eligible industrial sectors for their greenhouse gas emission costs incurred under this title, **but not for costs associated with other related or unrelated market dynamics.**" Thus nitrogen fertilizer manufacturers would receive some allowances for their greenhouse gas emission cost (direct emission + indirect electricity emission) only, and therefore are *not* compensated for costs related to the increases in the price of natural gas, which accounts for 70–90 percent of nitrogen fertilizer production costs. Increases in the price of natural gas resulting from climate change legislation would have a significant impact on the nitrogen price paid by U.S. farmers as indicated on the attached graph, which demonstrates the high correlation between the price of natural gas paid by U.S. nitrogen manufacturers and the price of nitrogen fertilizer (anhydrous ammonia) paid by U.S. farmers. For example, as natural gas prices increased from $3.68 to $8.07 per thousand cubic feet from 2000 to 2008, the nitrogen price paid by U.S. farmers rose from $227 to $755 per material ton.

I hope you will take the points that have been raised within this letter into consideration as you continue to address the economic impact of climate change policy on the agricultural sector. Specifically, we hope you will note that there is no established economic data available to support the statement that fertilizer costs would likely be unaffected until 2025 under a cap-and-trade policy.

Sincerely,

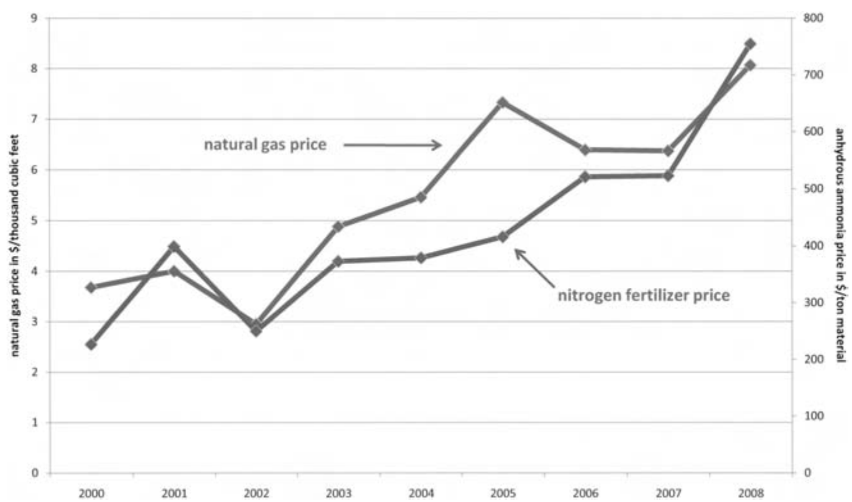
FORD B. WEST,
President.

CC:

Secretary of Agriculture, Hon. TOM VILSACK;
USDA Chief Economist, JOSEPH GLAUBER, PH.D.;
Subcommittee Ranking Member, Rep. BOB GOODLATTE.

ATTACHMENT

The Cost of Natural Gas Drives Nitrogen Prices Paid by U.S. Farmers



Data Source: USDA—retail price of anhydrous ammonia paid by U.S. farmers; EIA—U.S. wellhead price of natural gas.

SUBMITTED STATEMENT BY NATIONAL OILSEED PROCESSORS ASSOCIATION

The National Oilseed Processors Association (NOPA) offers its thanks and appreciation to Chairman Holden and Ranking Member Goodlatte for holding this hearing to review the potential economic impacts of climate change on the farm sector. NOPA also thanks you for the opportunity to submit for the record NOPA's views regarding the potential impact of global climate change legislation on the oilseed processing industry.

NOPA is a national trade association comprised of 15 member companies engaged in the production of food, feed, and renewable fuels from oilseeds, including soybeans. NOPA's member companies process more than 1.7 billion bushels of oilseeds annually at 65 plants located throughout the country, including 60 plants that process soybeans.

As your Committee begins consideration of global climate change legislation, we respectfully provide you with our perspectives on how such legislation may impact oilseed processors. Attached to our Written Statement is a document entitled "NOPA Estimates of Costs to NOPA Member Companies Associated with Global Climate Change (GCC) Legislation: Costs Due to CO_2 Allowances and Increased Energy Prices ($1,000s)" (see *Attachment A*). Also attached to our Written Statement (see *Attachment B*) is a letter to Chairman Holden and Ranking Member Goodlatte, informing them of the views of a coalition, of which NOPA is a member, including food, feed, ingredient, beverage, and consumer product processors, manufacturers, distributors, and retailers, on prospective climate change legislation.

Today, USDA will discuss the impacts of climate change legislation. NOPA believes the climate change legislation passed by the House will cause a significant restructuring of the U.S. economy and in particular agriculture from farm to fork. Conducting analysis on a dynamic and ever changing industry such as agriculture is no easy task. The climate change legislation being discussed today sets in law specific goals and targets that must be met through 2050. Assumptions play a key role in determining analysis and impact—because agriculture is so dynamic and ever changing, those assumptions will be subject to dissection and question.

With so many uncertainties and difficulty forecasting so far into the future, NOPA is concerned about the cost of allowances, increased energy cost, commodity cost, transportation cost, loss of productive cropland to trees and grass, acreage shifts, impact on livestock and poultry sectors, and compliance with our WTO obligations, to name a few.

While USDA and some of the other witnesses at today's hearing are discussing the impact of climate change legislation on farmers, NOPA believes analysis by USDA and the other witnesses should include the economic impact from farm to fork. Examples should include other ag-related industries such as processors (*e.g.,* oilseed, meat processors), food manufacturers, ag equipment manufacturers, exporters, and transportation.

The assumptions used to estimate the cost of carbon allowances varies; Charles River Associates (CRA) International, in a May 2009 study, estimated carbon allowances at \$22 CO_2 per ton in 2015, \$46 CO_2 per ton in 2030, and \$124 CO_2 per ton in 2050. USDA, on the other hand, has estimated \$12.64 CO_2 per ton in 2015, \$26.54 CO_2 per ton in 2030, and \$70.40 CO_2 per ton in 2050. The cost variance and implications are staggering: (1) carbon offsets are a potential income source for producers and forest landowners; this offset program could have a devastating impact on land use, taking productive crop land out of production and planting it to trees, thereby causing higher commodity prices and higher food prices for domestic and foreign consumers; (2) the cost of purchasing allowances by NOPA member companies on Day One is substantial—in the millions of dollars on an annual basis; and (3) acreage shifts will impact NOPA member facilities' ability to obtain soybeans for processing and could lead to higher transportation costs, impacting competitiveness for upstream customers and their ability to compete in domestic and international markets.

Depending on one's assumptions, some of USDA's preliminary analysis shows that in 2050: CO_2 allowance cost per ton—\$70.40; a loss of almost 60 million acres, of which 35 million acres comes from productive cropland and 24 million acres from pastureland; soybean acreage—29% below current baseline; and hog production slaughter—23% below current baseline. These assumptions could have a devastating impact on NOPA members' processing facilities, soybean farmers, livestock and poultry customers, other ag related businesses and, more importantly, the rural communities in which NOPA plants are located.

Our views and concerns are discussed below:

- **Direct Costs to Oilseed Processing Industry (*Attachment A*).** The American Clean Energy and Security Act of 2009 (H.R. 2454), Subtitle B of Title IV, defines "energy-intensive, trade exposed entities" (EITE) to include industrial sectors that have an energy or greenhouse gas intensity of at least five percent or a trade intensity of at least 15%. Entities meeting the EITE qualify for free allowances. NOPA members do not meet EITE. Without these allowances, firms in industrial sectors such as oilseed processing would incur energy-related costs that foreign competitors would not face, putting them at a significant market disadvantage.

  In the near term (2015–2019), NOPA members would spend an estimated \$790 million on purchasing greenhouse gas (GHG) allowances and additional energy costs to operate their facilities—that's about \$2.6 million per plant over that time period in additional annual operating costs. In the moderate term (2020–2024), NOPA members would incur an estimated \$1.1 billion on allowances and additional energy costs—that's about \$3.7 million per plant in additional annual operating costs. This means in the near-to-moderate term (2015–2024), NOPA members would incur nearly \$1.9 billion in additional costs.

- **Loss of Productive Cropland.** NOPA members are extremely concerned about the unintended and problematic consequences of agricultural producers taking arable cropland out of production and converting it to grassland or trees to earn carbon offsets. USDA estimates that by 2050, land converted to afforestation would increase to nearly 60 million acres—35 million from cropland and 24 million from pastureland. Any program that inadvertently incentivizes agricultural producers to take productive and environmentally sustainable cropland out of production to earn carbon offsets would devastate U.S. agricultural competitiveness and could severely strain the ability of the food, feed, and renewable fuels industry to meet worldwide demand.

Further analysis is needed to determine the impacts on agricultural production (including the livestock and poultry sectors), commodity prices, farm income, consumer food costs, and rural communities.

- **Impact—Unintended Consequences.** Our members, as well as one of their principal customers (*i.e.,* animal producers), have limited ability to pass costs on to users/consumers of their products; thus, we (and they) are very concerned with any cost impacts on our industry, including costs for allowances and energy price increases associated with the legislation. To the degree that our members can pass costs on to their customers, the result would be higher food prices domestically and higher prices on the products our members (and, in turn, our customers) export to other countries. Higher prices would make our industry less competitive both domestically and internationally, resulting in reduced revenue for farmers, processors and livestock/poultry producers, loss of jobs within the food and related industries (*e.g.,* logistics) chain, and increased food/feed prices for U.S. consumers.

  In circumstances in which our members cannot pass on these increased costs, they would experience higher operating costs at their facilities, rendering them less competitive both domestically and internationally. The result would be reduced revenue for both farmers and processors and the loss of jobs within the food and related industries chain.

  Higher operating costs and a less competitive business environment would result in a transfer of oilseed processing and related jobs, including animal production, to other countries and a transfer, not a reduction, in global GHG emissions. In fact, the climate change problem would be exacerbated to the degree that those operations are transferred to countries that use energy sources that are more carbon-intensive.

- **Underestimated Impact of Climate Change.** The impacts of climate change legislation on the food processing industry and transportation infrastructure, including the impacts of GHG mitigation policies, have not been studied adequately. A full review of the benefits and costs of carbon tax and cap-and-trade programs should be undertaken. In a high-volume, low-margin business like the one in which our members operate, domestic production can quickly move to foreign competitors, at the expense of U.S. production and jobs. If implemented in an aggressive or reckless manner, either a carbon cap-and-trade or carbon tax program would have disastrous economic consequences on the U.S. oilseed processing industry. Either program would result in food, feed, and renewable fuel prices increasing to such a degree that the industry could not absorb the associated costs, rendering the oilseed processing industry much less competitive on exports to foreign markets.

  For these critical reasons, NOPA opposes any unilateral climate-related legislation that calls for either a carbon tax or a mandatory cap on GHG emissions. We do not believe sufficient effort has been put towards the development of voluntary initiatives that provide the framework for effective, voluntary, pro-growth, technology-driven approaches to reduce energy use, and thereby achieve GHG reductions in an economically sound manner. We believe that global GHG emissions are best addressed through voluntary initiatives, as well as through increased research, development and deployment of innovative breakthrough technologies. NOPA and its members are focused on solutions that will continue to promote U.S. agriculture and the food, feed, and renewable fuels industry.

- **Distribution of Allowances.** Any cost of allowances for entities that emit more than 25,000 tons of GHGs annually would be directly added to the operating cost of each facility. One can safely assume that firms necessarily would need to cover added costs by passing them forward in the supply chain. This inevitably would impact costs for consumers, returns for processors, or a combination of both. However, there comes a point when it is no longer possible to pass on all such costs in a globally competitive market. Therefore, without an appropriate allocation of allowances, processing firms in the United States may not remain viable.

  If a cap-and-trade approach is taken, we believe it would work best—both for the oilseed processing industry and all energy-intensive sectors—if allowances are distributed proportionately to each industry's emissions, thereby mitigating the direct and indirect impacts on all regulated industries. Such a proportionate allocation would be the fairest system, because it would avoid arbitrarily picking winners and losers and assist all industries in making the challenging transition to a low-carbon economy. A fair distribution of allowances would provide an appropriate percentage of allowances to the food, feed, and renewable fuels sector. It would also avoid the impression that the allowances represent subsidies to favored industries—an accusation that could subject the U.S. to World Trade Organization (WTO) disputes and American companies to retaliatory tariffs. We cannot demonstrate international leadership by approving GHG legislation that undermines our international credibility on trade liberalization.

- **Climate Change is a Global Challenge.** Climate change is a global challenge requiring multilateral solutions that do not shift the economic burden to agricultural production, processing, and manufacturing of food and feed products and renewable fuels. Rising energy costs commensurate with either a carbon tax or an emissions cap imposed on U.S. operations would threaten the viability of not only the energy-intensive, import/export-sensitive U.S. oilseed processing industry, but other sectors of manufacturing in the U.S., resulting in some companies facing the decision to move operations out of the country. Hence, legislation must ensure that developed and developing nations alike share responsibility for addressing climate change. Additionally, any emission reductions from such legislation must be verifiable and enforceable, particularly with respect to impacts on international trade.
- **World Trade Organization (WTO) Obligations.** Any U.S. carbon reduction program must be structured in a manner to protect our competitive advantage while being consistent with our international trade obligations under the WTO, recognizing that many of our competitors likely do not have similar policies in place. Structuring a program in this manner would be a huge challenge, considering our WTO commitments. Any U.S. carbon reduction program could lead to allocation schemes and trade mechanisms that could face WTO challenges, already a very complex problem. Designing a program/scheme to address "carbon leakage" without risking retaliation from our overseas customers would be a very difficult task. If the U.S. fails in this task, the current global recession we are experiencing could be exacerbated by a wave of international protectionism.
- **Federal Preemption of Regional, State and Other Carbon Reduction Programs.** The oilseed processing industry supports Federal preemption of all regional, state and other carbon reduction programs or, at a minimum, the harmonization of these climate initiatives. Any legislation that allows regions, states and other entities to pursue their own programs would only lead to confusion, multiple sets of record-keeping and additional expense, all of which would serve to undermine regulatory effectiveness, create investment uncertainty, and negatively impact U.S. competitiveness. The objective should be to avoid unnecessarily driving up compliance costs and making environmental goals even more difficult to reach. To the degree that these other climate initiatives remain, it is paramount that they be harmonized with the Federal program to eliminate the cost and chaos multiple independent systems would impose on the regulated sectors.

Conclusion

During these difficult economic times, it is unwise to insert additional economic uncertainties into an already fragile marketplace without full consideration of the consequences. In the event Congress acts to limit GHG emissions, a full review of the benefits and costs of the legislation should be undertaken.

Thank you for allowing NOPA to share its views on global climate change legislation. We look forward to working with you and Members of the Committee in addressing the challenges and opportunities facing businesses across the country, but, in particular, rural businesses that serve domestic farmers and livestock and poultry producers.

ATTACHMENT A

Cap & Trade Legislative Proposals: Very Costly to the U.S. Oilseed Processing Industry

The National Oilseed Processors Association (NOPA) is an important stakeholder in the global climate change legislative proposals that are being considered by the U.S. Congress. NOPA is a national trade association that represents 15 companies engaged in the production of food, feed and renewable fuels from oilseeds, including soybeans. NOPA's 15 member companies process more than 1.7 billion bushels of oilseeds annually at 65 plants located throughout the country, including 60 plants which process soybeans.

Our members, as well as their customers (*i.e.,* animal producers), have very little ability to pass costs on to users/consumers of their products; thus, we are very concerned with any cost impacts on our industry, including costs for allowances and energy price increases associated with the legislation:

- To the degree that our members can pass costs on to their customers, the result would be higher food prices domestically and higher prices on the products our members (and, in turn, our customers) export to other countries. Higher prices would make our industry less competitive both domestically and internationally, resulting in reduced revenue for both farmers and processors, loss of jobs for our members, and increased food/feed prices for U.S. consumers.
- To the degree that our members cannot pass on costs, they would experience higher operating costs at their U.S. operations, rendering them less competitive both domestically and internationally. The result would be reduced revenue for both farmers and processors and the loss of jobs for our members.
- Higher operating costs and a less competitive business environment would result in a transfer of oilseed processing and related jobs, including animal production, to other countries and a transfer, not a reduction, in global GHG emissions. In fact, the climate change problem would be exacerbated to the degree that those operations are transferred to countries that use energy sources that are more carbon intensive.

Following are some of the highlights of NOPA's cost analysis (see attached)

- In the near term (2015–2019) NOPA members will spend an estimated **$790 million** on allowances and additional energy costs to operate their plants—that's about **$2.6 million** per plant over that time period in additional annual operating costs.
- In the moderate term (2020–2024) NOPA members will incur an estimated **$1.1 billion** on allowances and additional energy costs to operate their plants—that's about **$3.7 million** per plant in additional annual operating costs.
- In the near-to-moderate term (2015–2024) NOPA members will incur nearly **$1.9 billion** in additional costs.

October 2009

ATTACHMENT

10/13/2009

NOPA Estimates of Costs to NOPA Member Companies Associated with Global Climate Change (GCC) Legislation: Costs Due to CO_2 Allowances and Increased Energy Prices ($1,000s) [a] [b]

	Year				
	2015	2020	2030	2040	2050
CO_2 Allowances [c d e]	90,066	114,629	188,319	302,949	507,644
Natural Gas [c f]	41,106	54,808	78,787	126,744	184,977
Fuel Oil [c f]	681	795	1,305	2,100	3,348
Electricity [f]	25,500	51,000	71,400	114,750	155,550
Total	157,353	221,232	339,811	546,543	851,519
$/bushel	0.09	0.13	0.20	0.32	0.50

[a] Subject estimates are based on 1.7×10^9 bushels of soybeans crushed/year from NOPA Statistics (Crush) Reports for NOPA Fiscal Year 2007–2008.

[b] Subject estimates are based on fuel use and electricity utilization estimates for a hypothetical soybean processing plant from a 19 January 2009 NOPA submittal to the United Soybean Board with recommendations on updating of a National Renewable Energy Laboratory (NREL) database for soybean processing (electricity input: 1,500 kWh/1000 bushels of soybeans; heat input: 31 MMBTU/1000 bushels of soybeans, including 65.5% from natural gas/landfill gas, 0.5% from #2 fuel oil, 1% from #6 fuel oil and 33% from coal/biomass).

[c] Fossil fuel heat contents used in the subject estimates (1.01 MMBTU/1,000 CF of natural gas; 18.60 MMBTU/ton of coal; 5.85 MMBTU/bbl of fuel oil) are from a May 2009 "Average Heat Content of Fossil-Fuel Receipts" issued by the U.S. Energy Information Administration.

[d] Emission factors used in estimating greenhouse gas emissions from the burning of fossil fuels (0.0545 kg CO_2/CF of natural gas; 2,106.9 kg CO_2/metric ton of coal; 426.1 kg of CO_2/bbl of #2 fuel oil; 495.4 kg of CO_2/bbl of #6 fuel oil) are from USEPA's 2009 GHG "Fast Facts."

[e] Price of CO_2 allowances used in estimating costs for 2015, 2020, 2030, 2040 and 2050 ($22, $28, $46, $74 and $124/ton, respectively) are from a May 2009 report by CRA International entitled "Impact on the Economy of the American Clean Energy and Security Act of 2009 (H.R. 2454)."

[f] Increased prices in 2015, 2020, 2030, 2040 and 2050 for natural gas ($1.20/MMBTU, $1.60/MMBTU, $2.30/MMBTU, $3.70/MMBTU and $5.40/MMBTU, respectively), fuel oil ($0.12/gal, $0.14/gal, $0.23/gal, $0.37/gal and $0.59/gal, respectively) and electricity ($0.01/kWh, $0.02/kWh, $0.028/kWh, $0.045/kWh and $0.061/kWh, respectively) used in estimating costs are from a May 2009 report by CRA International entitled "Impact on the Economy of the American Clean Energy and Security Act of 2009 (H.R. 2454)."

ATTACHMENT B

December 2, 2009

Hon. TIM HOLDEN,
Chairman,
Subcommittee on Conservation, Credit, Energy, and Research,
Committee on Agriculture,
Washington, D.C.

Hon. BOB GOODLATTE,
Ranking Minority Member,
Subcommittee on Conservation, Credit, Energy, and Research,
Committee on Agriculture,
Washington, D.C.

Dear Chairman Holden and Ranking Member Goodlatte:

On July 20, 2009, we sent the attached letter to Senators Boxer and Inhofe, to inform them of the views of our coalition of food, feed, ingredient, beverage, and consumer product processors, manufacturers, distributors, and retailers on prospective climate change legislation. As industries which provide abundant and affordable food and essential consumer goods to all Americans, we felt it necessary to inform you via today's letter of our concerns with climate change policies that could have direct and indirect impacts on the cost of food, feed, and household products.

We have carefully followed the draft legislation released as a Chairman's mark by Senator Boxer. We do recognize and appreciate positive steps in certain areas, specifically the ability of a wider array of methane projects to qualify as offset opportunities. We are disappointed, however, that the draft legislation does not adopt any preemption or harmonization provisions, an omission that could result in additional Clean Air Act regulation of sources that already are subject to the emissions cap contemplated in this legislation.

As we have stated before, the facilities represented by this coalition emit roughly two percent of the nation's greenhouse gases (GHGs), but are especially vulnerable to indirect costs. Consumers of the products we produce could be negatively impacted by climate change legislation that significantly increases our energy, transportation, regulatory, and commodity costs. In our view, Congress should take care to avoid adverse impacts on food security, prices, and accessibility.

While we have a number of concerns with the draft legislation, three issues in particular are paramount as the Congress continues to modify the bill:

- **Allowances—**It is critical that any legislation provide allowances to the manufacturers, distributors, and retailers of food, feed, and household products. The distribution of allowances should be based upon an industry's historic emissions, and additional allowances should be distributed to reflect reductions in emissions between 2000 and 2012. Our industry will be at a significant economic disadvantage to other industries and our competitors around the globe unless the legislation fairly distributes allowances *pro rata* across all industrial sectors. While food and beverage producers account for 1.21% of the nation's direct GHG emissions (*Carbon Risks and Opportunities in the S&P 500* at 12), if cap-and-trade legislation is approved, our manufacturers will be more affected by it than this modest figure suggests. All members of the food supply chain are disproportionately vulnerable to indirect costs passed through by suppliers. When considering the total GHG emissions from each sector, including suppliers, the food, feed, and beverage sector has the fourth largest exposure to carbon costs—more than the chemical, retail, basic resources, and automobile and parts sectors. (*Carbon Risks and Opportunities in the S&P 500* at 13).
- **Preemption—**Comprehensive climate change legislation should preempt or, if necessary, harmonize state and regional climate change programs. In addition, comprehensive climate change legislation should explicitly preempt EPA regulation under the Clean Air Act, including EPA's authority to issue New Source

Performance Standards for sources that emit between 10,000 and 25,000 tons of CO_2e/year and requirements that certain sources be subject to Prevention of Significant Deterioration and Title V permitting. Exposing industry to additional regulation from either EPA or states and regions will yield little additional environmental benefit but could result in significantly higher costs.

- **Offsets—**Our organizations believe a viable offset system is essential to achieve cost containment, as demonstrated by recent EPA and CBO economic analyses. We urge the Committee to work with the food industry and our partners in agriculture and forestry to create an offset scheme that balances the need for affordable offsets with the need for productive land. In particular, we urge the Committee to devise an offset system that limits the retirement of frequently cultivated cropland. Sound climate change legislation should not pit our climate security needs against our food security needs.

We believe these issues will have a profound impact on the international competitiveness of our industry and our ability to provide U.S. consumers with abundant and affordable products. We would be pleased to discuss these or other issues related to climate change legislation with you or your staff in greater detail.

Sincerely,

American Bakers Association;
American Feed Industry Association;
American Frozen Food Institute;
American Meat Institute;
Corn Refiners Association;
Grocery Manufacturers Association;
Institute of Shortening and Edible Oils;
International Dairy Foods Association;
National Chicken Council;
National Council of Farmer Cooperatives;
National Grain and Feed Association;
National Meat Association;
National Renderers Association;
National Oilseed Processors Association;
National Turkey Federation;
North American Millers' Association;
Pet Food Institute;
Snack Food Association.

ATTACHMENT

July 20, 2009

Hon. BARBARA BOXER,
Chairman,
U.S. Senate Committee on Environment and Public Works,
Washington, D.C.

Hon. JAMES M. INHOFE,
Ranking Minority Member,
U.S. Senate Committee on Environment and Public Works,
Washington, D.C.

Dear Chairwoman Boxer and Ranking Member Inhofe:

As a coalition of food, feed, ingredient, beverage, and consumer product processors, manufacturers, distributors, and retailers, we respectfully provide you with our perspectives as your Committee begins consideration of climate change legislation, and how such legislation may impact providing abundant and affordable food and necessary consumer goods to all Americans. Specifically, as you develop climate legislation, we urge you to consider the direct and indirect impacts on the cost of food, feed, and household products.

Our facilities emit roughly two percent of the nation's greenhouse gases, but we are disproportionately vulnerable to indirect costs. As a result, poorly designed climate legislation could significantly increase the price of food and other household products. In particular, poorly designed climate legislation could significantly increase energy, transportation, regulatory, and commodity costs. These are paramount considerations Congress must consider and prioritize among the issues it addresses. Congress must take extreme care to avoid adverse impacts on food security, prices, safety, and accessibility to necessary consumer products. For this reason, we have joined together to represent the views of this vital segment of our economy as Congress debates this important issue.

If a cap-and-trade approach is taken, we believe that climate legislation should embrace the following principles:

- **Allowances—**The distribution of allowances should be based upon an industry's historic emissions and additional allowances should be distributed to reflect early action reductions in emissions between 2000 and 2012. Although we are an energy-intensive industry, H.R. 2454 fails to provide allowances to the manufacturers, distributors or retailers of food, feed, or household products and fails to provide transition assistance to low-income households struggling with rising food prices. Thus, our industry will be at a significant economic disadvantage to other industries unless the legislation fairly distributes allowances *pro rata* across all industrial sectors.
- **Threshold—**If a cap is adopted, EPA should not be authorized to lower the threshold for the cap in the future, or use the Clean Air Act to regulate greenhouse gas emissions from sources beneath that threshold. Capturing facilities emitting between 10,000 tons and 25,000 of CO_2e/year would more than double the number of facilities subject to regulation, but only increase the share of emissions subject to regulation by ½ of 1 percent, according to EPA.
- **Offsets**—A viable offset system is essential to contain costs. Food processors, farmers, forest landowners, and others should be permitted to generate offsets, including efforts to capture methane either on the farm or through modifications to wastewater systems, to reduce the cost of allowances without unnecessary limitations on the quantity of available offsets. No distinction should be drawn between the use of domestic and international offsets, and no restrictions should be placed on the use of offsets by covered facilities. A well designed offset system should strike a balance between the need for affordable offsets and the need for productive farmland.
- **Preemption—**Comprehensive climate legislation should preempt or, if necessary, harmonize state and regional climate programs. In addition, comprehensive climate legislation should explicitly preempt EPA regulation under the Clean Air Act, including EPA's authority to issue New Source Performance Standards for sources that emit between 10,000 and 25,000 tons of CO_2e/year.
- **Trade—**Climate legislation should be contingent on Senate ratification of an international commitment to reduce greenhouse gas emissions that includes all major sources of emissions and should not authorize the Administration to place border measures on goods imported from other nations that do not have equally stringent limits on GHG emissions. In general, climate legislation should be designed to comply with our trade obligations. We should not demonstrate global climate leadership by undermining our commitment to global trade.

In addition, we believe that Congress should carefully consider the cost of allowances between 2020 and 2050, resolve tax treatment questions raised last month by the Joint Committee on Tax, resolve the regulation of any futures or derivatives markets that arise as a result of climate legislation, and make significant financial incentives available for energy efficiency.

As you develop climate legislation, we urge you to carefully consider its impact on the price of food and household products. We believe that H.R. 2454 will increase food and feed prices and reduce the international competitiveness of our businesses, and look forward to working with you to craft climate legislation that reduces greenhouse gas emissions but which also ensures a safe and affordable supply of food.

Sincerely,

American Baking Association;
American Feed Industry Association;
American Frozen Food Institute;
American Meat Institute;
Grocery Manufacturers Association;
Institute for Shortening and Edible Oils;
National Chicken Council;
National Council of Farmer Cooperatives;
National Grain and Feed Association;
National Meat Association;
National Oilseed Processors Association;
National Turkey Federation;
North American Millers' Association;
Pet Food Institute;
Snack Food Association.

SUBMITTED REPORT BY HON. JOHN A. BOCCIERI, A REPRESENTATIVE IN CONGRESS FROM OHIO

NATIONAL SECURITY AND THE THREAT OF CLIMATE CHANGE

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Sherri Goodman
Executive Director, Military Advisory Board
General Counsel, The CNA Corporation

This document represents the best opinion of The CNA Corporation at the time of issue.

NATIONAL SECURITY
AND THE THREAT OF
CLIMATE CHANGE

To the reader,

MILITARY ADVISORY BOARD

General Gordon R. Sullivan, USA (Ret.)
Chairman, Military Advisory Board

Admiral Frank "Skip" Bowman, USN (Ret.)

Lieutenant General Lawrence P. Farrell Jr., USAF (Ret.)

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General Charles F. "Chuck" Wald, USAF (Ret.)

General Anthony C. "Tony" Zinni, USMC (Ret.)

During our decades of experience in the U.S. military, we have addressed many national security challenges, from containment and deterrence of the Soviet nuclear threat during the Cold War to terrorism and extremism in recent years.

Global climate change presents a new and very different type of national security challenge.

Over many months and meetings, we met with some of the world's leading climate scientists, business leaders, and others studying climate change. We viewed their work through the lens of our military experience as warfighters, planners, and leaders. Our discussions have been lively, informative, and very sobering.

Carbon dioxide levels in the atmosphere are greater now than at any time in the past 650,000 years, and average global temperature has continued a steady rise. This rise presents the prospect of significant climate change, and while uncertainty exists and debate continues regarding the science and future extent of projected climate changes, the trends are clear.

The nature and pace of climate changes being observed today and the consequences projected by the consensus scientific opinion are grave and pose equally grave implications for our national security. Moving beyond the arguments of cause and effect, it is important that the U.S. military begin planning to address these potentially devastating effects. The consequences of climate change can affect the organization, training, equipping, and planning of the military services. The U.S. military has a clear obligation to determine the potential impacts of climate change on its ability to execute its missions in support of national security objectives.

Climate change can act as a threat multiplier for instability in some of the most volatile regions of the world, and it presents significant national security challenges for the United States. Accordingly, it is appropriate to start now to help mitigate the severity of some of these emergent challenges. The decision to act should be made soon in order to plan prudently for the nation's security. The increasing risks from climate change should be addressed now because they will almost certainly get worse if we delay.

THE MILITARY ADVISORY BOARD

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Former Chief of Staff, U.S. Army
Chairman, Military Advisory Board

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Former Deputy Administrator-Naval Reactors, National Nuclear Security Administration

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GENERAL ANTHONY C. "TONY" ZINNI, USMC (Ret.)
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ACKNOWLEDGMENTS

We are thankful to several people for their support of this effort. Rear Adm. Richard Pittenger, USN (Ret.) of the Woods Hole Oceanographic Institution, and Dr. Fiona Horsfall of the National Oceanic and Atmospheric Administration provided many valuable insights into climate science and reviewed our draft report. Dr. Robert Frosch, former assistant secretary of the Navy for research and development and former NASA administrator, currently at Harvard University, also reviewed our draft report and provided suggestions for improvement regarding the science of climate change. Dr. Kent Butts of the Army War College, Dr. Geoffrey D. Dabelko of the Woodrow Wilson International Center for Scholars, and Franklin D. Kramer, former assistant secretary of defense, reviewed our report and provided valuable comments on sources of conflict and security issues related to climate change.

We thank the following persons for briefing the Military Advisory Board: Dr. James Hansen, lead climate scientist and director, NASA Goddard Institute for Space Studies; Dr. Anthony Janetos of the H. John Heinz III Center for Science, Economics and the Environment; Dr. Richard Moss, senior director, Climate and Energy, United Nations Foundation, formerly director of the U.S. Global Change Research Program Office; Mr. Justin Mundy, senior advisor to the Special Representative on Climate Change, UK Foreign and Commonwealth Office; Maj. Gen. Richard Engel, USAF (Ret.), deputy national intelligence officer for science and technology, National Intelligence Council; Mr. Randy Overbey, former president, Alcoa Primary Metals Development; Mr. Kenneth Colburn, of the Center for Climate Strategies; and Dr. Robert Socolow of Princeton University.

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EXECUTIVE SUMMARY

The purpose of this study is to examine the national security consequences of climate change. A dozen of the nation's most respected retired admirals and generals have served as a Military Advisory Board to study how climate change could affect our nation's security over the next 30 to 40 years—the time frame for developing new military capabilities.

The specific questions addressed in this report are:

1. What conditions are climate changes likely to produce around the world that would represent security risks to the United States?
2. What are the ways in which these conditions may affect America's national security interests?
3. What actions should the nation take to address the national security consequences of climate change?

The Military Advisory Board hopes these findings will contribute to the call President Bush made in his 2007 State of the Union address to "...help us to confront the serious challenge of global climate change" by contributing a new voice and perspective to the issue.

FINDINGS

Projected climate change poses a serious threat to America's national security.

The predicted effects of climate change over the coming decades include extreme weather events, drought, flooding, sea level rise, retreating glaciers, habitat shifts, and the increased spread of life-threatening diseases. These conditions have the potential to disrupt our way of life and to force changes in the way we keep ourselves safe and secure.

In the national and international security environment, climate change threatens to add new hostile and stressing factors. On the simplest level, it has the potential to create sustained natural and humanitarian disasters on a scale far beyond those we see today. The consequences will likely foster political instability where societal demands exceed the capacity of governments to cope.

Climate change acts as a threat multiplier for instability in some of the most volatile regions of the world. Projected climate change will seriously exacerbate already marginal living standards in many Asian, African, and Middle Eastern nations, causing widespread political instability and the likelihood of failed states.

Unlike most conventional security threats that involve a single entity acting in specific ways and points in time, climate change has the potential to result in multiple chronic conditions, occurring globally within the same time frame. Economic and environmental conditions in already fragile areas will further erode as food production declines, diseases increase, clean water becomes increasingly scarce, and large populations move in search of resources. Weakened and failing governments, with an already thin margin for survival, foster the conditions for internal conflicts, extremism, and movement toward increased authoritarianism and radical ideologies.

The U.S. may be drawn more frequently into these situations, either alone or with allies, to help provide stability before conditions worsen and are exploited by extremists. The U.S. may also be called upon to undertake stability and reconstruction efforts once a conflict has begun, to avert further disaster and reconstitute a stable environment.

Projected climate change will add to tensions even in stable regions of the world. The U.S. and Europe may experience mounting pressure to accept large numbers of immigrant and refugee populations as drought increases and food production declines in Latin America and Africa. Extreme weather events and natural disasters, as the U.S. experienced with Hurricane Katrina, may lead to increased missions for a number of U.S. agencies, including state and local governments, the Department of Homeland Security, and our already stretched military, including our Guard and Reserve forces.

Climate change, national security, and energy dependence are a related set of global challenges. As President Bush noted in his 2007 State of the Union speech, dependence on foreign oil leaves us more vulnerable to hostile regimes and terrorists, and clean domestic energy alternatives help us confront the serious challenge of global climate change. Because the issues are linked, solutions to one affect the other. Technologies that improve energy efficiency also reduce carbon intensity and carbon emissions.

RECOMMENDATIONS OF THE MILITARY ADVISORY BOARD:

1. The national security consequences of climate change should be fully integrated into national security and national defense strategies.

As military leaders, we know we cannot wait for certainty. Failing to act because a warning isn't precise enough is unacceptable. The intelligence community should incorporate climate consequences into its National Intelligence Estimate. The National Security Strategy should directly address the threat of climate change to our national security interests. The National Security Strategy and National Defense Strategy should include appropriate guidance to military planners to assess risks to current and future missions caused by projected climate change. The next Quadrennial Defense Review should examine the capabilities of the U.S. military to respond to the consequences of climate change, in particular, preparedness for natural disasters from extreme weather events, pandemic disease events, and other related missions.

2. The U.S. should commit to a stronger national and international role to help stabilize climate change at levels that will avoid significant disruption to global security and stability.

Managing the security impacts of climate change requires two approaches: mitigating the effects we can control and adapting to those we cannot. The U.S. should become a more constructive partner with the international community to help build and execute a plan to prevent destabilizing effects from climate change, including setting targets for long term reductions in greenhouse gas emissions.

3. The U.S. should commit to global partnerships that help less developed nations build the capacity and resiliency to better manage climate impacts.

As President Bush noted in his State of the Union speech, "Our work in the world is also based on a timeless truth: To whom much is given, much is required." Climate forecasts indicate countries least able to adapt to the consequences of climate change are those that will be the most affected. The U.S. government should use its many instruments of national influence, including its regional commanders, to assist nations at risk build the capacity and resiliency to better cope with the effects of climate change. Doing so now can help avert humanitarian disasters later.

4. The Department of Defense should enhance its operational capability by accelerating the adoption of improved business processes and innovative technologies that result in improved U.S. combat power through energy efficiency.

Numerous Department of Defense studies have found that combat forces would be more capable and less vulnerable by significantly reducing their fuel demand. Unfortunately, many of their recommendations have yet to be implemented. Doing so would have the added benefit of reducing greenhouse gas emissions.

5. The Department of Defense should conduct an assessment of the impact on U.S. military installations worldwide of rising sea levels, extreme weather events, and other projected climate change impacts over the next 30 to 40 years.

Many critical defense installations are located on the coast, and several strategically important ones are on low-lying Pacific islands. Sea level rise and storm surges will threaten these facilities. Planning and action can make these installations more resilient. Lack of planning can compromise them or cause them to be inundated, compromising military readiness and capability.

ABOUT THE REPORT

To better inform U.S. policymakers and the public about the threats to national security from global climate change, the CNA Corporation, a nonprofit national security analysis organization, convened a panel of retired senior military officers and national security experts and conducted an assessment of the national security implications of global climate change. In this context, we define national security to refer to the influence of climate change on geo-strategic balances and world events that could likely involve U.S. military forces or otherwise affect U.S. strategic interests anywhere in the world.

The Military Advisory Board consisted of retired flag and general officers from all four services, including service chiefs and some who served as regional combatant commanders (a regional combatant commander is a four-star officer who commands all U.S. forces in a given region of the world). The Military Advisory Board and the study team received briefings from the U.S. intelligence community, climate scientists, and business and state leaders. They also traveled to the United Kingdom to meet with high-level government and business leaders to learn what actions the United Kingdom is taking to address the threat of climate change. Members of the Military Advisory Board also presented their own views, based on experience, of the security effects of climate change on various regions of the world.

This report documents the results of that effort. We start with a discussion of the geo-strategic implications of climate change in the general sense—that is, how climate change can foster instability and affect international security. We then apply this background to address specific regional security challenges in Africa, Asia, the Middle East, Europe, and the Americas. That is followed by a discussion of the challenges from climate change that can have a direct impact on military systems and operations. We conclude with a set of findings and recommendations related to mitigation, adaptation, and preparation—specific actions the U.S. government should take in response to the challenges presented by climate change. Appendices provide background on members of the Military Advisory Board, and very briefly summarize the science of climate change and ways in which the earth's environment may potentially change.

CLIMATE CHANGE AND THE SCOPE OF THIS STUDY

Although there is a great deal of agreement among the world's climate scientists regarding the overall picture of a changing climate, there is also some disagreement about the extent of future changes.

Regardless of this continuing discussion, the board's view is quite clear: The potential consequences of climate change are so significant that the prudent course of action is to begin now to assess how these changes may potentially affect our national security, and what courses of action, if any, our nation should take.

This approach shows how a military leader's perspective often differs from the perspectives of scientists, policymakers, or the media. Military leaders see a range of estimates and tend not to see it as a stark disagreement, but as evidence of varying degrees of risk. They don't see the range of possibilities as justification for inaction. Risk is at the heart of their job: They

GENERAL GORDON R. SULLIVAN, USA (Ret.)

Chairman, Military Advisory Board | Former Chief of Staff, U.S. Army

ON RISK

Former U.S. Army Chief of Staff Gordon Sullivan enjoys a good debate. But he also knows there are times when debate must stop and action must begin. With respect to climate change, he says that time has arrived.

"We seem to be standing by and, frankly, asking for perfectness in science," Gen. Sullivan said. "People are saying they want to be convinced, perfectly. They want to know the climate science projections with 100 percent certainty. Well, we know a great deal, and even with that, there is still uncertainty. But the trend line is very clear."

"We never have 100 percent certainty," he said. "We never have it. If you wait until you have 100 percent certainty, something bad is going to happen on the battlefield. That's something we know. You have to act with incomplete information. You have to act based on the trend line. You have to act on your intuition sometimes."

> "We never have 100 percent certainty. We never have it. If you wait until you have 100 percent certainty, something bad is going to happen on the battlefield."

In discussing how military leaders manage risk, Gen. Sullivan noted that significant attention is often given to the low probability/high consequence events. These events rarely occur but can have devastating consequences if they do. American families are familiar with these calculations. Serious injury in an auto accident is, for most families, a low probability/high consequence event. It may be unlikely, but we do all we can to avoid it.

During the Cold War, much of America's defense efforts focused on preventing a Soviet missile attack—the very definition of a low probability/high consequence event. Our effort to avoid such an unlikely event was a central organizing principle for our diplomatic and military strategies.

When asked to compare the risks of climate change with those of the Cold War, Gen. Sullivan said, "The Cold War was a specter, but climate change is inevitable. If we keep on with business as usual, we will reach a point where some of the worst effects are inevitable."

"If we don't act, this looks more like a high probability/high consequence scenario," he added.

Gen. Sullivan shifted from risk assessment to risk management.

"In the Cold War, there was a concerted effort by all leadership—political and military, national and international—to avoid a potential conflict," he said. "I think it was well known in military circles that we had to do everything in our power to create an environment where the national command authority—the president and his senior advisers—were not forced to make choices regarding the use of nuclear weapons.

"The situation, for much of the Cold War, was stable," Gen. Sullivan continued. "And the challenge was to keep it stable, to stop the catastrophic event from happening. We spent billions on that strategy.

"Climate change is exactly the opposite. We have a catastrophic event that appears to be inevitable. And the challenge is to stabilize things—to stabilize carbon in the atmosphere. Back then, the challenge was to stop a particular action. Now, the challenge is to inspire a particular action. We have to act if we're to avoid the worst effects."

assess and manage the many risks to America's security. Climate change, from the Military Advisory Board's perspective, presents significant risks to America's national security. Before explaining some of those risks, we touch on an important scientific point.

A global average temperature increase of 1.3°F (plus or minus 0.3°F) occurred over the twentieth century. But the temperature change on its own is not what shapes this security assessment. Rather, it is the impact that temperature increases can have on natural systems, including:

- Habitats
- Precipitation patterns
- Extreme weather events
- Ice cover
- Sea level

Throughout this report, we do not attempt to tie our findings regarding security implications to any one particular projection of future temperature changes, precipitation changes, or sea level rise whether due to ocean expansion or ice sheet breakup. Rather, our goal is to articulate the possible security implications of climate change and to consider mitigating steps the nation could take as part of an overall national security plan.

GEO-STRATEGIC IMPLICATIONS OF CLIMATE CHANGE

GEO-STRATEGIC IMPLICATIONS OF CLIMATE CHANGE

One reason human civilizations have grown and flourished over the last five millennia is that the world's climate has been relatively stable. However, when climates change significantly or environmental conditions deteriorate to the point that necessary resources are not available, societies can become stressed, sometimes to the point of collapse [1].

For those concerned about national security, stability is a primary goal. Maintaining stability within and among nations is often a means of avoiding full-scale military conflicts. Conversely, instability in key areas can threaten our security. For these reasons, a great deal of our national security efforts in the post-World War II era have been focused on protecting stability where it exists and trying to instill it where it does not.

This brings us to the connection between climate change and national security.

As noted, climate change involves much more than temperature increases. It can bring with it many of the kinds of changes in natural systems that have introduced instability among nations throughout the centuries.

In this chapter, we consider some of the ways climate change can be expected to introduce the conditions for social destabilization. The sources of tension and conflict we discuss here are certainly not solely due to climate change; they have been discussed by the national security community for many years. However, climate change can exacerbate many of them [2].
For example:

- Some nations may have impaired access to food and water.
- Violent weather, and perhaps land loss due to rising sea levels and increased storm surges, can damage infrastructure and uproot large numbers of people.
- These changes, and others, may create large number of migrants . When people cross borders in search of resources, tensions can arise.

When climates change significantly or environmental conditions deteriorate to the point that necessary resources are not available, societies can become stressed, sometimes to the point of collapse.

- Many governments, even some that look stable today, may be unable to deal with these new stresses. When governments are ineffective, extremism can gain a foothold.
- While the developed world will be far better equipped to deal with the effects of climate change, some of the poorest regions may be affected most. This gap can potentially provide an avenue for extremist ideologies and create the conditions for terrorism.

THE DESTABILIZING IMPACTS OF CLIMATE CHANGE

REDUCED ACCESS TO FRESH WATER

Adequate supplies of fresh water for drinking, irrigation, and sanitation are the most basic prerequisite for human habitation. Changes in rainfall, snowfall, snowmelt, and glacial melt have significant effects on fresh water supplies, and climate change is likely to affect all of those things. In some areas of the Middle East, tensions over water already exist.

Mountain glaciers are an especially threatened source of fresh water [3]. A modest rise in temperature of about 2° to 4°F in mountainous

VICE ADMIRAL RICHARD H. TRULY, USN (Ret.)

Former NASA Administrator, Shuttle Astronaut and the first Commander of the Naval Space Command

ON DRAWING HIS OWN CONCLUSIONS

Retired Vice Adm. Richard H. Truly was a space shuttle commander and NASA administrator and is a member of the National Academy of Engineering. When he began service as director of the Department of Energy's National Renewable Energy Laboratory in 1997, he reminded his staff that he would be confronted with a new set of issues.

"I told them that I was unencumbered with experience or knowledge of the energy business and that I would need their help," Adm. Truly said. "I had a pretty steep learning curve."

One of the first issues he was asked to consider was the extent to which fossil fuel emissions were affecting the climate.

> "I wasn't convinced by a person or any interest group—it was the data that got me."

"I was a total agnostic," Truly said. "I had spent most of my life in the space and aeronautics world, and hadn't really wrestled with this. I was open-minded."

"Over the course of the next few years, I started really paying attention to the data. When I looked at what energy we had used over the past couple of centuries and what was in the atmosphere today, I knew there had to be a connection. I wasn't convinced by a person or any interest group—it was the data that got me. As I looked at it on my own, I couldn't come to any other conclusion. Once I got past that point, I was utterly convinced of this connection between the burning of fossil fuels and climate change. And I was convinced that if we didn't do something about this, we would be in deep trouble."

Adm. Truly noted an ironic twist about his path to this conclusion. "I was NASA administrator when Jim Hansen was first talking about these issues," he said, referring to NASA's top climate scientist. "But I was focused elsewhere then, and I should have listened more closely. I didn't become a convert until I saw the data on my own."

"The stresses that climate change will put on our national security will be different than any we've dealt with in the past. For one thing, unlike the challenges that we are used to dealing with, these will come upon us extremely slowly, but come they will, and they will be grinding and inexorable. But maybe more challenging is that they will affect every nation, and all simultaneously. This is why we need to study this issue now, so that we'll be prepared and not overwhelmed by the required scope of our response when the time comes."

When asked about his experience twenty-five years ago in space, and how it affects him today, Adm. Truly said, "It does change you, there's no doubt about it. I have images burned in my mind that will never go away—images of the earth and its fragility. I was a test pilot. I was an aviator. I was not an environmentalist. But I do love the natural environment, and seeing the earth from space was the experience that I return to when I think about what we know now about the climate."

"One of the things that struck me on my first day in space is that there is no blue sky. It's something that every human lives with on Earth, but when you're in space, you don't see it. It looks like there's nothing between you and the surface of the earth. And out beyond that, it looks like midnight, with only deep black and stars."

"But when you look at the earth's horizon, you see an incredibly beautiful, but very, very thin line. You can see a tiny rainbow of color. That thin line is our atmosphere. And the real fragility of our atmosphere is that there's so little of it."

regions can dramatically alter the precipitation mix by increasing the share falling as rain while decreasing the share falling as snow. The result is more flooding during the rainy season, a shrinking snow/ice mass, and less snowmelt to feed rivers during the dry season [4]. Forty percent of the world's population derives at least half of its drinking water from the summer melt of mountain glaciers, but these glaciers are shrinking and some could disappear within decades. Several of Asia's major rivers—the Indus, Ganges, Mekong, Yangtze, and Yellow—originate in the Himalayas [4]. If the massive snow/ice sheet in the Himalayas—the third-largest ice sheet in the world, after those in Antarctic and Greenland—continues to melt, it will dramatically reduce the water supply of much of Asia.

Most countries in the Middle East and northern Africa are already considered water scarce, and the International Water Resource Management Institute projects that by 2025, Pakistan, South Africa, and large parts of India and China will also be water scarce [5]. To put this in perspective: the U.S. would have to suffer a decrease in water supply that produces an 80 percent decrease in per capita water consumption to reach the United Nations definition of "water scarce." These projections do not factor in climate change, which is expected to exacerbate water problems in many areas.

IMPAIRED FOOD PRODUCTION

Access to vital resources, primarily food and water, can be an additional causative factor of conflicts, a number of which are playing out today in Africa. Probably the best known is the conflict in Darfur between herders and farmers. Long periods of drought resulted in the loss of both farmland and grazing land to the desert. The failure of their grazing lands compelled the nomads to migrate southward in search of water and herding ground, and that in turn led to conflict with the farming tribes occupying those lands. Coupled with population growth, tribal, ethnic, and religious differences, the competition for land turned violent. Probably more than any other recent conflict, Darfur provides a case study of how existing marginal situations can be exacerbated beyond the tipping point by climate-related factors. It also shows how lack of essential resources threatens not only individuals and their communities but also the region and the international community at large.

> In some areas of the Middle East, tensions over water already exist.

Worldwide food production will be affected by climate change in a variety of ways. Crop ecologists estimate that for every 1.8°F rise in temperature above historical norms, grain production will drop 10 percent [6].

Most of the world's growth in food demand is occurring on the Indian subcontinent and in sub-Saharan Africa, areas already facing food shortages [6]. Over the coming decades, these areas are expected to become hotter and drier [7].

HEALTH CATASTROPHES

Climate change is likely to have major implications for human health. While some impacts, such as reduced deaths from cold temperatures in some areas, will be positive, the World Health Organization estimates that the overall impact will be negative [8].

The major concern is significant spreading of the conditions for vector-borne diseases, such as dengue fever and malaria, and food-borne diseases, such as salmonellosis [8]. The decline in available fresh water in some regions will also have an impact, as good health and adequate supplies of clean water are inextricably linked.

A health emergency involving large numbers of casualties and deaths from disease can quickly expand into a major regional or global security challenge that may require military support, ranging from distribution of vaccines to full-scale stability operations [9].

LAND LOSS AND FLOODING: DISPLACEMENT OF MAJOR POPULATIONS

About two-thirds of the world's population lives near coastlines [10], where critically important facilities and infrastructure, such as transportation routes, industrial facilities, port facilities, and energy production and distribution facilities are located. A rise in sea level means potential loss of land and displacement of large numbers of people. Even in our own nation, Hurricane Katrina showed the social upheaval and tensions that can result from land loss and displaced populations. But while the impact of inundation from one-time occurrences such as Hurricane Katrina is temporary, even as it is devastating, inundation from climate change is likely to be permanent on the scale of human lifetimes. Rising sea levels will also make coastal areas more vulnerable to flooding and land loss through erosion.

Storm surges will also take a greater toll on coastal communities and infrastructure as sea levels rise. According to a Pacific Institute study, a six-inch rise in the water level of San Francisco Bay would mean a fairly routine one-in-ten-year storm would wreak as much damage as a far more serious "hundred-year storm" would have caused before the sea level rise [11]. In the U.S., we may be able to cope with such a change, but poorer nations would be greatly challenged.

Most of the economically important major rivers and river deltas in the world—the Niger, the Mekong, the Yangtze, the Ganges, the Nile, the Rhine, and the Mississippi—are densely populated along their banks. As sea levels rise and storm surges increase, saline water can contaminate groundwater, inundate river deltas and valleys, and destroy croplands.

SECURITY CONSEQUENCES OF THESE DESTABILIZING EFFECTS

GREATER POTENTIAL FOR FAILED STATES AND THE GROWTH OF TERRORISM

Many developing countries do not have the government and social infrastructures in place to cope with the types of stressors that could be brought on by global climate change.

When a government can no longer deliver services to its people, ensure domestic order, and protect the nation's borders from invasion, conditions are ripe for turmoil, extremism and terrorism to fill the vacuum. Lebanon's experience with the terrorist group Hezbollah and the Brazilian government's attempts to reign in the slum gang First Capital Command [12] are both examples of how the central governments' inability to provide basic services has led to strengthening of these extra-governmental entities.

MASS MIGRATIONS ADD TO GLOBAL TENSIONS

The reasons for mass migrations are very complex. However, when water or food supplies shift or when conditions otherwise deteriorate (as from sea level rise, for example), people will likely move to find more favorable conditions [13]. Although climate change may force migrations of workers due to economic conditions, the greatest concern will be movement of asylum seekers and refugees who due to ecological devastation become settlers:

- By 2025, 40 percent of the world's population will be living in countries experiencing significant water shortages [14].
- Over the course of this century, sea level rise could potentially cause the displacement of tens of millions of people from low-lying areas such as Bangladesh [15].

Migrations in themselves do not necessarily have negative effects, although taken in the context of global climate change a net benefit is highly unlikely. Three types of migration patterns occur.

ADMIRAL T. JOSEPH LOPEZ, USN (Ret.)

Former Commander-in-Chief, U.S. Naval Forces Europe and of Allied Forces, Southern Europe

ON CLIMATE CHANGE AND THE CONDITIONS FOR TERRORISM

Some Americans believe we don't need to worry about climate change for decades. They say the issue isn't as urgent as the war on terror. Adm. Lopez, the retired top NATO commander in Bosnia, has a different take. He sees a strong connection between the two.

"Climate change will provide the conditions that will extend the war on terror," Adm. Lopez said.

"You have very real changes in natural systems that are most likely to happen in regions of the world that are already fertile ground for extremism," Adm. Lopez said. "Droughts, violent weather, ruined agricultural lands—those are the kinds of stresses we'll see more of under climate change."

Those changes in nature will lead to changes in society. "More poverty, more forced migrations, higher unemployment. Those conditions are ripe for extremists and terrorists."

In the controversial war on terrorism, Adm. Lopez noted, there is general agreement on at least one thing: It's best to stop terrorism before it develops. "In the long term, we want to address the underlying conditions that terrorists seek to exploit. That's what we'd like to do, and it's a consensus issue—we all want to do that. But climate change prolongs those conditions. It makes them worse."

"Dealing with instability and how you mitigate that leads to questions about the role U.S. security forces can play," Adm. Lopez added. "What can we do to alleviate the problems of instability in advance? And keep in mind this will all be under a challenged resource situation. This is very complicated. Of course, the military can be a catalyst for making this happen, but it can't do it all. This is also about economics, politics, and diplomacy.

"In the military, we've often run into problems associated with what we call 'stovepipes,' where each branch of the service has its own way of doing things. And we've learned that stovepipes don't work well. We have to take the same approach with our government, to ensure that the many agencies are working together. In those cases where we do get involved, the task should not automatically be the responsibility of the U.S. military."

He also described other layers of complexity. Even in those cases where the U.S. may choose to embrace such a role, the best solutions may require a nongovernmental component. "If you don't include economists or far-thinking, out-of-the-box business people in this, you'll get shortchanged." He also said the U.S. "can't imply that we'll do this all alone. We need to make sure we don't give that impression. The same forces of economics, business, politics, diplomacy, and military and security interests can function to build coalitions in order to maintain stability when challenged by dramatic climate change."

> "Climate change will provide the conditions that will extend the war on terror."

The greatest concern will be movement of asylum seekers and refugees who due to ecological devastation become settlers...

Some migrations take place within countries, adding to a nation's political stress, causing economic upheaval—positive and negative—and distracting from other issues. As a developed nation, the U.S. was able to absorb the displacement of people from the Gulf Coast in the wake of Hurricane Katrina without suffering economic or political collapse, but not without considerable turmoil.

Some migrations cross international borders. Environmental degradation can fuel migrations in less developed countries, and these migrations can lead to international political conflict. For example, the large migration from Bangladesh to India in the second half of the last century was due largely to loss of arable land, among other environmental factors. This affected the economy and political situation in the regions of India that absorbed most of this population shift and resulted in violence between natives and migrants [16].

A third form of migration involves not only crossing international borders but moving across vast regions while doing so. Since the 1960s, Europe has experienced this kind of "south to north" migration, with an influx of immigrants from Africa and Asia. The shift in demographics has created racial and religious tensions in many European countries, as evidenced in the 2005 civil unrest in France.

POTENTIAL ESCALATION OF CONFLICTS OVER RESOURCES

To live in stability, human societies need access to certain fundamental resources, the most important of which are water and food. The lack, or mismanagement, of these resources can undercut the stability of local populations; it can affect regions on a national or international scale.

Disputes over key resources such as water do not automatically trigger violent outcomes, and no recent wars have been waged solely over water resources. In areas with a strong government and societal cohesiveness, even tense disputes and resource crises can be peacefully overcome. In fact, in recent years, arguments have been made that multinational cooperation over precious water resources has been more an instrument of regional peace than of war [17].

Nevertheless, resource scarcity always has the potential to be a contributing factor to conflict and instability in areas with weak and weakly supported governments [19]. In addition, there is always the potential for regional fighting to spread to a national or international scale. Some recent examples include: the 1994 genocide in Rwanda that was furthered by violence over agricultural resources; the situation in Darfur, Sudan, which had land resources at its root and which is increasingly spilling over into neighboring Chad; the 1970s downfall of Ethiopian Emperor Haile Selassie through his government's inability to respond to food shortages; and the 1974 Nigerian coup that resulted largely from an insufficient response to famine [19].

Whether resource scarcity proves to be the impetus for peaceful cooperation or an instigator of conflict in the future remains to be seen. Regions that are already water scarce (such as Kuwait, Jordan, Israel, Rwanda, Somalia, Algeria, and Kenya) may be forced to confront this choice as climate change exacerbates their water scarcity.

REGIONAL IMPACTS OF CLIMATE CHANGE

REGIONAL IMPACTS OF CLIMATE CHANGE

AFRICA

VULNERABLE TO CLIMATE CHANGE IMPACTS

Africa's importance to U.S. national security can no longer be ignored. Indeed, with the recent establishment of a U.S. African Command, the U.S. has underscored Africa's strategic importance. Its weak governments and the rising presence of terrorist groups make Africa important to the fight against terrorism. Moreover, Africa is also of strategic value to the U.S. as a supplier of energy; by 2015, it will supply 25 to 40 percent of our oil, and it will also be a supplier of strategic minerals such as chrome, platinum, and manganese.

Such changes will add significantly to existing tensions and can facilitate weakened governance, economic collapses, massive human migrations, and potential conflicts.

Reductions in soil moisture and further loss of arable land may be the most significant of the projected impacts of climate change in Africa. At the same time, extreme weather events are likely to increase. These expected changes portend reduced supplies of potable water and food production in key areas. Such changes will add significantly to existing tensions and can facilitate weakened governance, economic collapses, massive human migrations, and potential conflicts. In Somalia, for example, alternating droughts and floods led to migrations of varying size and speed and prolonged the instability on which warlords capitalized.

Increased political instability in Africa potentially adds additional security requirements for the U.S. in a number of ways. Stability operations, ranging from humanitarian direct delivery of goods and the protection of relief workers, to the establishment of a stable and reconstructed state, can place heavy demands on the U.S. military. While the nature of future stability operations is a matter of speculation, historically some stability operations have involved significant military operations and casualties. Political instability also makes access to African trade and resources, on which the U.S. is reliant for both military and civilian uses, a riskier proposition.

UNSTABLE GOVERNMENTS AND TERRORIST HAVENS

Africa is increasingly crucial in the ongoing battle against civil strife, genocide, and terrorism. Numerous African countries and regions already suffer from varying degrees of famine and civil strife. Darfur, Ethiopia, Eritrea, Somalia, Angola, Nigeria, Cameroon, Western Sahara—all have been hit hard by tensions that can be traced in part to environmental causes. Struggles that appear to be tribal, sectarian, or nationalist in nature are often triggered by reduced water supplies or reductions in agricultural productivity.

The challenges Africa will face as a result of climate change may be massive, and could present serious threats to even the most stable of governments. Many African nations can

GENERAL CHARLES F. "CHUCK" WALD, USAF (Ret.)

Former Deputy Commander, Headquarters U.S. European Command (USEUCOM)

ON CLIMATE CHANGE IN AFRICA

When asked why Americans should be interested in African security issues, retired Air Force Gen. Chuck Wald gave a number of reasons.

"We ought to care about Africa because we're a good country," Gen. Wald said. "We have a humanitarian character; it's one of our great strengths, and we shouldn't deny it. Some may be tempted to avert their eyes, but I would hope we instead see the very real human suffering taking place there. We should be moved by it, challenged by it. Even in the context of security discussions, I think these reasons matter, because part of our security depends on remaining true to our values.

"There are exotic minerals found only in Africa that have essential military and civilian uses," Gen. Wald continued. "We import more oil from Africa than the Middle East—probably a shock to a lot of people—and that share will grow. Africa could become a major exporter of food.

"My view is that we'll be drawn into the politics of Africa, to a much greater extent than in the past. A lot of Americans today would say Africa is an optional engagement. I don't think that's the case, even today, but it certainly won't be in the future."

To show how climate change can worsen conditions that are already quite desperate, Gen. Wald described a trip to Nigeria.

"We landed in Lagos late in the afternoon," Gen. Wald said. "This is a city, now, with roughly 17 million people. The best way to describe our drive from the airport to the hotel is that it reminded me of a 'Mad Max' movie. There were massive numbers of people on the roads, just milling around. There were huge piles of trash. There were fires along the roadside and in the distance—huge fires. It was just short of anarchy.

"That's the situation today. Even in a time of relative stability, there is very little civil governance, and very little ability to serve huge numbers of people with basics like electricity, clean water, health care, or education.

"If you add rising coastal waters and more extreme weather events, you then have millions of people who could be displaced. There really is no controlled place for them to go, no capacity for an organized departure, and no capacity to make new living situations. When you add in the effects of climate change, it adds to the existing confusion and desperation, and puts more pressure on the Nigerian government. It makes the possibility of conflict very real. If the delta is flooded, or if major storms damage their drilling capacity, you lose the primary source of income.

> "My view is that we'll be drawn into the politics of Africa, to a much greater extent than we have in the past."

"Culturally, you have a country that is split geographically between Muslims and Christians. If migrations occur, you put real pressure on that country. It's already tense and fragile. When you exacerbate that situation with climate change effects, it's not hard to postulate on the dangers."

best be described as failed states, and many African regions are largely ungoverned by civil institutions. When the conditions for failed states increase—as they most likely will over the coming decades—the chaos that results can be an incubator of civil strife, genocide, and the growth of terrorism.

LESS EFFECTIVE GOVERNANCE AND POTENTIAL MIGRATIONS

More than 30 percent of the world's refugees and displaced persons are African. Within the last decade, severe food shortages affected twenty-five African countries and placed as many as 200 million people "on the verge of calamity" [20].

Expected future climate change will exacerbate this problem. The Sahara desert is spreading [21], and the sub-Saharan region is expected to suffer reduced precipitation [22]. As climate changes and agricultural patterns are disrupted, the geopolitics of the future will increasingly be the politics of scarcity. Potential

...the chaos that results can be an incubator of civil strife, genocide, and the growth of terrorism.

rainfall decreases in North Africa would likely exacerbate the problem of migration to Europe. Reduced rainfall and increasing desertification of the sub-Saharan region will likely also result in migrations to Europe, as well as migrations within the African continent.

LAND LOSS AND WEATHER DISASTERS

Sea level rise could also result in the displacement of large numbers of people on the African continent, as more than 25 percent of the African population lives within 100 kilometers (sixty-two miles) of the coast, and six of Africa's ten largest cities are on the coast. Nigeria and Mozambique are particularly vulnerable to the effects of sea level rise and storm surges. Two cyclones in 2000 displaced 500,000 people in Mozambique and caused 950,000 people to require some form of humanitarian assistance [23]. The Niger Delta accounts for about 7.5 percent of Nigeria's land area and a population of 20 million people.

In light of the potential magnitude of the human crisis that could result from major weather-related natural disasters and the magnitude of the response and recovery efforts that would be required, stability operations carried out by international militaries will likely occur more frequently.

HEALTH CHALLENGES WILL CONTINUE TO ESCALATE

Severe and widespread continental health issues complicate an already extremely volatile environment. Climate change will have both direct and indirect impacts on many diseases endemic to Africa such as malaria and dengue fever [24]. Increases in temperature can expand the latitude and altitude ranges for malaria, and flooding from sea level rise or severe weather events can increase the population of malaria vectors. For example, a temperature rise of 2°F can bring a malaria epidemic to Kenya. Excessive flooding is also conducive to the spread of cholera.

VICE ADMIRAL PAUL G. GAFFNEY II, USN (Ret.)

Former President, National Defense University; Former Chief of Naval Research and Commander, Navy Meteorology and Oceanography Command

ON MILITARY RESEARCH AND CLIMATE SCIENCE

The Department of Defense and the intelligence community have in the past used their immense capability for data collection and analysis to address national and international environmental questions. Retired Vice Adm. Paul G. Gaffney II says we have the capacity to do this again, this time for better understanding and monitoring of climate change.

The DoD offers equipment, talent and, as Adm. Gaffney put it, "Data, data, data."

"You will find the defense and intelligence communities have extraordinary amounts of data, and, if done in a careful and deliberate manner, data collected in the past and into the future can be made available to climate scientists," Adm. Gaffney said. "Be it imagery, other satellite records, data from Navy oceanographic ships and vehicles, surface warships and submarines, or observations collected by aircraft—you can find ways to smooth it to protect what must be protected if the raw data cannot be released. If climate change is, in fact, a critical issue for security, then the military and intelligence communities should be specifically tasked to aggressively find ways to make their data, talent, and systems capabilities available to American efforts in understanding climate change signals.

"Most of our ships are already outfitted to collect basic atmospheric and oceanic information. U.S. military platforms are all over the world, all of the time; they become platforms of opportunity to collect data for this global issue."

Adm. Gaffney also cited staff capabilities.

"The quality of personnel from the defense and intelligence organizations is exceptional," he said. "Within the DoD, we have labs that are as good as any that exist anywhere in the world, using whatever metrics you want—papers published, patents, Nobel laureates.

"Look at the Navy ocean modelers and remote sensing experts. They worked with scientists at NASA's Jet Propulsion Lab to unlock the secrets of El Niño, using space-borne altimetry data and new numerical ocean circulation models. The mission was a military one, but it ultimately played a role in helping us understand more about the climate."

Throughout the Cold War, the U.S. and the Soviet Union each collected data in the Arctic. Ice thickness and sub-ice ocean conditions affecting acoustics were critical security issues.

> "The mission was a military one, but it ultimately played a role in helping us understand more about the climate."

After the breakup of the Soviet Union, many saw that that data could be used to determine temperature and ice condition changes over time. The two sides collaborated on ways to share and reconcile the data, and in 1996 released the Arctic Ocean Atlas to the world's scientific community. The data have advanced understanding of climate change in significant ways.

"I think there's another component to this," said Adm. Gaffney. "Defense employees [military and civilian] actually have a responsibility to the nation when they have a certain skill. They have a responsibility to share that with the public and the nation, as long as security is not compromised. They've done this in the past. And I'd love to see them able to do this more often in the future."

ASIA

CLIMATE CHANGE CAN AFFECT IMPORTANT U.S. STRATEGIC INTERESTS

Most climate projections indicate increasing monsoon variability, resulting in increases in both flood and drought intensity in temperate and tropical Asia [24]. Almost 40 percent of Asia's population of nearly 4 billion lives within forty-five miles of its nearly 130,000-mile-long coastline. Sea level rise, water availability affecting agricultural productivity, and increased effects of infectious disease are the primary climate effects expected to cause problems in Asia.

SEA LEVEL RISE MAY THREATEN MILLIONS

Some of the most vulnerable regions in the world to sea level rise are in southern Asia, along the coasts of Pakistan, India, Sri Lanka, Bangladesh, and Burma; and Southeast Asia, along the coasts between Thailand and Vietnam, including Indonesia and the Philippines.

Asia, where hundreds of millions of people rely on waters from vanishing glaciers on the Tibetan plateau, could be among the hardest hit regions.

Sandy coastlines backed by densely populated, low-lying plains make the Southeast Asian region particularly vulnerable to inundation. Coastal Malaysia, Thailand, and Indonesia could all be threatened with flooding and the loss of important coastal farmlands.

The location and topography of Bangladesh make it one of the most vulnerable countries in the world to a rise in sea level. Situated at the northeastern region of South Asia on the Bay of Bengal, it is about the size of Iowa with a population of almost 150 million. It is very flat and low lying, except in the northeast and southeast regions, and has a coastline exceeding 300 miles. About 10 percent of Bangladesh is within three feet of mean sea level. Over the next century, population rise, land scarcity and frequent flooding coupled with increased storm surge and sea level rise could cause millions of people to cross the border into India. Migration across the border with India is already such a concern that India is building a fence to keep Bangladeshis out.

India and Pakistan have long, densely populated and low-lying coastlines that are very vulnerable to sea level rise and storm surge. Coastal agriculture, infrastructure, and onshore oil exploration are at risk. Possible increases in the frequency and intensity of storm surges could be disproportionately large in heavily developed coastal areas and also in low-income rural areas, particularly such low-lying cities such as Mumbai, Dhaka and Karachi.

WATER STRESS AFFECTS ASIA'S ABILITY TO FEED ITS PEOPLE

By 2050, regions dependent on glacial melting for water may face serious consequences. Asia, where hundreds of millions of people rely on waters from vanishing glaciers on the Tibetan plateau, could be among the hardest hit regions.

Climate change has the potential to exacerbate water resource stresses in most regions of Asia [7]. Most countries in Asia will experience

ADMIRAL JOSEPH W. PRUEHER, USN (Ret.)

Former Commander-in-Chief of the U.S. Pacific Command (PACOM) and Former U.S. Ambassador to China

ON CLIMATE CHANGE IN THE PACIFIC

In a discussion of climate change issues in the Pacific region, retired Adm. Joseph Prueher first considered the issue from a singular perspective: the impact climate change may have on the region's governments and their relative stability.

Using Singapore as an example, he said, "It's a democracy, but with a very strong leadership. They've prospered, but owing to lack of space they have many restrictions we do not have. If one looks ahead to the effects of climate change, you start with the understanding that Singapore, low lying and very hot, will face more storms and more moisture. It will face coastal impacts. Those kinds of changes, in a crowded nation, create a whole set of issues that effect not just the economy and culture, but the security dynamic as well."

Adm. Prueher then shifted the conversation to the region's governments in general.

"It may well be that in very crowded nations, a stronger government is necessary in order to avoid instability," he said. "In Asia, one sees a whole line of countries with governments exercising very firm control. But when you look to the future to consider the kinds of impacts we may see—flooding, extreme weather events, real disruptions—you also have to consider some steps that we in the U.S. would think offensive. Those are steps these governments may feel they need to take in order to avoid chaos."

Referencing low-lying regions where arable land will be lost, he said, "You see mass destruction in countries where the government is not robust. When people can't cope, governing structures break down."

Adm. Prueher noted that how a government responds presents a new set of issues for American political and military leaders.

"Most of our security forces are for protecting our nation from outside, but that's not necessarily the case in the rest of the world," Adm. Prueher said. "Military personnel elsewhere are often directed internally. They focus on keeping internal order. There might be cases where the U.S. military might be in a position to help deal with the effects of climate change—with floods or the migrations that might result from them. The immediate goal would be to relieve suffering, not to preserve governments. But if you're partnering with a nation's army keeping domestic order, that can be a real challenge."

When asked about China, Adm. Prueher noted that the European Union is working to identify ways of cooperating with the Chinese on the development of clean coal technologies. And he cautioned against those in the U.S. who oppose any kind of technology exchange with China.

"Yes, China is focused heavily on growth. Yes, there is what I think is a quite remote possibility of future military conflict. And, yes, it is a real challenge to negotiate with them; one can count on them to negotiate toward what they perceive to be their own national interest," he said. "Reasonable enough. But on the issue of carbon emissions, it doesn't help us to solve our problem if China doesn't solve theirs. And that means we need to engage them on many fronts. Issues of great importance to our world will not get solved without U.S.-Chinese cooperation. I happen to like dealing with the Chinese. You may not, or you may be suspicious of them, but we need to cooperate.

"They have 1.3 billion people, 200 million of whom are under-employed or unemployed," Adm. Prueher said. "They have a great deal of pride and see themselves as a great nation. Most of what we say to enhance environmental progress in China is seen by them as a way to stop them from continuing economic growth.

"Not talking to the Chinese is not an option."

LIEUTENANT GENERAL LAWRENCE P. FARRELL JR., USAF (Ret.)

Former Deputy Chief of Staff for Plans and Programs, Headquarters U.S. Air Force

ON CLIMATE, ENERGY AND BATTLEFIELD READINESS

Retired Air Force Lt. Gen. Larry Farrell sees a great deal of uncertainty about climate change and appears willing to engage any credible scientist in discussions of discrepancies among climate models.

"You might say I'm from Missouri on this issue—you have to show me," he said. "And there is still much uncertainty and debate on this issue." Despite this, Gen. Farrell sees indications that some change is occurring.

"Clearly, there has been some warming over the past 100 years and some climate change. These changes have been accompanied by fairly significant increases in the greenhouse gases carbon dioxide and methane. If there is a connection between warming trends and greenhouse gases, our use of energy may be playing a part in this. If these trends continue into the future, the changes could well exacerbate existing social and political instabilities and create new ones. The military has the obligation to assess the potential military implications of these trends." Gen. Farrell's preference is to focus on solutions.

"If you advocate intelligent energy solutions, you'll solve this problem," Gen. Farrell said, before walking through a long list of reasons for a focus on energy.

A key concern for Gen. Farrell: battlefield readiness.

"Seventy percent of the tonnage on the battlefield is fuel," he said. "That's an amazing number. Between fuel and water, it's almost everything we take to the battlefield. Food and ammo are really quite small in comparison.

"Delivering that fuel requires secure lines of communication," Gen. Farrell said. "If you have bases nearby, you may be able to deliver it with much less risk, but that's a supply line issue. And we see in Iraq how dangerous it can be to transport fuel.

"The military should be interested in fuel economy on the battlefield," he said. "It's a readiness issue. If you can move your men and materiel more quickly, if you have less tonnage but the same level of protection and firepower, you're more efficient on the battlefield. That's a life and death issue."

Gen. Farrell talked about the challenge of focusing on long-term issues.

"Climate change is not something people can recognize," he said. "In geologic times, it's quick. But in human terms, it's still very slow. It's hard to get all of us to do something about it. And that leads me to believe we should deal with other things that are a problem today but that also get us to the heart of climate change. That's where I get to the issue of smart energy choices.

"Focus on conservation and on energy sources that aren't based in carbon. Move toward a hydrogen economy, in part because you know it will ultimately give you efficiency and, yes, profit. When you pursue these things, you build alliances along the way. That's safety. It's a benefit we see right now."

He suggested another reason as well: There are military impacts that come from our energy use.

"We're forced to be interested in parts of the world because of our energy consumption," he said. "Solving the energy problem solves a real security problem. You get to choose your points of engagement. It's like one of the things your grandmother told you. 'Don't go looking for trouble. If you find trouble, you have to deal with it—but don't go looking for it!' Well, when we go looking for oil, we're really looking for trouble."

substantial declines in agricultural productivity because of higher temperatures and more variable rainfall patterns [25]. Net cereal production in South Asia, for example, is projected to decline by 4 to 10 percent by the end of this century under the most conservative climate change projections.

But the problem isn't just water scarcity—too much water can also be a problem. By 2050, snow melting in the high Himalayas and increased precipitation across northern India are likely to produce flooding, especially in catchments on the western side of the Himalayas, in northern India, Nepal, Bangladesh, and Pakistan.

RISING SPREAD OF INFECTIOUS DISEASE

Climate change is expected to increase the geographic range of infectious diseases such as malaria, dengue fever, and schistosomiasis and increase the risk of water-borne disease. Climate projections indicate the Asia/Pacific region as a whole is likely to become warmer and wetter in the coming decades, creating conditions more conducive to disease vectors such as mosquitoes. With the exception of east central China and the highlands of west China, much of the Asia/Pacific region is exposed to malaria and dengue or has conditions suitable for their spread. This region will continue to be a hot spot for these diseases in the decades ahead, with certain regions becoming more prone to epidemics.

EUROPE

THREATENED BY CLIMATE PROBLEMS FROM OTHER PARTS OF THE WORLD

Europe is getting warmer overall, northern Europe is getting wetter, and southern Europe is getting drier. (For the purposes of this report, Europe includes the western part of the former Soviet Union.)

The developed nations of Europe will likely be able to deal with the direct climate changes expected for that region, but some of the less developed nations (the Balkans, for instance) might be stressed. Europe has already experienced extreme weather events that herald potential climate change effects: the more than 35,000 deaths associated with the heat wave of 2003 are a reminder of the vulnerability of all nations to climate extremes [26]. However, the major impact on Europe from global climate change is likely to be migrations, now from the Maghreb (Northern Africa) and Turkey, and increasingly, as climate conditions worsen, from Africa.

With its shortages of water, the Mediterranean area could experience considerable strain.

DIRECT IMPACTS: HOTTER TEMPERATURES AND RISING SEAS

Most of Europe has experienced surface air temperature increases during the twentieth century (1.44°F on average), with the largest increases over northwest Russia and the Iberian Peninsula. Temperatures in Europe since 1990 have been the warmest since records have been kept. More heat waves across all of Europe are likely to increase stress on human health and could produce an increased risk of malaria and dengue fever in southern Europe. Agricultural zones would move north, and the Mediterranean regions, especially in Spain, would suffer a greater loss of productivity.

Precipitation is expected to increase in the north but decrease in the central and eastern Mediterranean zones and south Russia, with acute water shortages projected in the Mediterranean area, especially in the summer.

MITIGATION AND ADAPTATION TO CLIMATE CHANGE IN EUROPE

The capacity for adaptation to these changes is very high in most of prosperous, industrial Europe, but less so in lesser-developed places like the Balkans, Moldova, and the Caucasus. With its shortages of water, the Mediterranean area could experience considerable strain. In northern Europe, countries may build higher dikes, as they have done in the past, but at a certain point that may not be sufficient, and much port and other coastal infrastructure would have to be moved further inland, at great expense. Some northern migration within Europe might be expected—the Italians already face a large Albanian immigration, and others may press north from the Balkans.

THE PRIMARY STRATEGIC CONCERN OF EUROPEANS: MASSIVE MIGRATIONS TO EUROPE

The greater threat to Europe lies in migration of people from across the Mediterranean, from the Maghreb, the Middle East, and sub-Saharan Africa. Environmental stresses and climate change are certainly not the only factors driving migrations to Europe. However, as more people migrate from the Middle East because of water shortages and loss of their already marginal agricultural lands (as, for instance, if the Nile Delta disappears under the rising sea level), the social and economic stress on European nations will rise.

It is possible that Europeans, given their long and proximate association with the sub-Saharan African countries, may undertake more stability operations, as they have in Sierra Leone and Côte d'Ivoire. Their militaries, and in particular their navies and coast guards, would also have to increase their activities in securing their borders and in intercepting migrants moving by sea, as is now going on through the Canary Islands.

MIDDLE EAST

ABUNDANT OIL, SCARCE WATER AND INTERNATIONAL CONFLICT

The Middle East has always been associated with two natural resources, oil (because of its abundance) and water (because of its scarcity). The Persian Gulf contains more than half (57 percent) of the world's oil reserves, and about 45 percent of the world's natural gas reserves. And because its production costs are among the world's lowest, the Persian Gulf region is likely to remain the world's largest oil exporter for the foreseeable future. At the end of 2003, Persian Gulf countries produced about 32 percent of the world's oil. Because of its enormous oil endowment, the Middle East is one of the most strategically significant regions of the world. The security impacts of climate change on the Middle East are greatly magnified by its historical and current levels of international conflict, and competition for increasingly scarce resources may exacerbate the level of conflict. This is the region of the world in which the U.S. is most engaged militarily.

WATER: INCREASING STRESS ON AN EXISTING SHORTAGE

In this region, water resources are a critical issue; throughout history, cultures here have flourished around particular water sources. With the population explosion underway, water will become even more critical. Of the countries in the Middle East, only Egypt, Iran, and Turkey have abundant fresh water resources. Roughly two-thirds of the Arab world depends on sources outside their borders for water. The most direct effect of climate change to be felt in the Middle East will be a reduction in precipitation. But the change will not be uniform across the region.

The flows of the Jordan and Yarmuk rivers are likely to be reduced, leading to significant water stress in Israel and Jordan, where water demand already exceeds supply. Exacerbation of water shortages in those two countries and in Oman, Egypt, Iran, and Iraq are likely to threaten conventional crop production, and salinization of coastal aquifers could further threaten agriculture in those regions.

SEA LEVEL RISE

Sea level rise combined with increased water demand from growing populations are likely to exacerbate saltwater intrusion into coastal fresh water aquifers, already a considerable problem for the Gaza Strip. Salinization of coastal aquifers could further threaten agriculture in these regions. Additional loss of arable land and decreases in food security could encourage migration within the Middle East and Africa, and from the Middle East to Europe and elsewhere.

INFLAMING A REGION OF POLITICAL INSTABILITY

Climate change has the potential to exacerbate tensions over water as precipitation patterns change, declining by as much as 60 percent in some areas. In addition, the region already suffers from fragile governments and infrastructures, and as a result is susceptible to natural disasters. Overlaying this is a long history of animosity among countries and religious groups. With most of the world's oil being in the Middle East and the industrialized and industrializing nations competing for this resource, the potential for escalating tensions, economic disruption, and armed conflict is great.

GENERAL ANTHONY C. "TONY" ZINNI, USMC (Ret.)

Former Commander-in-Chief of U.S. Central Command (CENTCOM)

ON CLIMATE CHANGE, INSTABILITY AND TERRORISM

A starting point in understanding this connection might be to "look at how climate change effects could drive populations to migrate," Gen. Zinni said. "Where do these people move? And what kinds of conflicts might result from their migration? You see this in Africa today with the flow of migrations. It becomes difficult for the neighboring countries. It can be a huge burden for the host country, and that burden becomes greater if the international community is overwhelmed by these occurrences.

"You may also have a population that is traumatized by an event or a change in conditions triggered by climate change," Gen. Zinni said. "If the government there is not able to cope with the effects, and if other institutions are unable to cope, then you can be faced with a collapsing state. And these end up as breeding grounds for instability, for insurgencies, for warlords. You start to see real extremism. These places act like Petri dishes for extremism and for terrorist networks."

In describing the Middle East, the former CENTCOM commander said, "The existing situation makes this place more susceptible to problems. Even small changes may have a greater impact here than they may have elsewhere. You already have great tension over water. These are cultures often built around a single source of water. So any stresses on the rivers and aquifers can be a source of conflict. If you consider land loss, the Nile Delta region is the most fertile ground in Egypt. Any losses there could cause a real problem, again because the region is already so fragile. You have mass migrations within the region, going on for many decades now, and they have been very destabilizing politically."

Gen. Zinni referenced the inevitability of climate change, with global temperatures sure to increase. But he also stressed that the intensity of those changes could be reduced if the U.S. helps lead the way to a global reduction in carbon emissions. He urged action now, even if the costs of action seem high.

"It's not hard to make the connection between climate change and instability, or climate change and terrorism."

"We will pay for this one way or another," he said. "We will pay to reduce greenhouse gas emissions today, and we'll have to take an economic hit of some kind. Or we will pay the price later in military terms. And that will involve human lives. There will be a human toll.

"There is no way out of this that does not have real costs attached to it. That has to hit home."

THE WESTERN HEMISPHERE

RISKS FOR THE UNITED STATES AND OUR NEIGHBORS

Latin America includes some very poor nations in Central America and in the Caribbean, and their ability to cope with a changing climate will present challenges for them and thus for the U.S. Global climate change can lead to greater intensity of hurricanes as sea surface temperatures rise, with enormous implications for the southeastern U.S., Central America, and Caribbean nations. Loss of glaciers will strain water supply in several areas, particularly Peru and Venezuela. Rising sea levels will threaten all coastal nations. Caribbean nations are especially vulnerable in this regard, with the combination of rising sea levels and increased hurricane activity potentially devastating to some island nations.

The primary security threats to the U.S. arise from the potential demand for humanitarian aid and a likely increase in immigration from neighbor states. It is important to remember that the U.S. will be dealing with its own climate change issues at the same time.

INCREASING WATER SCARCITY AND GLACIAL MELT

The melting of glaciers at an accelerated rate in Venezuela and the Peruvian Andes is a particular concern because of the direct reliance on these glaciers for water supplies and hydroelectric power. The Peruvian plains, northeast Brazil, and Mexico, already subject to drought, will find that droughts in the future will last longer. That would lead to further land degradation and loss of food production—a blow to Latin America, which is particularly dependent on food production for subsistence, and to Brazil, whose economy is fueled by food exports.

Drought and decreased rainfall is projected to also affect the central southern U.S. That could have significant impact on food production and sources of water for millions. The High Plains (or "Ogallala") aquifer underlies much of the semi-arid west-central U.S. The aquifer provides water for 27 percent of the irrigated land in the country and supplies about 30 percent of the groundwater used for irrigation. In fact, three of the top grain-producing states—Texas, Kansas, and Nebraska—each get 70 to 90 percent of their irrigation water from the Ogallala aquifer [27]. Human-induced stresses on this groundwater have resulted in water-table declines greater than 100 feet in some areas [28]. This already difficult situation could be greatly exacerbated by a decrease in rainfall predicted for the region. Similarly, a recent study by the National Research Council on the Colorado River basin (the river is the main water source for tens of millions of people in the Southwest) predicted substantial decreases in river flow, based on higher population coupled with the climate change affects [29].

STORMS AND SEA LEVEL RISE

In looking at the relationship between warmer temperatures and storm intensity, a panel convened by the World Meteorological Organization concluded: "It is likely that some increase in tropical cyclone peak wind-speed and rainfall

ADMIRAL DONALD L. "DON" PILLING, USN (Ret.)

Former Vice Chief of Naval Operations

ON OPERATIONAL CHALLENGES OF CLIMATE CHANGE

Retired Adm. Donald L. Pilling, former vice chief of naval operations, highlighted one of the reasons government agencies have been slow to respond to the issue of climate change.

"One of the problems in talking about this issue is that no one can give you a date by which many of the worst effects will be occurring," Adm. Pilling said. "If it's 2050, there isn't a guy in uniform today who will be wearing a uniform then. The Pentagon talks about future year plans that are six years down the road."

Still, Adm. Pilling was able to talk about the issue and the planning challenges it might offer. He enumerated a list of operational impacts, starting with the assumption that there would be increased instances of large migrations—people fleeing homelands that have felt the impacts of climate changes.

"This is key because it's easy to see how our allies can be consumed by this," Adm. Pilling said. "They won't have time to participate in exercises at sea because all of their assets will be focused on protecting the border and beaches. Europe will be focused on its own borders. There is potential for fracturing some very strong alliances based on migrations and the lack of control over borders.

"Open seas at the Arctic means you have another side of this continent exposed," he said. "Between the Canadians and us, there are a handful of ships oriented for the northernmost latitudes. But there is not much flexibility or depth there."

He said that an increase in the frequency or intensity of hurricanes could have a destabilizing effect on maintenance and the stability of ships and fleets. "It may cause you to move ships north to avoid hurricanes. If a ship's captain thinks he's in the middle of hurricane season, he's going to go out—get away from port. It impacts maintenance schedules and impacts operational structures. And that doesn't factor in the damage that hurricanes can do to our ports and maintenance facilities. We spent a few billion to restore Pascagoula after Hurricane Katrina—and we're not done yet. But at least that's an impact you can see. People can get their hands around that."

"There is potential for fracturing some very strong alliances based on migrations and the lack of control over borders."

Over time, some of the operational issues related to climate change would be increasingly difficult to resolve.

"At headquarters, they would need to be much more thoughtful about investment decisions," he said. "Why invest significant resources in bases that are in low-lying regions? Why invest in bases that may continue to be flooded? Those are tough questions to ask, but I'd ask them."

will occur if the climate continues to warm. Model studies and theory project a 3-5% increase in wind-speed per degree Celsius increase of tropical sea surface temperatures" [30]. Warming seas and their link to storm energy are especially worrisome for Central American and small Caribbean island nations that do not have the social infrastructure to deal with natural disasters.

Flooding could increase with sea level rises, especially in the low-lying areas of North America—inundation models from the University of Arizona project that a sea level rise of three feet would cause much of Miami, Fort Myers, a large portion of the Everglades, and all of the Florida Keys to disappear [31].

In the past, U.S. military forces have responded to natural disasters, and are likely to continue doing so in the foreseeable future [32]. The military was deployed to Central America after Hurricane Mitch in 1998 and to Haiti following the rains and mudslides of 2004. The U.S. military was also heavily involved in the response to Hurricane Katrina. Climate change will likely increase calls for this type of mission in the Americas in the future.

INCREASED MIGRATION/REFUGEE FLOWS INTO THE U.S.

The greater problem for the U.S. may be an increased flow of migrants northward into the U.S. Already, a large volume of south to north migration in the Americas is straining some states and is the subject of national debate. The migration is now largely driven by economics and political instability. The rate of immigration from Mexico to the U.S. is likely to rise because the water situation in Mexico is already marginal and could worsen with less rainfall and more droughts. Increases in weather disasters, such as hurricanes elsewhere, will also stimulate migrations to the U.S. [32].

GENERAL PAUL J. KERN, USA (Ret.)

Former Commanding General, U.S. Army Materiel Command

ON WEATHER, LOGISTICS, AND THE CAUSES OF WAR

In 1989, Gen. Kern commanded a brigade based at Fort Stewart, Georgia, and was preparing to send men and materiel to Turkey in advance of NATO training exercises. Those plans were interrupted by Hurricane Hugo, which appeared headed to Savannah, the port of departure for the mission.

"We were all ready to go, but the ships involved in transport had to be sent to Norfolk," Gen. Kern said. "So we broke down the shipments that had already been assembled for delivery. We then moved our aviation assets out, and moved base families into shelters. Ultimately, the hurricane hit Charleston, and did major damage to the airbase there. That meant one of my military battalions was deployed to Charleston to help with the recovery there."

"These weren't immense challenges for us—they were things we could handle," Gen. Kern said. "But the planned training exercises—preparing us for our core military mission—were not as good as they could have been. It's a very subtle thing, but there you have it in a nutshell: Extreme weather can affect your readiness."

Looking ahead, Gen. Kern, now retired from active duty, discussed wider global trends that the military must address to achieve an optimal state of readiness. He believes "the critical factors for economic and security stability in the twenty-first century are energy, water, and the environment. These three factors need to be balanced for people to achieve a reasonable quality of life. When they are not in balance, people live in poverty, suffer high death rates, or move toward armed conflict."

The need for water illustrates the consequences of imbalance. "When water is scarce, people move until they can find adequate supply," he said. "As climate change causes shifts in accessibility to water, we observe large movements of refugees and emigration."

He said Africa offers prime examples of this, and referenced a passage from the book Transboundary Rivers, Sovereignty and Development (Anthony Turton, Peter Ashton, and Eugene Cloete, eds.), which states that "there is a vast and growing literature that cites water as a likely cause of wars in the twenty-first century, and the 15 international basins in the Southern African Development Community (SADC) are regularly named as points of tension, second only to the arid and hostile Middle East."

He quoted from a letter written to him by Anthony Turton, a soldier in the war over the Okavong River basin, who wrote that "to serve one's country on the field of battle is truly noble, but to serve as a peace-builder is truly great." Turton also wrote that in his new role of restoring river basins, he has "found personal peace."

Gen. Kern also cited the late Nobel Laureate, Dr. Rick Smalley, of Rice University, who often lectured on the world's top 10 problems. Smalley listed energy, water, food, and the environment at the top of his list.

"While the military community has not focused on these issues, we often find ourselves responding to a crisis created by the loss of these staples, or by a conflict over claims to one or more of them," Gen. Kern said. "In my view, therefore, military planning should view climate change as a threat to the balance of energy access, water supplies, and a healthy environment, and it should require a response. Responding after the fact with troops—after a crisis occurs—is one kind of response. Working to delay these changes—to accommodate a balance among these staples—is, of course, another way."

"Military planning should view climate change as a threat to the balance of energy access, water supplies, and a healthy environment, and it should require a response."

DIRECT IMPACTS ON MILITARY SYSTEMS, INFRASTRUCTURE, AND OPERATIONS

DIRECT IMPACTS ON MILITARY SYSTEMS, INFRASTRUCTURE, AND OPERATIONS

Climate change will stress the U.S. military by affecting weapons systems and platforms, bases, and military operations. It also presents opportunities for constructive engagement.

WEAPONS SYSTEMS AND PLATFORMS

Operating equipment in extreme environmental conditions increases maintenance requirements—at considerable cost—and dramatically reduces the service life of the equipment. In Iraq, for instance, sandstorms have delayed or stopped operations and inflicted tremendous damage to equipment. In the future, climate change—whether hotter, drier, or wetter—will add stress to our weapons systems.

A stormier northern Atlantic would have implications for U.S. naval forces [34]. More storms and rougher seas increase transit times, contribute to equipment fatigue and hamper flight operations. Each time a hurricane approaches the U.S. East Coast, military aircraft move inland and Navy ships leave port. Warmer temperatures in the Middle East could make operations there even more difficult than they are today. A Center for Naval Analyses study showed that the rate at which U.S. carriers could launch aircraft was limited by the endurance of the flight deck crew during extremely hot weather [34].

BASES THREATENED BY RISING SEA LEVELS

During the Cold War, the U.S. established and maintained a large number of bases throughout the world. U.S. bases abroad are situated to provide a worldwide presence and maximize our ability to move aircraft and personnel. Climate change could compromise some of those bases. For example, the highest point of Diego Garcia, an atoll in the southern Indian Ocean that serves as a major logistics hub for U.S. and British forces in the Middle East, is only a few feet above sea level. As sea level rises, facilities there will be lost or will have to relocated. Although the consequences to military readiness are not insurmountable, the loss of some forward bases would require longer range lift and strike capabilities and would increase the military's energy needs.

Closer to home, military bases on the eastern coast of the United States are vulnerable to hurricanes and other extreme weather events. In 1992, Hurricane Andrew ravaged Homestead Air Force Base in Florida so much that it never reopened; in 2004 Hurricane Ivan knocked out Naval Air Station Pensacola for almost a year. Increased storm activity or sea level rise caused by future climate change could threaten or destroy essential base infrastructure. If key military bases are degraded, so, too, may be the readiness of our forces.

Climate change—whether hotter, drier, or wetter—will add stress to our weapons systems.

MILITARY OPERATIONS

Severe weather has a direct effect on military readiness. Ships and aircraft operations are made more difficult; military personnel themselves must evacuate or seek shelter. As retired

Army Gen. Paul Kern explained of his time dealing with hurricanes in the U.S. Southern Command: "A major weather event becomes a distraction from your ability to focus on and execute your military mission."

In addition, U.S. forces may be required to be more engaged in stability operations in the future as climate change causes more frequent weather disasters such as hurricanes, flash floods, and extended droughts.

THE ARCTIC: A REGION OF PARTICULAR CONCERN

A warming Arctic holds great implications for military operations. The highest levels of planetary warming observed to date have occurred in the Arctic, and projections show the high northern latitudes warming more than any other part of the earth over the coming century. The Arctic, often considered to be the proverbial "canary" in the earth climate system, is showing clear signs of stress [33].

The U.S. Navy is concerned about the retreat and thinning of the ice canopy and its implications for naval operations. A 2001 Navy study concluded that an ice-free Arctic will require an "increased scope of naval operations" [35]. That increased scope of operations will require the Navy to consider weapon system effectiveness and various other factors associated with operating in this environment. Additionally, an Arctic with less sea ice could bring more competition for resources, as well as more commercial and military activity that could further threaten an already fragile ecosystem.

As extreme weather events becomes more common, so do the threats to our national electricity supply.

DEPARTMENT OF DEFENSE ENERGY SUPPLIES ARE VULNERABLE TO EXTREME WEATHER

The DoD is almost completely dependent on electricity from the national grid to power critical missions at fixed installations and on petroleum to sustain combat training and operations. Both sources of energy and their distribution systems are susceptible to damage from extreme weather.

The national electric grid is fragile and can be easily disrupted. Witness the Northeast Blackout of 2003, which was caused by trees falling onto power lines in Ohio. It affected 50 million people in eight states and Canada, took days to restore, and caused a financial loss in the United States estimated to be between $4 billion and $10 billion [36]. People lost water supplies, transportation systems, and communications systems (including Internet and cell phones). Factories shut down, and looting occurred.

As extreme weather events becomes more common, so do the threats to our national electricity supply.

One approach to securing power to DoD installations for critical missions involves a combination of aggressively applying energy efficiency technologies to reduce the critical load (more mission, less energy); deploying renewable energy sources; and "islanding" the installation from the national grid. Islanding allows power generated on the installations to flow two ways—onto the grid when there is excess production and from the grid when the load exceeds local generation. By pursuing these actions to improve resiliency of mission, DoD would become an early adopter of technologies that would help transform the grid, reduce our load, and expand the use of renewable energy.

For deployed systems, the DoD pays a high price for high fuel demand. In Iraq, significant combat forces are dedicated to moving fuel and protecting fuel supply lines. The fuel delivery situation on the ground in Iraq is so limited that that the Army has established a "Power Surety Task Force" to help commanders of forward operating bases cut the number of fuel convoys by using energy more efficiently. Maj. Gen. Richard Zilmer, USMC, commander of the multinational force in the Anbar province of Iraq, asked for help in August 2006. His request was for renewable energy systems. According to Gen. Zilmer, "reducing the military's dependence on fuel for power generation could reduce the number of road-bound convoys … 'Without this solution [renewable energy systems], personnel loss rates are likely to continue at their current rate. Continued casualty accumulation exhibits potential to jeopardize mission success….'" Along a similar vein, Lt. Gen. James Mattis, while commanding general of the First Marine Division during Operation Iraqi Freedom, urged: "Unleash us from the tether of fuel."

Energy-efficiency technologies, energy conservation practices and renewable energy sources are the tools forward bases are using to stem their fuel demand and reduce the "target signature" of their fuel convoys.

Numerous DoD studies dating from the 2001 Defense Science Board report "More Capable Warfighting Through Reduced Fuel Burden" have concluded that high fuel demand by combat forces detracts from our combat capability, makes our forces more vulnerable, diverts combat assets from offense to supply line protection, and increases operating costs. Nowhere are these problems more evident than in Iraq, where every day 2.4 million gallons of fuel is moved through dangerous territory, requiring protection by armored combat vehicles and attack helicopters [37].

DoD planners estimate that it costs $15 to deliver one gallon of fuel from its commercial supplier to the forward edge of the battlefield and about $26 to deliver a gallon of fuel from an airborne tanker, not counting the tanker aircraft cost. Furthermore, DoD's procedures for determining the types of systems it needs do not take these fuel burden considerations into account. DoD should require more efficient combat systems and should include the actual cost of delivering fuel when evaluating the advantages of investments in efficiency [38, 39].

… reducing the military's dependence on fuel for power generation could reduce the number of road-bound convoys …

DoD should have an incentive to accurately account for the cost of moving and protecting fuel and to invest in technologies that will provide combat power more efficiently. Deploying technologies that make our forces more efficient also reduces greenhouse gas emissions. The resulting technologies would make a significant contribution to the vision President Bush expressed in his State of the Union speech when he said, "America is on the verge of technological breakthroughs that will … help us to confront the serious challenge of global climate change."

Given the human and economic cost of delivering fuel to combat forces and the almost total dependence on the electric grid for critical missions, DoD has strong operational economic incentives to aggressively pursue energy efficiency in its combat systems and its installations. By investing at levels commensurate with its interests, DoD would become an early adopter of innovative technologies and could stimulate others to follow.

ENGAGEMENT OPPORTUNITIES

Climate change threats also create opportunities for constructive engagement such as stability operations and capacity building. The U.S. military helped deliver relief to the victims of the 2005 Indian Ocean tsunami because it is the only institution capable of rapidly delivering personnel and materiel anywhere in the world on relatively short notice. DoD Directive 3000.05, issued in 2006, provides the mandate to conduct military and civilian stability operations in peacetime as well as conflict to maintain order in states and regions. The Combatant Command's Theater Security Cooperation Program, which seeks to engage regional states, could be easily focused on climate change mitigation and executed in concert with other U.S. agencies through U.S. embassy country teams. The objective would be to build the host nation military's capabilities and capacity to support civilian government agencies. It also enhances good governance and promotes stability, making failed states and terrorist incursion less likely. Because many climate change problems cross borders, it could also promote regional communication and cooperation.

If the frequency of natural disasters increases with climate change, future military and political leaders may face hard choices about where and when to engage. Deploying troops affects readiness elsewhere; choosing not to may affect alliances. And providing aid in the aftermath of a catastrophic event or natural disaster can help retain stability in a nation or region, which in turn could head off U.S. military engagement in that region at a later date.

ADMIRAL FRANK "SKIP" BOWMAN, USN (Ret.)

Former Director, Naval Nuclear Propulsion Program; Former Deputy Administrator-Naval Reactors, National Nuclear Security Administration

ON CLIMATE CHANGE, ENERGY, AND NATIONAL SECURITY

Adm. Bowman's more than thirty-eight years of naval service in the nuclear submarine community lead him to these thoughts: "Our nuclear submarines operate in an unforgiving environment. Our Navy has recognized this environment and has mitigated the risk of reactor and undersea operations through a combination of: a) careful selection of motivated, intelligent people whom we train and qualify to the highest standards; b) rigorous quality assurance of component design and manufacturing; c) verbatim compliance with strict rules of operation; d) routine examination of all aspects of reactor and submarine operations; and, e) a constant sharing of the lessons we learn through these processes. These components lead to a defense in depth against a very low probability, but high consequence event. We should begin planning for a similar approach in dealing with potential climate change effects on our national security."

Adm. Bowman notes that today, a raging debate is underway over a potential set of climate-induced global changes that could have a profound impact on America's national security interests. Our Military Advisory Board has heard the arguments, some depicting near-doomsday scenarios of severe weather and oceanic changes exacerbated by man-made emissions of greenhouse gases to our environment, others depicting a much less severe outcome as merely one in many observed cyclic weather patterns over time, with virtually no man-made component.

Adm. Bowman concludes that regardless of the probability of the occurrence, the projected weather-driven global events could be dire and could adversely affect our national security and military options significantly. He therefore argues that the prudent course is to begin planning, as we have in submarine operations, to develop a similar defense in depth that would reduce national security risks even if this is a low probability event, given the potential magnitude of the consequences. He feels that as the debate over cause, effect, and magnitude continues, we in the military should begin now to take action to provide a resilient defense against the effects of severe climate change, not only within our own borders, but also to provide resiliency to those regions of unrest and stress that already are threatening our national security today.

The admiral further believes that "our national security is inextricably linked to our country's energy security." Thoughtful national policy is required as we debate a correct course of future energy policy. International participation is necessary for this global issue. Adm. Bowman firmly believes that "energy and economic security—key components of our national security—must be undergirded by alternative forms of energy available indigenously and from countries whose values are not at odds with our own. As our economy and GDP have grown, so have our energy needs. This demand for energy strains available supplies: energy sources used for one purpose, such as electricity generation, are not available for other needs. Natural gas used for electricity is not available as feedstock for many industries that depend on it, like the chemical industry, the fertilizer industry, and the plastics industry. Short-term decisions made over the past decade to build cheap gas generation placed an unsustainable demand on natural gas and has resulted in hundreds of thousands of U.S. jobs moving offshore."

"Our nuclear submarines operate in an unforgiving environment. Our Navy has recognized this environment and has mitigated the risk. … We should begin planning for a similar approach in dealing with potential climate change effects on our national security."

Adm. Bowman warns that this interdependence between energy policy and national security must be viewed over the long haul as the country addresses global climate change. "Coal and nuclear electricity generation remain the obvious choices for new U.S. generation. However, to meet the concerns over measured and measurable increases in CO_2 concentrations in our atmosphere and their potential effect on climate, the country, as a matter of national urgency, must develop the technologies to capture and sequester CO_2 from coal generation. This technology is not available today on a commercial scale, and the lead time for its development is measured in tens of years, not months.

Therefore, Adm. Bowman argues, we should begin developing plans to shore up our own defenses against the potentially serious effects of climate, regardless of the probability of that occurrence, while making more resilient those countries ill-prepared today to deal with that potential due to disease, poor sanitation, lack of clean water, insufficient electricity, and large coastal populations. In doing so, these plans must recognize the interdependency of energy and security.

WEATHER AND WARFARE

An increase in extreme weather can make the most demanding of tasks even more challenging.

Increases in global temperatures will increase the likelihood of extreme weather events, including temperature extremes, precipitation events, and intense tropical cyclone activity [7].

With this in mind, we ask the obvious: How does extreme weather affect warfare?

The impacts are significant. There are countless historical examples of how weather events have affected the outcome of a conflict.

- Typhoons (Divine Wind) twice saved Japan from invasion by Kublai Khan and his Mongol horde.
- North Sea gales badly battered the Spanish Armada in 1588 when Sir Francis Drake defeated it, saving England from invasion.

An increase in extreme weather can make the most demanding of tasks even more challenging.

- The severe and unpredictable Russian winter has defeated three invading armies: Charles XII of Sweden in 1708, Napoleon in 1812 and Hitler in 1941.
- During the American Revolution, George Washington would have been surrounded at the Battle of Long Island had adverse winds not prevented the British from landing and cutting him off.
- Hardships from a severe drought in 1788 are thought to be the spark that caused the French Revolution.
- Napoleon was defeated at the Battle of Waterloo in large part because a torrential downpour obscured visibility and delayed the French attack.

Though technology allows us to overcome many obstacles, weather still poses great threats to successful military operations on the land, sea, or in the air.

- During World War II, Typhoon Cobra capsized three destroyers, a dozen more ships were seriously damaged and 793 men died. This natural disaster, called the Navy's worst defeat in open seas in World War II, killed nearly a third as many as in the attack on Pearl Harbor.
- Many know that D-Day awaited the right weather before it began. Many don't know that a freak storm destroyed floating docks shortly beforehand, almost canceling the invasion.
- During the 1991 Persian Gulf War, heavy winds prevented Saddam Hussein from launching Scud missiles at Israel and coalition forces.
- During the Persian Gulf War and the Iraq war, sandstorms delayed or stopped operations and did tremendous damage to equipment. In March 2003, the entire invasion of Iraq was stalled for three days because of a massive sandstorm.

These examples are not meant to suggest that weather changes will put the American military at a disadvantage. They do, however, help illustrate ways in which climate change can add new layers of complexity to military operations. An increase in extreme weather can make the most demanding of tasks even more challenging.

FINDINGS AND RECOMMENDATIONS

FINDINGS AND RECOMMENDATIONS

This report is intended to advance a more rigorous national and international dialogue on the impacts of climate change on national security. We undertook this analysis for the primary purpose of presenting the problem and identifying first-order solutions. We therefore keep this list of findings and recommendations intentionally brief. We hope it will stimulate further discussion by the public and a more in-depth analysis by those whose job it is to plan for our national security.

FINDINGS

Finding 1:
Projected climate change poses a serious threat to America's national security.

Potential threats to the nation's security require careful study and prudent planning—to counter and mitigate potential detrimental outcomes. Based on the evidence presented, the Military Advisory Board concluded that it is appropriate to focus on the serious consequences to our national security that are likely from unmitigated climate change. In already-weakened states, extreme weather events, drought, flooding, sea level rise, retreating glaciers, and the rapid spread of life-threatening diseases will themselves have likely effects: increased migrations, further weakened and failed states, expanded ungoverned spaces, exacerbated underlying conditions that terrorist groups seek to exploit, and increased internal conflicts. In developed countries, these conditions threaten to disrupt economic trade and introduce new security challenges, such as increased spread of infectious disease and increased immigration.

Overall, climate change has the potential to disrupt our way of life and force changes in how we keep ourselves safe and secure by adding a new hostile and stressing factor into the national and international security environment.

Finding 2:
Climate change acts as a threat multiplier for instability in some of the most volatile regions of the world.

Many governments in Asia, Africa, and the Middle East are already on edge in terms of their ability to provide basic needs: food, water, shelter and stability. Projected climate change will exacerbate the problems in these regions and add to the problems of effective governance. Unlike most conventional security threats that involve a single entity acting in specific ways at different points in time, climate change has the potential to result in multiple chronic conditions, occurring globally within the same time frame. Economic and environmental conditions in these already fragile areas will further erode as food production declines, diseases increase, clean water becomes increasingly scarce, and populations migrate in search of resources. Weakened and failing governments, with an already thin margin for survival, foster the conditions for internal conflict, extremism, and movement toward increased authoritarianism and radical ideologies. The U.S. may be drawn more frequently into these situations to help to provide relief, rescue, and logistics, or to stabilize conditions before conflicts arise.

Because climate change also has the potential to create natural and humanitarian disasters on a scale far beyond those we see today, its consequences will likely foster political instability where societal demands exceed the capacity of governments to cope. As a result, the U.S. may also be called upon to undertake stability and reconstruction efforts once a conflict has begun.

Finding 3:
Projected climate change will add to tensions even in stable regions of the world.

Developed nations, including the U.S. and Europe, may experience increases in immigrants and refugees as drought increases and food production declines in Africa and Latin America. Pandemic disease caused by the spread of infectious diseases and extreme weather events and natural disasters, as the U.S. experienced with Hurricane Katrina, may lead to increased domestic missions for U.S. military personnel—lowering troop availability for other missions and putting further stress on our already stretched military, including our Guard and Reserve forces.

Our current National Security Strategy, released in 2002 and updated in 2006, refers to globalization and other factors that have changed the security landscape. It cites, among other factors, "environmental destruction, whether caused by human behavior or cataclysmic mega-disasters such as floods, hurricanes, earthquakes or tsunamis. Problems of this scope may overwhelm the capacity of local authorities to respond, and may even overtax national militaries, requiring a larger international response. These challenges are not traditional national security concerns, such as the conflict of arms or ideologies. But if left unaddressed they can threaten national security."

In addition to acknowledging the national security implications of extreme weather and other environmental factors, the National Security Strategy indicates that the U.S. may have to intervene militarily, though it clearly states that dealing with the effects of these events should not be the role of the U.S. military alone.

Despite the language in our current National Security Strategy, there is insufficient planning and preparation on the operational level for future environmental impacts. However, such planning can readily be undertaken by the U.S. military in cooperation with the appropriate civilian agencies, including the State Department, the United States Agency for International Development, and the intelligence community.

Finding 4:
Climate change, national security, and energy dependence are a related set of global challenges.

As President Bush noted in his 2007 State of the Union speech, dependence on foreign oil leaves us more vulnerable to hostile regimes and terrorists, and clean domestic energy alternatives help us confront the serious challenge of global climate change. Because the issues are linked, solutions to one affect the others. Technologies that improve energy efficiency also reduce carbon intensity and carbon emissions.

RECOMMENDATIONS

Recommendation 1:
The national security consequences of climate change should be fully integrated into national security and national defense strategies.
As military leaders, we know we cannot wait for certainty. Failing to act because a warning isn't precise is unacceptable. Numerous parts of the U.S. government conduct analyses of various aspects of our national security situation covering different time frames and at varying levels of detail. These analyses should consider the consequences of climate change.

The intelligence community should incorporate climate consequences into its National Intelligence Estimate. The National Security Strategy should directly address the threat of climate change to our national security interests. It also should include an assessment of the national security risks of climate change and direct the U.S. government to take appropriate preventive efforts now.

The National Security Strategy and the National Defense Strategy should include appropriate guidance to military planners to assess risks to current and future missions of projected climate change, guidance for updating defense plans based on these assessments, and the capabilities needed to reduce future impacts. This guidance should include appropriate revisions to defense plans, including working with allies and partners, to incorporate climate mitigation strategies, capacity building, and relevant research and development.

The next Quadrennial Defense Review should examine the capabilities of the U.S. military to respond to the consequences of climate change, in particular, preparedness for natural disasters from extreme weather events, pandemic disease events, and other missions the U.S. military may be asked to support both at home and abroad. The capability of the National Guard and Reserve to support these missions in the U.S. deserve special attention, as they are already stretched by current military operations.

The U.S. should evaluate the capacity of the military and other institutions to respond to the consequences of climate change. All levels of government—federal, state, and local—will need to be involved in these efforts to provide capacity and resiliency to respond and adapt.

Scientific agencies such as the National Oceanic and Atmospheric Administration (NOAA), the National Aeronautics and Space Administration (NASA) and the United States Geologic Survey (USGS) should also be brought into the planning processes.
The defense and intelligence communities should conduct research on global climate and monitor global climate signals to understand their national security implications. Critical security-relevant knowledge about climate change has come from the partnership between environmental scientists and the defense and intelligence communities. That partnership, vibrant in the 1990s, should be revived.

Recommendation 2:
The U.S. should commit to a stronger national and international role to help stabilize climate changes at levels that will avoid significant disruption to global security and stability.
All agencies involved with climate science, treaty negotiations, energy research, economic policy, and national security should participate in an interagency process to develop a deliberate policy to reduce future risk to national security

from climate change. Actions fall into two main categories: mitigating climate change to the extent possible by setting targets for long-term reductions in greenhouse gas emissions and adapting to those effects that cannot be mitigated. Since this is a global problem, it requires a global solution with multiple relevant instruments of government contributing.

While it is beyond the scope of this study to recommend specific solutions, the path to mitigating the worst security consequences of climate change involves reducing global greenhouse gas emissions. Achieving this outcome will also require cooperation and action by many agencies of government.

Recommendation 3:
The U.S. should commit to global partnerships that help less developed nations build the capacity and resiliency to better manage climate impacts.

Some of the nations predicted to be most affected by climate change are those with the least capacity to adapt or cope. This is especially true in Africa, which is becoming an increasingly important source of U.S. oil and gas imports. Already suffering tension and stress resulting from weak governance and thin margins of survival due to food and water shortages, Africa would be yet further challenged by climate change. The proposal by DoD to establish a new Africa Command reflects Africa's emerging strategic importance to the U.S., and with humanitarian catastrophes already occurring, a worsening of conditions could prompt further U.S. military engagement. As a result, the U.S. should focus on enhancing the capacity of weak African governments to better cope with societal needs and to resist the overtures of well-funded extremists to provide schools, hospitals, health care, and food.

The U.S. should target its engagement efforts, through regional military commanders and other U.S. officials, toward building capacity to mitigate destabilizing climate impacts. For example, regional commanders have routinely used such engagement tools as cooperation on disaster preparedness to help other nations develop their own ability to conduct these efforts.

Cooperative engagement has the potential to reduce the likelihood of war fighting. As Gen. Anthony C. (Tony) Zinni (Ret.) has said: "When I was commander of CENTCOM, I had two missions: engagement and war fighting; If I do engagement well, I won't have to do war fighting." The U.S. cannot do this alone; nor should the military be the sole provider of such cooperative efforts. But the U.S. can lead by working in cooperation with other nations. Such efforts promote greater regional cooperation, confidence building and the capacity of all elements of national influence to contribute to making nations resilient to the impacts of climate change.

Recommendation 4:
The Department of Defense should enhance its operational capability by accelerating the adoption of improved business processes and innovative technologies that result in improved U.S. combat power through energy efficiency.

DoD should require more efficient combat systems and should include the actual cost of delivering fuel when evaluating the advantages of investments in efficiency. Numerous DoD studies dating from the 2001 Defense Science Board report "More Capable Warfighting Through Reduced Fuel Burden" have concluded that high fuel demand by combat forces detracts from our combat capability, makes our forces more vulnerable, diverts combat assets from offense to supply line protection, and increases operating costs. Nowhere are these problems more evident than in Iraq, where every day 2.4 million gallons of fuel is moved through dangerous territory, requiring protection by armored combat vehicles and attack helicopters.

Deploying technologies that make our forces more efficient also reduces greenhouse gas emissions. DoD should invest in technologies that will provide combat power more efficiently. The resulting technologies would make a significant contribution to the vision President Bush expressed in his State of the Union when he said, "America is on the verge of technological breakthroughs that … will help us to confront the serious challenge of global climate change."

Recommendation 5:
DoD should conduct an assessment of the impact on U.S. military installations worldwide of rising sea levels, extreme weather events, and other possible climate change impacts over the next 30 to 40 years.

As part of prudent planning, DoD should assess the impact of rising sea levels, extreme weather events, drought, and other climate impacts on its infrastructure so its installations and facilities can be made more resilient.

Numerous military bases, both in the U.S. and overseas, will be affected by rising sea levels and increased storm intensity. Since World War II, the number of overseas bases has diminished, and since the Base Realignment and Closure process began the number of stateside bases has also declined. This makes those that remain more critical for training and readiness, and many of them are susceptible to the effects of climate change. For example, the British Indian Ocean Territory island of Diego Garcia, an atoll in the southern Indian Ocean, is a major logistics hub for U.S. and British forces in the Middle East. It is also only a few feet above sea level at its highest point. The consequences of the losing places like Diego Garcia are not insurmountable, but are significant and would require advance military planning. The Kwajalein is a low-lying atoll, critical for space operations and missile tests. Guam is the U.S. gateway to Asia and could be moderately or severely affected by rising sea levels. Loss of some forward bases would require us to have longer range lift and strike capabilities and possibly increase our military's energy needs.

Military bases on the eastern coast of the U.S. are vulnerable to hurricanes and other extreme weather events. In 1992, Hurricane Andrew virtually destroyed Homestead Air Force Base in Florida. In 2004 Hurricane Ivan knocked out Naval Air Station Pensacola for almost a year. Most U.S. Navy and Coast Guard bases are located on the coast, as are most U.S. Marine Corps locations. The Army and Air Force also operate bases in low-lying or coastal areas. One meter of sea level rise would inundate much of Norfolk, Virginia, the major East Coast hub for the U.S. Navy. As key installations are degraded, so is the readiness of our forces.

APPENDICES

APPENDIX 1:
BIOGRAPHIES, MILITARY ADVISORY BOARD MEMBERS

ADMIRAL FRANK "SKIP" BOWMAN, USN (Ret.)

Former Director, Naval Nuclear Propulsion Program;
Former Deputy Administrator-Naval Reactors, National Nuclear Security Administration

Admiral Skip Bowman was director, Naval Nuclear Propulsion, Naval Sea Systems Command. Prior assignments include deputy administrator for naval reactors in the Naval Nuclear Security Administration, Department of Energy; chief of naval personnel; and director for Political-Military Affairs and deputy director of naval operations on the Joint Staff.

He was commissioned following graduation in 1966 from Duke University. In 1973, he completed a dual master's program in nuclear engineering and naval architecture/marine engineering at the Massachusetts Institute of Technology and was elected to the Society of Sigma Xi. Admiral Bowman has been awarded the honorary degree of Doctor of Humane Letters from Duke University.

In 2005, Admiral Bowman was named president and CEO of the Nuclear Energy Institute. NEI is the policy organization for the commercial nuclear power industry. In 2006, Admiral Bowman was made an Honorary Knight Commander of the Most Excellent Order of the British Empire in recognition of his commitment in support of the Royal Navy submarines program.

LIEUTENANT GENERAL LAWRENCE P. FARRELL JR., USAF (Ret.)

Former Deputy Chief of Staff for Plans and Programs, Headquarters U.S. Air Force

Prior to his retirement from the Air Force in 1998, General Farrell served as the deputy chief of staff for plans and programs, Headquarters U.S. Air Force, Washington, D.C. He was responsible for planning, programming and manpower activities within the corporate Air Force and for integrating the Air Force's future plans and requirements to support national security objectives and military strategy.

Previous positions include vice commander, Air Force Materiel Command, Wright-Patterson Air Force Base, Ohio, and deputy director, Defense Logistics Agency, Arlington, Virginia. He also served as deputy chief of staff for plans and programs at Headquarters U.S. Air Force in Europe. A command pilot with more than 3,000 flying hours, he flew 196 missions in Southeast Asia and commanded the 401st Tactical Fighter Wing, Torrejon Air Base, Spain. He was also the system program manager for the F-4 and F-16 weapons systems with the Air Force Logistics Command, Hill Air Force Base, Utah.

General Farrell is a graduate of the Air Force Academy with a bachelor's degree in engineering and an MBA from Auburn University. Other education includes the National War College and the Harvard Program for Executives in National Security.

General Farrell became the president and CEO of the National Defense Industrial Association in September 2001.

VICE ADMIRAL PAUL G. GAFFNEY II, USN (Ret.)

Former President, National Defense University; Former Chief of Naval Research and Commander, Navy Meteorology and Oceanography Command

Admiral Gaffney has been the Naval Research Laboratory commander and worked in a number of other science and oceanography administration assignments. He served as the 10th president of the National Defense University, and before that as chief of naval research. He also was the senior uniformed oceanography specialist in the Navy, having served as commander of the Navy Meteorology and Oceanography Command from 1994 to 1997. He was appointed by President George W. Bush to the Ocean Policy Commission and served during its full tenure from 2001 to 2004. He served in Japan, Vietnam, Spain, and Indonesia, and traveled extensively in official capacities.

He has been recognized with a number of military decorations; the Naval War College's J. William Middendorf Prize for Strategic Research, the Outstanding Public Service Award from the Virginia Research and Technology Consortium, and the Potomac Institute's Navigator Award. He has served on several boards of higher education and was a member of the Ocean Studies Board of the National Re-search Council from 2003 to 2005. He has been selected to be a public trustee for the New Jersey Consortium and chaired the Governor's Commission to Protect and Enhance New Jersey's Military Bases.

He graduated from the U.S. Naval Academy in 1968 and has a master's degree in mechanical engineering (ocean) from Catholic University and a master's of business administration from Jacksonville University.

Admiral Gaffney is currently the president of Monmouth University in West Long Branch, New Jersey.

GENERAL PAUL J. KERN, USA (Ret.)

Former Commanding General, U.S. Army Materiel Command

General Kern was commanding general, Army Materiel Command from 2001 to 2004, and senior advisor for Army Research, Development and Acquisition from 1997 to 2001.

General Kern had three combat tours. Two were in Vietnam as a platoon leader and troop commander. His third was as commander of the Second Brigade of the 24th Infantry in Desert Shield/Desert Storm. The Second Brigade played a pivotal role in the historic attack on the Jalibah Airfield, which allowed the Twenty-Fourth Infantry Division to secure key objectives deep inside of Iraq. He also served as the assistant division commander of the division after its redeployment to Fort Stewart, Georgia.

General Kern's assignments included senior military assistant to Secretary of Defense William Perry. During that period, he accompanied Secretary Perry to more than 70 countries, meeting numerous heads of state, foreign ministers, and international defense leaders. He participated in U.S. operations in Haiti, Rwanda, Zaire, and the Balkans, and helped promote military relations in Central and Eastern Europe, South America, China, and the Middle East.

General Kern received the Defense and Army Distinguished Service Medals, Silver Star, Defense Superior Service Medal, Legion of Merit, two Bronze Star Medals for valor, three Bronze Star Medals for service in combat, and three Purple Hearts. He has been awarded the Society of Automotive Engineers Teeter Award, the Alumni Society Medal from the University of Michigan, and the German Cross of Honor of the Federal Armed Forces (Gold).

A native of West Orange, New Jersey, General Kern was commissioned as an armor lieutenant following graduation from West Point in 1967. He holds master's degrees in both civil and mechanical engineering from the University of Michigan, and he was a Senior Security Fellow at the John F. Kennedy School of Government at Harvard University.

He is an adviser to Battelle Memorial Institute and holds the Chair of the Class of 1950 for Advanced Technology at the United States Military Academy.

General Kern is a member of the Cohen Group, which provides strategic advice and guidance to corporate clients.

ADMIRAL T. JOSEPH LOPEZ, USN (Ret.)

Former Commander-in-Chief, U.S. Naval Forces Europe and of Allied Forces, Southern Europe

Admiral Lopez's naval career included tours as commander-in-chief of U.S. Naval Forces Europe and commander-in-chief, Allied Forces, Southern Europe from 1996 to 1998. He commanded all U.S. and Allied Bosnia Peace Keeping Forces in 1996; he served as deputy chief of naval operations for resources, warfare requirements and assessments in 1994 to 1996,; commander of the U.S. Sixth Fleet in 1992 to 1993; and senior military assistant to the secretary of defense in 1990 to 1992.

Admiral Lopez was awarded numerous medals and honors, including two Defense Distinguished Service Medals, two Navy Distinguished Service Medals, three Legion of Merits, the Bronze Star (Combat V), three Navy Commendation Medals (Combat V) and the Combat Action Ribbon. He is one of just two flag officers in the history of the U.S. Navy to achieve four-star rank after direct commission from enlisted service.

He holds a bachelor's degree (cum laude) in international relations and a master's degree in management. He has been awarded an honorary doctorate degree in humanities from West Virginia Institute of Technology and an honorary degree in information technology from Potomac State College of West Virginia University.

Admiral Lopez is president of Information Manufacturing Corporation (IMC), an information technology service integrator with major offices in Manassas, Virginia, and Rocket Center, West Virginia.

ADMIRAL DONALD L. "DON" PILLING, USN (Ret.)

Former Vice Chief of Naval Operations

Admiral Pilling assumed duties as the 30th vice chief of naval operations, the Navy's chief operating officer and second-ranking officer, from November 1997 until his retirement from active service in October 2000.

Ashore, he was assigned to a variety of defense resources and planning billets. In his earlier career, he served four years in program analysis and evaluation in the Office of the Secretary of Defense. As a more senior officer, he served as a Federal Executive Fellow at the Brookings Institution in 1985-86. A member of the National Security Council staff from 1989 until 1992, Admiral Pilling was selected to flag rank in 1989 while serving there. From 1993 to 1995, he was the director for programming on the staff of the Chief of Naval Operations, and later served as the Navy's chief financial officer from 1996 to 1997.

Admiral Pilling also commanded a warship; a destroyer squadron; a cruiser destroyer group; a carrier battle group; the U.S. Sixth Fleet; and NATO's Naval Striking and Support Forces Southern Europe.

Admiral Pilling has a bachelor's degree in engineering from the U.S. Naval Academy and a doctorate in mathematics from the University of Cambridge.

He served as vice president for strategic planning at Battelle Memorial Institute and became president and CEO of LMI, a nonprofit research organization, in 2002.

ADMIRAL JOSEPH W. PRUEHER, USN (Ret.)

Former Commander-in-Chief of the U.S. Pacific Command (PACOM) and Former U.S. Ambassador to China

Admiral Prueher completed thirty-five years in the United States Navy in 1999. His last command was commander-in-chief of the U.S. Pacific Command (CINCPAC); the largest military command in the world, spanning over half the earth's surface and including more than 300,000 people. Admiral Prueher also served as ambassador to China from 1999 to 2001. He served two presidents and was responsible for directing, coordinating, and managing the activities of all United States executive branch activities in China.

From 1989 through 1995, Admiral Prueher served as commandant at the U.S. Naval Academy at Annapolis; commander of Carrier Battle Group ONE based in San Diego; commander of the U.S. Mediterranean Sixth Fleet and of NATO Striking Forces based in Italy; and as vice chief of naval operations in the Pentagon.

Admiral Prueher graduated from Montgomery Bell Academy in Nashville, Tennessee, and then graduated with distinction in 1964 from the U.S. Naval Academy, later receiving a master's degree in international relations from George Washington University. He is also a graduate of the Naval War College in Newport, Rhode Island. In addition to co-authoring the Performance Testing manual used by naval test pilots for many years, he has published numerous articles on leadership, military readiness, and Pacific region security issues. Admiral Prueher has received multiple military awards for combat flying as well as naval and Joint Service. The governments of Singapore, Thailand, Japan, Korea, the Philippines, Indonesia, and Australia have decorated him.

Admiral Prueher is a consulting professor at Stanford University's Institute of International Studies and senior adviser on the Preventive Defense Project. He is on the board of trustees of the Nature Conservancy of Virginia.

GENERAL GORDON R. SULLIVAN, USA (Ret.)

Chairman, Military Advisory Board
Former Chief of Staff, U.S. Army

General Sullivan was the 32nd chief of staff—the senior general officer in the Army and a member of the Joint Chiefs of Staff. As the chief of staff of the Army, he created the vision and led the team that helped transition the Army from its Cold War posture.

His professional military education includes the U.S. Army Armor School Basic and Advanced Courses, the Command and General Staff College, and the Army War College. During his Army career, General Sullivan also served as vice chief of staff in 1990 to 1991; deputy chief of staff for operations and plans in 1989 to 1990; commanding general, First Infantry Division (Mechanized), Fort Riley, Kansas, in 1988 to 1989; deputy commandant, U.S. Army Command and General Staff College, Fort Leavenworth, Kansas, in 1987 to 1988; and assistant commandant, U.S. Army Armor School, Fort Knox, Kentucky, from 1983 to 1985. His overseas assignments included four tours in Europe, two in Vietnam and one in Korea. He served as chief of staff to Secretary of Defense Dick Cheney in the administration of President George H.W. Bush.

General Sullivan was commissioned a second lieutenant of armor and awarded a bachelor of arts degree in history from Norwich University in 1959. He holds a master's degree in political science from the University of New Hampshire.

General Sullivan is the president and chief operating officer of the Association of the United States Army, headquartered in Arlington, Virginia. He assumed his current position in 1998 after serving as president of Coleman Federal in Washington, D.C.

VICE ADMIRAL RICHARD H. TRULY, USN (Ret.)

Former NASA Administrator, Shuttle Astronaut and the first Commander of the Naval Space Command

Admiral Truly served as NASA's eighth administrator from 1989 to 1992, and his career in aviation and space programs of the U.S. Navy and NASA spanned 35 years. He retired as a vice admiral after a Navy career of more than thirty years. As a naval aviator, test pilot and astronaut, he logged over 7,500 hours and made over 300 carrier-arrested landings, day and night.

Admiral Truly was the first commander of Naval Space Command from 1983 to 1986 and became the first naval component commander of U.S. Space Command upon its formation in 1984. While still on active duty following the *Challenger* accident, he was called back to NASA as associate administrator for space flight in 1986 and led the accident investigation. He spearheaded the painstaking rebuilding of the space shuttle, including winning approval of President Reagan and the Congress for building of *Endeavor* to replace the lost *Challenger*. In 1989, President Reagan awarded him the Presidential Citizen's Medal.

Truly's astronaut career included work in the Air Force's Manned Orbiting Laboratory program, and NASA's Apollo, Skylab, Apollo-Soyuz and space shuttle programs. He piloted the *747/Enterprise* approach and landing tests in 1977, and lifted off in November 1981 as pilot aboard *Columbia*, the first shuttle to be reflown into space, establishing a world circular orbit altitude record. He commanded *Challenger* in August-September 1983, the first night launch/landing mission of the space shuttle program.

He served as vice president of the Georgia Institute of Technology and director of the Georgia Tech Research Institute (GTRI) from 1992 to 1997. Admiral Truly retired in January 2005 as director of the Department of Energy's National Renewable Energy Laboratory (NREL).

Truly is a member of the National Academy of Engineering. He has previously served on the board of visitors to the U.S. Naval Academy, the Defense Policy Board, the Army Science Board, and the Naval Studies Board. He is a member of the National Research Council Space Studies Board, a trustee of Regis University and the University Corporation for Atmospheric Research, and a member of the advisory committee to the Colorado School of Mines Board of Trustees.

GENERAL CHARLES F. "CHUCK" WALD, USAF (Ret.)

Former Deputy Commander, Headquarters U.S. European Command (USEUCOM)

From 2001 to 2002 General Wald was deputy chief of staff for air and space operations at the Pentagon, and from December 2002 until his retirement in 2006 General Wald was deputy commander, Headquarters U.S. European Command, Stuttgart, Germany. USEUCOM is responsible for all U.S. forces operating across 91 countries in Europe, Africa, Russia, parts of Asia and the Middle East, and most of the Atlantic Ocean.

General Wald commanded the 31st Fighter Wing at Aviano Air Base, Italy, where on Aug. 30, 1995, he led one of the wing's initial strike packages against the ammunition depot at Pale, Bosnia-Herzegovina, in one of the first NATO combat operations. General Wald commanded the Ninth Air Force and U.S. Central Command Air Forces, Shaw Air Force Base, South Carolina, where he led the development of the Afghanistan air campaign for Operation Enduring Freedom, including the idea of embedding tactical air control parties in ground special operations forces. He has combat time as an O-2A forward air controller in Vietnam and as an F-16 pilot flying over Bosnia. The general has served as a T-37 instructor pilot and F-15 flight commander. Other duties include chief of the U.S. Air Force Combat Terrorism Center, support group commander, operations group commander, and special assistant to the chief of staff for National Defense Review. He was also the director of strategic planning and policy at Headquarters U.S. Air Force, and served on the Joint Staff as the vice director for strategic plans and policy.

General Wald is a command pilot with more than 3,600 flying hours, including more than 430 combat hours over Vietnam, Cambodia, Laos, Iraq, and Bosnia. The general earned his commission through the Air Force ROTC program in 1971.

Currently, General Wald serves as president of Wald and Associates, an international management consulting and strategic planning firm, and is an adjunct lecturer at the Atlantic Council. He is also a member of the Bipartisan Policy Center, National Commission on Energy Policy, and the Securing America's Future Energy Commission.

GENERAL ANTHONY C. "TONY" ZINNI, USMC (Ret.)

Former Commander-in-Chief of U.S. Central Command (CENTCOM)

General Zinni's joint assignments included command of U.S. Central Command (CENTCOM), which is responsible for U.S. military assets and operations in the Middle East, Central Asia and East Africa.

General Zinni's joint assignments also include command of a joint task force and he has also had several joint and combined staff billets at task force and unified command levels. He has made deployments to the Mediterranean, the Caribbean, the Western Pacific, Northern Europe, and Korea. He has held numerous command and staff assignments that include platoon, company, battalion, regimental, Marine Expeditionary Unit, and Marine expeditionary force command. His staff assignments included service in operations, training, special operations, counter-terrorism and manpower billets. He has also been a tactics and operations instructor at several Marine Corps schools and was selected as a fellow on the Chief of Naval Operations Strategic Studies Group.

General Zinni joined the Marine Corps in 1961 and was commissioned an infantry second lieutenant in 1965. General Zinni holds a bachelor's degree in economics from Villanova University, a master's in international relations from Salvae Regina College, a master's in management and supervision from Central Michigan University, and honorary doctorates from William and Mary College and the Maine Maritime Academy.

He has worked with the University of California's Institute on Global Conflict and Cooperation, the U.S. Institute of Peace, and the Henry Dunant Centre for Humanitarian Dialogue in Geneva. He is on the Interna-tional Council at the Joan B. Kroc Institute for Peace and Justice. He is also a Distinguished Advisor at the Center for Strategic and International Studies, a member of the Council on Foreign Relations. He has also been appointed as a member of the Virginia Commission on Military Bases.

General Zinni has co-authored, with Tom Clancy, a New York Times bestseller on his career entitled *Battle Ready*. His book, *The Battle For Peace: A Frontline Vision Of America's Power And Purpose*, was published in 2006.

APPENDIX 2: CLIMATE CHANGE SCIENCE—A BRIEF OVERVIEW

There is a vast amount of scientific literature on the subject of climate change, and a complete discussion on the current state of the world climate and its deviation from climatological norms could fill volumes. In this appendix we discuss the consensus of the science community on climate change, effects observed thus far, and projections about what may happen in the future.

We have drawn information from the Intergovernmental Panel on Climate Change (IPCC), peer-reviewed scientific literature, and data, reports, and briefings from various respected sources, including the National Academy of Sciences, National Oceanic and Atmospheric Administration, National Air and Space Administration, and the United Kingdom's Hadley Centre for Climate Change

CURRENT CONSENSUS

The IPCC's latest assessment report affirmed the following:

- While natural forces have influenced the earth's climate (and always will), human-induced changes in levels of atmospheric greenhouse gases are playing an increasingly dominant role.
- After considering the influences of the known causes of climate change—natural- and human-induced—the significant increase in the average global temperatures over the last half century can be attributed to human activities with a certainty of more than 90 percent [7].
- Those temperature increases have already affected various natural systems in many global regions.
- Future changes to the climate are inevitable.

CHANGING GLOBAL TEMPERATURES

INCREASED CARBON MEANS INCREASED TEMPERATURES

Throughout its history, the earth has experienced oscillations between warm and cool periods. These shifts in climate have been attributed to a variety of factors, known as "climate forcings," that include orbital variations, solar fluctuations, landmass distribution, volcanic activity, and the atmosphere's concentration of greenhouse gases, such as carbon dioxide, methane, and water vapor. The changes we see today are occurring at a more rapid rate than is explainable by known natural cycles [15].

Throughout the earth's past, temperature and greenhouse gas concentration have been closely linked through the planet's natural greenhouse effect; i.e. greenhouse gases trap heat in the atmosphere and thereby warm the earth. Throughout Earth's previous four glacial and warming cycles, atmospheric CO_2 concentration, and temperature show a high degree of correlation. Other greenhouse gases, such as methane, also show a similar relationship with temperature.

The recent and rapid rise in atmospheric CO_2 levels is of concern to climate scientists and policymakers. CO_2 concentrations never exceeded 300 parts per million by volume (ppmv) during previous large swings in climate conditions, but the CO_2 concentration now is about 380 ppmv [41], representing a 35 percent increase since the onset of the industrial revolution in the mid-eighteenth century. CO_2 levels are likely at their highest levels in the last 20 million years, and "the current rate of increase is unprecedented during at least the last 20,000 years" [41].

Thus, the current atmosphere is significantly different from its preindustrial state in a way that is compatible with increased heating.

AVERAGE GLOBAL TEMPERATURES HAVE ALREADY BEGUN TO RISE

Average global surface temperature is the most fundamental measure of climate change, and there is no dispute that the earth's average temperature has been increasing over the last century (albeit not uniformly), with an acceleration in warming over the last 50 years. Over the last century, the average surface temperature around the world has increased by 1.3°F ± 0.3°F [7]. Temperatures since the 1950s were "likely the highest [of any 50-year period] in at least the past 1,300 years" [7]. Of the hottest twelve years on record since temperatures began to be measured in the 1850s, eleven have occurred in the last twelve years [7].

The burning of fossil fuels (such as oil, natural gas, and coal) is the main source of the rise in atmospheric CO_2 over the last two and a half centuries; deforestation and other changes in land use are responsible for a portion of the increase as well.

Human activities have also been responsible for a portion of the rise in other heat-trapping greenhouse gases, such as methane, which has risen 148 percent since preindustrial times, and nitrous oxide, which has risen 18 percent during the same period. Currently, half of the annual methane emitted is from activities such as burning fossil fuel and agricultural processes; [41] humans are responsible for about a third of nitrous oxide emissions, mainly from agriculture.

There is no known natural forcing that can account for the severity of the recent warming. For example, while claims are made that variation in the intensity of the sun is responsible, the variation in solar radiation's effect on the climate is estimated to be less than 5 percent as strong as that of human-induced greenhouse gases [7].

MORE THAN TEMPERATURE RISE: OBSERVED IMPACTS ON EARTH'S NATURAL SYSTEMS

A 1.3°F increase in average global surface temperature over the last century may seem like an insignificant change, but in fact it has had a marked impact on many of the earth's natural systems.

PRECIPITATION PATTERNS HAVE CHANGED

A change in the temperature of the atmosphere has a great impact on pre-cipitation patterns. As an air mass warms, it is able to hold more water vapor, so a warmer atmosphere can absorb more surface moisture and produce drier ground conditions. However, this increase in atmospheric content will also lead to more severe heavy rain events, when this higher water-content atmosphere drops its moisture.

Changes in precipitation amounts have been detected over large portions of the world. Annual precipitation has increased 5 to 10 percent over the past century across eastern North America, northern Europe, and northern and central Asia [7, 41]. The Mediterranean region experienced drying [7]. The tropics have witnessed a slightly lower increase, of 2 to 3 percent, and most of sub-Saharan Africa has shown a decrease in precipitation of 30 to 50 percent [42].

The Northern Hemisphere subtropics experienced a decrease in precipitation of approximately 2 percent [41]. Some of the most noticeable drying occurred in the Sahel and portions of southern Asia [7]. No significant change was detected in rainfall patterns across wide areas in the Southern Hemisphere; however, precipitation was noticeably decreased in southern Africa [41].

EXTREME WEATHER EVENTS ARE MORE FREQUENT

Since 1950, cold days and nights and frost days have become less frequent, while hot days and nights and heat waves have become more frequent [7].

Global patterns of both heavy precipitation events and intense droughts have changed over recent decades. The increase in heavy precipitation events is consistent with the general increase in temperatures and the commensurate increase in atmospheric water vapor content. Droughts have become more intense, particularly in the tropics and subtropics, because of higher temperatures, more frequent heat waves, and changes in precipitation patterns [7].

The combination of increasing atmospheric temperatures and increased sea surface temperatures can increase the energy of tropical storms [43]. Preliminary observations since 1970 suggest that this effect has been observed in the North Atlantic and perhaps other regions as well [7].

ICE AND SNOW COVER IS DISAPPEARING

Glacial ice and snow cover are disappearing in many regions around the world. The Arctic region, in particular, is one of the areas being affected most by rising temperatures. As a result of temperatures that have increased at nearly twice the global average rate, Arctic sea ice is thinning and shrinking in extent, glaciers are melting throughout the region, and the snow season has shortened. Alaskan glaciers have retreated at a rapid pace; in fact, the amount of glacial mass lost in Alaska alone represents half of the estimated worldwide total [44]. There will be little to no sea ice in the Arctic's summers toward the end of this century [7]. Glaciers in other regions, such as high-altitude glaciers in tropical areas, are also melting at an increasing rate [7].

Increased melting of the Greenland ice sheet is one of the most worrisome Earth responses observed thus far. Data from NASA's Goddard Space Flight Center show that the seasonal melt area over Greenland has trended upward at 7 percent per year over the last twenty-five years, and the ice shelf surrounding Greenland has thinned by 230 feet over the last five years [15]. Recent satellite data analyzed by NASA have shown that from 2003 through 2005, Greenland annually lost three times more ice through melting than it gained through snowfall [45].

Antarctica's ice cover has also responded to the increasing temperature, but in different ways. West Antarctica has lost ice mass, while the ice sheet in East Antarctica has thickened. The thickening has been explained as being due to increased snow fall (as a result of warming temperatures that lead to more water vapor in the atmosphere) [46] as well as a slowing of glaciers for reasons unrelated to climate [45].

The melting of ice cover is an important positive feedback that reinforces heating, because of ice's contribution to the reflectivity of the earth. As ice melts, it exposes either land or water, depending on its location. Because land and water both reflect less solar radiation than ice, they reinforce rising temperatures, which in turn melts more ice. Once such loops begin, predicting their stopping point is difficult.

OCEANS ARE WARMING

The oceans have an enormous capacity to hold heat; because of their volume and heat capacity they require extremely large inputs of heat to change their temperatures. Nevertheless, the global mean sea surface temperature increased 0.9°F globally in the twentieth century [47], and the IPCC stated that "global ocean heat content has increased significantly since the late 1950s" [41].

SEA LEVELS ARE RISING

Ocean temperature is important to sea level rise because as temperatures increase, water expands, causing sea levels to rise. Because of the thermal inertia of the oceans, once sea level begins to rise because of thermal ex-pansion, it will continue to do so for centuries regardless of any mitigative actions.

Sea levels are also raised by the melting of land-based ice and snow because of the direct transfer of water into the sea. Sea-based ice, however, does not raise sea levels as it melts.

From 1961 through 2003, global mean sea level has risen about three inches, with nearly half of that increase occurring between 1993 and 2003 [7]. Over the entirety of the twentieth century, sea levels have risen nearly seven inches. The IPCC concluded that this rise was caused by thermal expansion of the ocean as well as melting of mountain glaciers and snow cover [7].

OCEAN SALINITY HAS CHANGED

Oceanographers have observed dramatic changes in salinity levels in the oceans. Oceans in the mid- and high latitudes have shown evidence of freshening, while those in tropical regions have increased in salinity [7].

Increases in ocean acidity have also been observed since preindustrial times. Increased atmospheric CO_2 is absorbed in the ocean where it combines with water to form carbonic acid, a mild acid. Most people are familiar with acid rain; this is its ocean equivalent. Forecasts project the increase in acidity over the coming century to be three times as great as the increase over the last 250 years [7]. Higher acidity could have a major impact on ocean life by preventing the formation of shells and skeletons of some very numerous and important zooplankton [48]. Coral reefs are particularly vulnerable.

FUTURE SCENARIOS: A CHOICE FOR HUMANS

To help illustrate the changes in climate that may occur, the IPCC developed a set of more than three dozen scenarios that describe different paths along which the world may evolve over the next century [49]. These paths are divided into six overarching categories distinguished by the assumptions made for factors such as economic growth, interactions among nations, population growth, and technological advances.

The scenarios were used as inputs to drive various climate models. The IPCC's 2007 report documents a range of climate change outcomes for the next century for each of the six categories used. According to the IPCC report, when considering the climate model results for each scenario, the average temperature projected in years 2090 to 2099 is expected to exceed the average temperature observed from 1980 to 1999 by 2.0° to 11.5°F. Sea levels are projected to rise between seven and twenty-three inches. This projection does not include the effect of potential changes in ice flow dynamics of large, land-based glaciers that may further contribute to the rise in sea level. To put this in perspective, recall that over the last century, the temperature increased about 1.3°F, and the sea level increased seven inches.

Because most of the inter-model studies assessed by the IPCC focus on three specific scenario categories, the IPCC's 2007 report necessarily focuses mostly on the same three. The "low" scenario (i.e., the one that results in the lowest temperature increase) describes a future in which population levels come under control, the global economy moves away from a manufacturing focus, and nations work together on improvements in environmental sustainability and developing clean technologies. The "medium" scenario describes a future where the assumptions regarding population and economic growth are similar to those made in the low scenario. Moreover, in the "medium" scenario the IPCC assumes the development of efficient technologies, and the production of energy from a variety of sources other than fossil fuels. The "high" scenario is the same as the "middle" scenario except energy production remains heavily focused on fossil fuel sources.

Each of the IPCC scenarios lead to different projections for temperature change; however, they all project significant global warming, with the most intense warming occurring in the Arctic and the high northern latitudes.

Some of the areas hardest hit by temperature increases will also very likely experience significantly less rainfall by the end of the century. Domestically, the southwestern portion of the United States will very likely experience the worst combination of these factors. Decreasing precipitation and markedly increasing temperatures will also stress northern and southern Africa and the Middle East.

While the earth's natural systems will continue to experience greater stress due to future climate changes, so will some key human systems [24]:

• **Coastal populations:** Increases in flooding and inundation from rising seas and more intense storms will affect coastal populations across the world, particularly those in Bangladesh and low-lying island nations.

• **Agriculture:** Temperature increases of a few degrees and increases in atmospheric CO_2 levels may help agricultural productivity in mid- and high latitudes but will surely hurt agriculture in the tropics and subtropics, where crops already exist at the top of their temperature range; higher increases in temperature, as well as heat waves, changes in precipitation, and increased pests, will hurt agricultural productivity across much of the globe.

• **Water resources:** Five billion people are expected to live in water-stressed countries by 2025 even without factoring in climate change. Expected changes in climate will exacerbate water-stress in some areas (including most of Asia, southern Africa, and the Mediterranean), while alleviating it in others (such as the United Kingdom). Areas that depend on tropical mountain glaciers for water (such as Lima, Peru), will face a precarious situation as the glaciers continue to melt and eventually disappear. Developing nations with little capacity to manage water will be among the hardest hit.

• **Health:** Rising temperatures and heat waves will increase the number of heat-related deaths in summer months. This increase will be partially offset by decreases in cold-related winter deaths. The reach of vector-borne diseases, such as malaria and dengue fever, is expected to spread. Increasing frequency of floods will harm human health by its direct impact on populations as well as by facilitating the spread of disease to affected areas. Vital health infrastructure can be damaged, making minor and treatable injuries become life-threatening.

A WILD CARD: ABRUPT CLIMATE CHANGE

For many years it was believed that climate changes have been gradual—that the earth gradually cycles between glacial periods and warm interglacial periods. We now know this is not always the case [50].

Abrupt climate changes present the most worrisome scenario for human societies because of the inherent difficulties in adapting to sudden changes. Abrupt sea level rise is particularly worrisome. The great ice sheets along the edges of Greenland and the West Antarctic are vulnerable to sudden breakup: as the edges of the sheet thaw and meltwater seeps to the ice-ground boundary, the meltwater will act as a lubricant and facilitate a slippage into the sea. This physical phenomenon is an example of a positive feedback mechanism that, once started, is difficult to reverse [15]. Melting of these ice sheets would be catastrophic. The Greenland Ice Sheet could raise sea levels by twenty-three feet over a millennium [7]; the West Antarctic Ice Sheet would have a more immediate impact, raising sea levels more than three feet per century for five centuries [41]. The probability of a collapse of the West Antarctic Ice Sheet before 2100 is estimated to be between 5 and 10 percent [7].

None of these abrupt climate changes are projected by the climate models driven by the IPCC's 2007 future scenarios. However, if temperature increases were at the high end of the ranges projected by the models, abrupt climate changes such as those discussed above are more likely to occur. Such abrupt climate changes could make future adaptation extremely difficult, even for the most developed countries.

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SUBMITTED REPORT BY HON. TIMOTHY J. WALZ, A REPRESENTATIVE IN CONGRESS FROM MINNESOTA

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The Other Side of the Coin:

The Economic Benefits of Climate Legislation

J. Scott Holladay
Jason A Schwartz

Policy Brief No. 4
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Printed in the United States of America.

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Contents

Acknowledgments

Thanks to Michael A. Livermore and Richard L. Revesz for inspiring and guiding this project.

Executive Summary

This policy brief conducts an informal analysis of the costs and benefits of H.R. 2454: the American Clean Energy and Security Act of 2009. EPA has prepared a formal estimate of this bill's costs, but has not considered the benefits.

Using data provided by EPA, as well as new calculations of the damages from greenhouse gas emissions recently developed by a federal interagency task force, this brief estimates the benefits of H.R. 2454's cap on greenhouse gas emissions. The results indicate that H.R. 2454 is cost-benefit justified under most reasonable assumptions about the likely "social cost of carbon." The breakeven social cost of carbon, above which the legislation is cost-benefit justified, ranges from \$7.70 to \$8.97. These figures are in the very low end of the range of SCC values considered by the interagency review process. Using conservative assumptions, the benefits of H.R. 2454 could likely exceed the costs by as much as nine-to-one, or more.

The estimated benefits do not include a significant number of ancillary and un-quantified benefits, such as the reduction of co-pollutants (particularly sulfur dioxide and nitrogen dioxide), the prevention of species extinction, and lower maintenance costs for energy infrastructure. Due to those limitations, the benefits estimates should be considered to be very conservative. IPI calls on EPA to conduct a full, formal analysis of the benefits of climate legislation, including whether alternate and more stringent climate policies might be even more cost-benefit justified.

Introduction

Over the past several years, as Congress has debated various climate change bills, both the House of Representatives and the Senate have wisely sought assistance from the Environmental Protection Agency (EPA) in advance of their deliberations, to investigate the likely economic consequences of the proposed legislation.[1] Most recently, before the House passed the American Clean Energy and Security Act (H.R. 2454) by a slim margin in June of 2009, Representatives Waxman and Markey sent letters asking EPA for "technical assistance" to "estimate the economic impacts" of the legislation.[2] Waxman and Markey also requested additional economic analyses from the Energy Information Administration (EIA) and the Congressional Budget Office (CBO).[3]

Unfortunately, EPA, EIA, and CBO interpreted those requests for economic analysis to apply only to the costs of such legislation and not the benefits. In fact, while EPA developed sophisticated analytical models and projected the likely costs under a variety of scenarios, the agency's report clearly states that "[n]one of the models used in this analysis currently represent the benefits of [climate change] abatement."[4] Similarly, in a table presenting the economic impacts of legislation, under the entry "Benefits from Reduced Climate Change," EPA simply wrote "Not Estimated."[5] The analyses conducted by EIA and CBO do not calculate the benefits either.[6] Meanwhile, Congress has not explicitly asked EPA or any other government agency to complete a systematic review of the potential scope and magnitude of the benefits that climate change legislation will generate.

A balanced and rigorous analysis of costs and benefits is an invaluable decisionmaking tool for legislators. In order to craft specific legislative language, to compare a bill with competing legislative alternatives, and ultimately to cast a rational and educated vote, legislators need to understand the full range of consequences—both positive and negative—that their decisions will have on the economy, the environment, and public health. But so far, in its study of climate change legislation, Congress has focused its information-gathering efforts much more on costs than benefits. Climate change is arguably one of the most complex issues to face Congress in recent memory, and yet Congress is essentially conducting its deliberations after having reviewed barely half the data.

The direct benefits of climate change legislation like H.R. 2454 will result from reducing the emissions of greenhouse gas pollutants (GHGs, which principally include carbon dioxide, methane, nitrous oxide, sulfur hexafluoride, perfluorocarbons, and hydrofluorocarbons). Cutting national GHG emissions will mitigate the speed and severity of climate change effects, including the myriad impacts on the environment, the economy, public health, and national security.

A rough estimate of such benefits can actually be generated through a straightforward calculation: projected tons of greenhouse gas emissions avoided, multiplied by the monetary valuation of incremental damage from each ton of greenhouse gas emissions. The first figure has already been calculated by EPA and other agencies, published in the various economic analyses of H.R. 2454. The second figure—also known as the "social cost of carbon" (SCC)—has until recently only ever been estimated by federal agencies on a rather ad hoc basis.[7]

But in a newly finalized regulation on energy efficiency standards, the Department of Energy "rel[ies] on a new set of values recently developed by an interagency process that conducted a more thorough review of existing estimates of the social cost of carbon."[8] Now that a consistent range of SCC estimates exists and has the support of multiple federal agencies, computing the benefits of climate legislation becomes possible. Simply by using figures already calculated, peer-reviewed, and published by various federal agencies, this policy brief conducts a preliminary but balanced cost-benefit analysis of the main climate change proposal now under consideration by Congress: H.R. 2454, the American Clean Energy and Security Act of 2009.

Analytical Scenarios and Models

This policy briefs relies principally on data generated and analyzed by EPA in its study of the economic consequences of H.R. 2454, the American Clean Energy and Security Act of 2009. Reports published on H.R. 2454 by the Energy Information Administration (EIA) and the Congressional Budget Office (CBO) also offer cost estimates and provide useful comparisons. Unfortunately, the raw data released by EIA does not extend beyond the year 2030.[9] Given that H.R. 2454 proposes significant GHG reductions in the years 2031 through 2050,[10] the lack of data for this period would seriously compromise the integrity of any estimation of the benefits from GHG reductions. Similarly, CBO's report does not contain sufficient raw data to support a thoroughly balanced cost-benefit analysis.[11] Because EPA's analysis covers the full time period through the year 2050, and because in many cases EPA offers year-by-year raw data in an online annex,[12] relying on EPA's work will allow for a more complete cost-benefit comparison.

Any cost-benefit analysis of a policy proposal needs a baseline scenario or reference case against which to compare the effects of the policy. In EPA's latest analysis of H.R. 2454, the agency updates its reference case to account both for separate federal energy legislation recently enacted into law and for the recent economic downturn.[13] Both factors result in lower projections for total greenhouse gas emissions in the "no policy" scenario. The bill proposes reductions relative to 2005 U.S. emissions, so the new baseline implies that fewer emissions will need to be cut to achieve the reduction targets, thereby lowering the overall costs of compliance.[14]

Notably, the baseline scenario does not assume the future existence of any additional domestic or international climate policies not already in effect.[15] For example, the scenario does not include the recently announced—but not yet finalized or enforced—fuel economy standards for passenger cars and light-duty trucks,[16] nor does the scenario assume any new international climate treaty will emerge from the upcoming negotiations in Copenhagen this winter.[17]

EPA has estimated the reduction in GHG emissions for a variety of possible policy alternatives. This brief will focus on calculating the costs and benefits of moving from the baseline emissions level (termed "Scenario 1") to the basic emissions profile under H.R. 2454 (called "Scenario 2"). Other scenarios project emissions levels if certain legislative provisions are altered or if domestic political and economic conditions change.[18] Changes to the existing bill or the current political climate are hard to predict, so this analysis does not address such alternatives. Ideally, Congress should ask EPA to conduct a complete cost-benefit analysis of a range of policy scenarios. This brief simply demonstrates that such analysis is feasible and takes a preliminary look at the most straightforward case. This focus is not intended to suggest that H.R. 2454 contains the optimal suite of climate policies; indeed, this analysis will conclude that a more stringent GHG cap could maximize net benefits.

Scenario 2 models the various provisions of H.R. 2454.[19] The scenario includes bonus allowances for carbon capture and sequestration, energy efficiency standards, output-based rebates, international offsets, and allocations to local energy providers used to lower consumers' utility rates. These are all stipulations of the current bill. The scenario does not explicitly model the strategic allowance reserve, assuming that emitters will purchase allowances and the pool will be used up. The scenario does predict significant actions by other countries. Countries that have already made international commitments to cut their emissions under the Kyoto Protocol (with the exception of Russia) are expected to continue to cut emissions even beyond Kyoto's current implementation period, and ultimately to reduce their emissions by the year 2050 to fifty percent below their 1990-level emissions. The rest of the world is assumed to reduce their emissions as well, but more gradually and less stringently.

EPA has used two economic models to estimate the emissions reductions and costs associated with H.R. 2454.[20] The Applied Dynamic Analysis of the Global Economy (ADAGE) model is a dynamic Computable General Equilibrium model of the U.S. economy, including international trade. The Intertemporal General Equilibrium Model (IGEM) models only the U.S. economy, but has a more detailed representation of energy and environmental issues; perhaps importantly, because it does not model international emissions, IGEM does not capture possible emissions leakage.[21] ADAGE offers a more complete representation of the full global economy,[22] but is less useful for conducting counterfactual policy experiments. EPA's online data annex provides year-by-year results for IGEM but only five-year snapshots for ADAGE,[23] making analysis based on IGEM data more transparent. Ultimately, each model has its own strengths and weaknesses,[24] and so this policy brief will use EPA's data generated under both ADAGE and IGEM.

Most of H.R. 2454's provisions begin to take effect in 2012 and last until 2050.[25] For both the ADAGE and IGEM models, EPA has published data through the year 2050, so this policy brief will calculate costs and benefits of H.R. 2454 from 2012 through 2050.[26] The costs of climate change policy may be concentrated more intensely in earlier years, especially beginning in the year 2025, when emissions reduction targets under H.R. 2454 become much more stringent.[27] Moreover, compliance costs for environmental standards historically have tended to decrease over time, with the deployment and innovation of new advanced technologies and compliance strategies.[28] In contrast, the benefits of climate change policy may increase over time, because "future emissions are expected to produce larger incremental damage as physical and economic systems become more stressed as the magnitude of climate change increases."[29] Therefore, focusing on the period from

2012 through 2050 may tend to overestimate the total costs and underestimate the total benefits of climate change mitigation.

EPA, the Department of Energy, and various other federal agencies often use different base years to calculate the impacts of inflation and different discount rates to reflect the fact that benefits in the future are worth less than benefits today. To make the data comparable, this policy brief presents all monetary values in terms of 2007 U.S. dollars and uses a discount rate of 5%.[30] The discount rate is calculated from the year 2009.

The choice of discount rate is particularly important in analyzing the benefits of climate change legislation because the costs and benefits are realized at different times. While the discounting of costs and benefits is necessary and appropriate in many contexts, certain applications of a discount rate—especially a rate as high as 5%—to calculating the social cost of carbon are highly controversial. This policy brief will apply a discount rate to all stages of analysis, to be consistent with the current practices of federal agencies; however, this brief will also make note of when the application of a particular discount rate is likely too high. See other publications from the Institute for Policy Integrity for more detail on why discounting should be inapplicable in certain contexts.[31]

All calculations, estimates, and charts presented in this policy brief were generated using a Microsoft Excel spreadsheet, which is available online at the Institute for Policy Integrity's website.[32]

Costs

In its economic analysis, EPA presents its cost calculations as an average annual loss of consumption per U.S. household. Specifically, EPA estimates that under H.R. 2454, average annual household consumption will decline by $80 to $111 (in 2005$) per year relative to the baseline scenario.[33] Using the raw data made available on EPA's website, it is possible to calculate the total, cumulative costs on a nationwide basis from 2012 through 2050. Since costs and benefits fluctuate year-by-year with the stringency of H.R. 2454's provisions, it is more transparent to use annual and cumulative figures (rather than a single average) when comparing the costs and benefits of climate legislation.

The following table shows total costs for select years, as well as cumulatively over the 2012-2050 period, under both the ADAGE and IGEM models. According to EPA, these cost calculations "include the effects of higher energy prices, price changes for other goods and services, impacts on wages, and returns to capital."[34] Importantly, the cost figures have been adjusted to reflect the value of emissions allowances that will be auctioned off under H.R. 2454's cap-and-trade scheme, with some revenues being returned to consumers and to lower- and middle-income families. On the other hand, notably, "[t]he cost estimates do not account for the benefits of avoiding the effects of climate change."[35] Also, EPA's cost estimates do not include the government's costs of administering, monitoring, and enforcing H.R. 2454.[36]

Table 1: Cost Estimates by Model (in Millions of 2007$)

Year	ADAGE Model	IGEM Model
2015	$6,998	$2,181
2020	$8,602	$7,188
2025	$10,417	$11,836
2030	$20,219	$16,280
2035	$23,918	$21,236
2040	$27,844	$23,026
2045	$29,989	$23,925
2050	$30,077	$24,091
Total from 2012-2050	**$732,979***	**$589,403**

*Note: ADAGE data is only available in five-year increments. Annual values were interpolated to make the ADAGE results directly comparable to IGEM.

Some of ADAGE and IGEM's cost predictions for early years (2010-2013) are negative due to investment spurred by the passage of the Act and the relatively high initial caps.[37] Because the cumulative figures calculated in Table 1 exclude negative costs in years 2010 and 2011 (since the cap does not take effect until 2012), these cost estimates are higher than some of EPA's predictions that average costs from 2010-2050.[38]

Several assumptions made by EPA for the sake of "simplicity" are likely to results in "an overestimation of abatement costs."[39] For example, EPA predicts that most emissions reduction measures will be implemented at costs below the marginal price of emissions allowances. More specifically, EPA believes the relationship between abatement costs and allowance prices will follow a convex curve, suggesting a factor greater than two. However, for the sake of simplicity, EPA chose to approximate abatement costs by dividing allowance prices by two—an assumption that will inevitably lead to an overestimation of abatement costs.

Finally, EPA's cost analysis does not model the effects of the bill's new source performance standards for methane emissions from landfills and coal mines, or of H.R. 2454's separate cap on hydrofluorocarbon emissions.[40] Therefore, these emissions will not be considered in the benefits analysis of this policy brief, despite the significant GHG reductions such provisions would achieve.

Benefits

Climate legislation like H.R. 2454 would achieve both direct and indirect benefits. The potential direct benefits result from capping GHG emissions, thereby mitigating the speed and severity of the myriad impacts of climate change on the environment, the economy, public health, and national security. Such benefits are approximated by the "social cost of carbon" (SCC), which assigns a specific monetary value to the marginal impact over time of one additional ton of carbon dioxide-equivalent emissions.[41]

Cutting GHG emissions is also likely to generate several significant indirect benefits. For example, in addition to trapping heat in the atmosphere, carbon dioxide is also absorbed by bodies of water and leads to ocean acidification, which threatens the balance of many marine ecosystems; yet ocean acidification and its effects are not typically reflected in SCC approximations. Another significant category of ancillary benefits derives from the reduction of non-target, non-GHG co-pollutants as businesses make changes to decrease their GHG emissions. Reducing such co-pollutants, like nitrogen dioxide, will achieve significant economic and health benefits, which are not otherwise included in the SCC estimates.

Calculating the Total GHG Emissions Avoided

The first step in the benefits equation is to calculate the projected tons of greenhouse gas emissions that H.R. 2454's policies would prevent from entering the atmosphere. The following figures were generated from the raw data available on EPA's website, and they represent net emissions reductions under H.R. 2454 on a global basis, taking into account any domestic or international offsets.[42]

Table 2: GHG Reduction Estimates by Model (in Millions of Metric Tons of Carbon Dioxide-Equivalents)

Year	ADAGE Model	IGEM Model
2015	1,277	1,948
2020	1,776	2,225
2025	2,559	2,506
2030	3,180	2,778
2035	3,655	3,039
2040	4,214	3,384
2045	5,207	3,896
2050	6,149	4,410
Total from 2012-2050	**121,490***	**113,768**

*Note: ADAGE data is only available in five-year increments. Annual values were interpolated to make the ADAGE results directly comparable to IGEM.

These numbers do not include an addition 39-40 billion metric tons of carbon dioxide-equivalents avoided due to discounted offsets, international forestry set-asides, new source performance standards for landfills and coal mines, and a separate cap for hydrofluorocarbon emissions.[43] Not all of those additional provisions were modeled in EPA's cost estimates, and so they have been excluded from this benefits calculation. However, these figures should be kept in mind when reviewing the total economic justification for the bill, since all these additional provisions might very well generate benefits in excess of their costs.

Determining the Social Cost of Carbon

The "social cost of carbon" (SCC) is a monetary measure of the incremental damage resulting from GHG emissions. The SCC assigns a net present value to the marginal impact of one additional ton of carbon dioxide-equivalent emissions released at a specific point in time. SCC estimates take into consideration such factors as net agricultural productivity loss, human health effects, property damages from sea level rise, and changes in ecosystem services.[44]

However, all current SCC calculations involve a great deal of uncertainty that likely results in underestimation. Scientific knowledge about climate risks continues to grow more precise, but currently remains incomplete. For example, as EPA recently affirmed, "the current trajectory for [global] GHG emissions is higher than typically modeled" and the "current regional population and income trajectories…are more asymmetric than typically modeled."[45] As a result, actual climate change and vulnerability to climate change is likely much greater than captured by current SCC estimates.

Additionally, the economic models used to value costs and benefits cannot yet quantify all the likely and potential damages from climate change. Table 3 lists the impacts of climate change—some positive, but mostly negative—that have historically been omitted from the economic models used to calculate the SCC. The result of such significant omissions, according to EPA, is that current SCC estimates are "very likely" to be underestimations.[46]

In a forthcoming article, Jody Freeman and Andrew Guzman detail the five "methodological limitations of these models [that] almost certainly cause them to understate the impact and cost of climate change": "optimism about project temperature rise; failure to account for the possibility of catastrophic loss; omission of cross-sectoral [and cumulative] impacts; exclusion of non-market costs; and optimism about projected economic growth (which assumes productivity will be unaffected by climate change)."[47]

Table 3: List of Impacts <u>Omitted</u> from the FUND Model[48]

Agriculture	Reduction in growing season (e.g., in Sahel/southern Africa)
	Increase in growing season in moderate climates
	Impact of precipitation changes on agriculture
	Impact of weather variability on crop production
Biomes/ Ecosystems	Reverse of carbon uptake, amplification of climate change
	Thresholds or "tipping points" associated with species loss, ecosystem collapse, and long-term catastrophic risk (e.g., Antarctic ice sheet collapse)
	Species existence value and the value of having the option for future use
	Earlier timing of spring events; longer growing season
	Poleward and upward shift in habitats; species migration
	Shifts in ranges of ocean life
	Increases in algae and zooplankton
	Range changes/earlier migration of fish in rivers
	Impacts on coral reefs
	Ecosystem service disruption (e.g. loss of cold water fish habitat in the U.S.)
	Coral bleaching due to ocean warming
Energy	Energy production/infrastructure
	Water temperature/supply impacts on energy production
Foreign Affairs	Social and political unrest abroad that affects U.S. national security (e.g., violent conflict or humanitarian crisis)
	Damage to foreign economies that affects the U.S. economy
	Domestic valuation of international impacts
Forest	Longer fire seasons, longer burning fires, and increased burn area
	Disappearance of alpine habitat in the United States
	Tropical forest dieback in the Amazon
GDP/ Economy	Insurance costs with changes in extreme weather, flooding, sea level rise
	Global transportation and trade impacts from Arctic sea ice melt
	Distributional effects within regions
	Vulnerability of societies highly dependent on climate-sensitive resources
	Infrastructure costs (roads, bridges)
	Extreme weather events (droughts, floods, fires, and heavy winds)
Health	Increased deaths, injuries, infectious diseases, stress-related disorders with more frequent extreme weather (droughts, floods, fires, and heavy winds)
	Increases in malnutrition
	Air quality interactions (e.g., ozone effects, including premature mortality)
Snow/ Glacier	Changes in Arctic/Antarctic ecosystems
	Enlargement and increased numbers of glacial lakes; increased flooding
	Snow pack in southeastern United States
Tourism	Changes in tourism revenues due to ecosystems and weather events
	Arctic hunting/travel/mountain sports
Water	River flooding
	Infrastructure, water supply
	Precipitation changes on water supply; increased runoff in snow-fed rivers
	Increasing ground instability and avalanches

In recent years, various federal agencies have selected a wide range of SCC estimates on a rather ad hoc and inconsistent basis. For example, in 2008, the Department of Transportation assumed a value of $7 per ton of carbon dioxide for emissions reductions achieved by a proposed vehicle efficiency standard.[49] But by the following year, the agency was instead using a mean value of $33 for essentially the same regulation (and was also analyzing possible values at $2 and $80).[50] The Department of Energy has at times used a range of $0-$20,[51] while in other rulemakings has copied the Department of Transportation's figures.[52] Finally, in 2008, EPA developed a technical support document on the SCC. Using both a meta-analysis of existing literature and a specific economic model, EPA calculated a wide range of possible SCC estimates from -$6 to $695.[53] Though EPA has declared that many of these estimates are "highly preliminary, under evaluation, and likely to be revised,"[54] the agency has used them in recent rulemakings.[55]

Over the past several months, a collection of federal agencies has been working to develop a more consistent methodology for selecting SCC estimates to use in economic analysis.[56] Though the results of this interagency effort are still preliminary, the Department of Energy now feels confident enough in the interagency review process to begin using this new set of numbers in its rulemakings.[57]

The interagency review process made a number of crucial judgments in developing its SCC estimates. First, the interagency review concluded that a global SCC value should be "primary," even though a domestic SCC should also be considered.[58] In the past, some federal agencies (such as the Department of Transportation) have at times decided to count only climate change costs imposed directly on the United States, excluding broader global effects.[59] Some analysts believe the United States's share of climate effects will be comparatively small, because of the country's "relatively temperate climate, [the] small dependence of its economy on climate, the positive amenity value of a warmer climate in many parts of the United States, its advanced health system, and [its] low vulnerability to catastrophic climate change."[60]

However, as EPA has observed, such a decision would falsely assume that Americans are unwilling to pay to avoid international damages caused by U.S. emissions and that international impacts will not produce security risks or economic disruptions felt within U.S. borders.[61] In short, the global value is the "preferred" measurement since climate change "involves a global public good in which the emissions of one nation may inflict significant damages on other nations and [where] the United States is actively engaged in promoting an international agreement to reduce worldwide emissions."[62] This brief will discuss the global versus domestic issue in greater detail in the section on "Comparing Costs and Benefits," with particular attention to how current SCC estimates do not consider domestic valuations of international impacts and how U.S. action on climate change is likely a prerequisite to future international efforts, which will in turn benefit U.S. interests.

The interagency review process chose to focus on existing SCC estimates that (1) are derived from peer-reviewed studies, (2) do not weight the monetized damages to one country more than those in other countries, (3) use a "business as usual" climate scenario, and (4) are based on the most recent version of each of three major integrated economic assessment model (FUND, DICE, and PAGE). The review process then came to its own SCC estimates using averages weighted for each separate economic model, because "there appears to be no scientifically valid reason to prefer any of the three major [models]."[63]

Finally, the interagency review process selected a 3% growth rate to apply to the SCC values. Any SCC estimate is specific to pollution emitted at a particular point in time: for example, the costs imposed by GHGs released in the year 2010 will be lower than the costs imposed by GHGs released in the year 2011. The SCC is assumed to increase steadily over time, because "future emissions are expected to produce larger incremental damages as physical and economic systems become more stressed as the magnitude of climate change increases."[64] The review process selected a 3% growth rate, consistent with international recommendations and with the most recently peer-reviewed literature.[65]

Imbedded within the various SCC values calculated by the interagency review process are discount rates. Averting climate change will mostly produce benefits in the future, and discount rates are traditionally applied to account for a general preference for immediate benefits, so that a benefit accruing years from now is not worth as much as a benefit accruing today. Because in the context of climate change benefits accrue not just in the future but to future generations of people, the practice of discounting is quite controversial. See other publications by the Institute for Policy Integrity for more detail on the economic and ethical problems with discounting the costs and benefits of climate legislation.[66]

The interagency review process acknowledged that "[t]he choice of a discount rate, especially over long periods of time, raises highly contested and exceedingly difficult questions of science, economics, philosophy, and law."[67] Nevertheless, the process drew on literature that uses 3% and 5% discount rates, applied either constantly each year or via a "random walk" method that better accounts for uncertainty.[68] The Department of Energy also averaged the estimates associated with a constant 3% and a constant 5% rate, to generate a central figure that it prefers to use.

The following table shows the range of SCC estimates developed by the interagency review process at these various discount rates. Because discounting is such a controversial practice in the realm of climate change, this policy brief will also look at EPA's 2008 estimates of the SCC that used the slightly lower 2% discount rate.[69]

Table 4: Net Present Global SCC Estimates at 3% Growth Rate (in 2007$, per Metric Ton of CO_2-Equivalent Emissions)

Year of Emission	Discount Rate					
	Constant 5%*	**Random-Walk 5%***	**Average of 3% & 5% (Constant)†**	**Constant 3%***	**Random-Walk 3%***	**Constant 2%‡**
2007	$5	$10	$19	$33	$55	$68
2010	$5.46	$10.93	$20.76	$36.06	$60.10	$74.31
2015	$6.33	$12.67	$24.07	$41.80	$69.67	$86.14
2020	$7.34	$14.69	$27.90	$48.46	$80.77	$99.86
2025	$8.51	$17.02	$32.35	$56.18	$93.63	$115.77
2030	$9.87	$19.74	$37.50	$65.13	$108.55	$134.20
2035	$11.44	$22.88	$43.47	$75.50	$125.84	$155.58
2040	$13.26	$26.52	$50.39	$87.53	$145.88	$180.36
2045	$15.37	$30.75	$58.42	$101.47	$169.11	$209.09
2050	$17.82	$35.65	$67.73	$117.63	$196.05	$242.39

* Model-Weighted Mean Calculated by Interagency Process in 2009
† Department of Energy's Average of the SCC Estimates at the Constant 3% and Constant 5% Discount Rates
‡ Central Estimate of Meta-Analysis Conducted by EPA in 2008

Bear in mind that, for the reasons discussed above, all these estimates are still likely to be *under*estimates.

Quantification of Direct Benefits

Calculating the direct benefits of H.R. 2454's cap on GHG emissions is simply a matter of multiplying the projected GHG emissions avoided by the social cost of carbon. The following tables show the projected GHG emissions under either ADAGE or IGEM, multiplied by all six

SCC estimates in the range developed by federal agencies. In both tables, the benefits have been discounted at a 5% rate (consistent with EPA's discounting of costs), above and beyond any discounting already factored into the SCC values, to account for the fact that the benefits of reducing future emissions do not begin accruing until a later date.

Table 5: Direct Benefits under ADAGE Model (in Millions of 2007$, at a 5% Discount Rate)

	SCC Estimate					
Year	**Constant 5%** ($5 in 2007)	**Random-Walk 5%** ($10 in 2007)	**Average of 3% & 5%** ($19 in 2007)	**Constant 3%** ($33 in 2007)	**Random-Walk 3%** ($55 in 2007)	**Constant 2%** ($68 in 2007)
2015	$6,035	$12,070	$22,933	$39,832	$66,386	$82,077
2020	$7,623	$15,246	$28,966	$50,310	$83,850	$103,670
2025	$9,980	$19,960	$37,924	$65,868	$109,780	$135,728
2030	$11,264	$22,529	$42,804	$74,345	$123,908	$153,195
2035	$11,760	$23,521	$44,689	$77,618	$129,364	$159,941
2040	$12,314	$24,628	$46,792	$81,271	$135,452	$167,468
2045	$13,821	$27,643	$52,522	$91,222	$152,036	$187,972
2050	$14,826	$29,652	$56,339	$97,851	$163,086	$201,633
Total from 2012-2050	**$408,714**	**$817,428**	**$1,553,113**	**$2,697,512**	**$4,495,853**	**$5,558,509**

The wide range of possible SCC values generates a wide range of benefit estimates: the variability in estimated benefits is purely a function of the SCC range.[70] A starting social cost of carbon of $5 in 2007 generates benefits of approximately $409 billion over the life of the bill, while a social cost of carbon of $68 in 2007 generates benefits of about $5.5 trillion dollars. Using the SCC figures preferred by the Department of Energy in its recent rulemaking, benefits total about $1.5 trillion. The benefit estimates are relatively small during the early years of the cap, but rise as the cap's stringency increases and the SCC values grow. Despite being discounted, the benefits in 2050 are forecasted to be more than twice as large as those in 2012.

Table 6: Direct Benefits under IGEM Model (in Millions of 2007$, at a 5% Discount Rate)

	SCC Estimate					
Year	**Constant 5%** ($5 in 2007)	**Random-Walk 5%** ($10 in 2007)	**Average of 3% & 5%** ($19 in 2007)	**Constant 3%** ($33 in 2007)	**Random-Walk 3%** ($55 in 2007)	**Constant 2%** ($68 in 2007)
2015	$9,205	$18,410	$34,979	$60,753	$101,256	$125,189
2020	$9,551	$19,102	$36,293	$63,035	$105,058	$129,890
2025	$9,773	$19,547	$37,138	$64,504	$107,506	$132,916
2030	$9,838	$19,676	$37,385	$64,932	$108,220	$133,800
2035	$9,777	$19,554	$37,153	$64,529	$107,548	$132,969
2040	$9,889	$19,778	$37,579	$65,268	$108,780	$134,492
2045	$10,342	$20,683	$39,298	$68,255	$113,759	$140,647
2050	$10,632	$21,264	$40,401	$70,171	$116,952	$144,595
Total from 2012-2050	**$382,982**	**$765,964**	**$1,455,332**	**$2,527,681**	**$4,212,802**	**$5,208,555**

The IGEM model generates a similarly wide range of possible benefit values, reflecting the wide range of SCC estimates. The possible benefits run from $383 billion to $5.2 trillion, and total nearly $1.5 trillion using the SCC values preferred by the Department of Energy's recent rulemaking. Those cumulative benefits are consistently smaller than those from the ADAGE model due to lower estimates of overall GHG reductions (see Table 2). The IGEM model projects larger benefits in the early years of the regulation, but significantly smaller benefits during the final years covered under this cap. Even after discounting, those smaller benefits in future years lead IGEM to forecast smaller cumulative benefits over the life of H.R. 2454.

Again, bear in mind that these figures represent discounted benefits. The choice of a discount rate as high as 5% is controversial, and it can be useful in cost-benefit analysis to present the results using a discount rate of 0% as well.[71] The following chart compares the stream of benefits over time under both models at either a 0% or 5% discount rate, assuming an SCC value starting at $19 for year 2007 emissions (the value preferred by the Department of Energy).

Chart 1: Benefit Streams at 0% and 5% Discount Rates

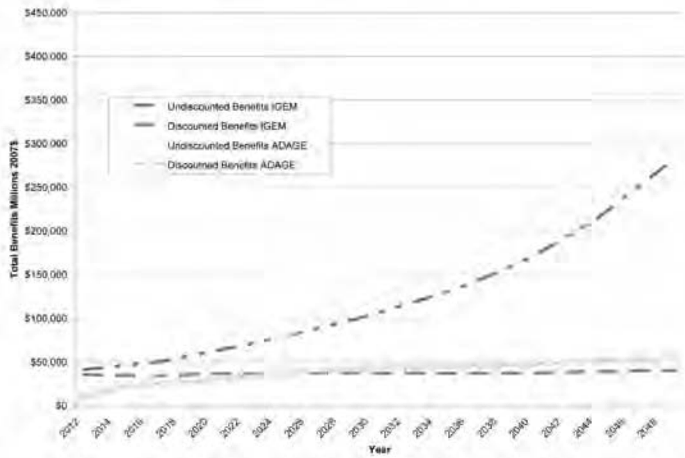


Chart 1 illustrates the importance of selecting a discount rate when estimating the benefits (or costs) of a long-term policy such as H.R. 2454. The benefits at a 0% discount rate rise very quickly as the level of emissions drops and the social cost of carbon increases, but discounting those large benefits at a 5% rate reduces their size tremendously. Assuming a starting SCC of $19 and using the IGEM model, a discount rate of 0% leads to cumulative benefit estimates of around $5.0 trillion, while discounting at 5% leads to a total benefits estimate of around $1.5 trillion.

Notably, there is only a 6%-18% difference between the ADAGE and IGEM models in either the 0% or 5% discount rate cases, whereas there is a 246%-286% difference between discounting and not discounting benefits. In other words, the choice of discount rate and the choice of SCC values are far more important than the choice of economic model when forecasting the long-run costs and benefits.

Quantification and Qualitative Discussion of Ancillary Benefits

The SCC estimates undeniably do not yet reflect all impacts of climate change (see Table 3); those omissions must be rectified in order to accurately calculate direct benefits. However, the policies implemented by climate legislation like H.R. 2454 will also generate several ancillary benefits, wholly apart from any effect tied to climate change, and definitely not captured in the social cost of carbon. These benefits include reduced ocean acidification, increased forest preservation, and reductions in local air pollutants such as sulfur dioxide, nitrogen dioxide, and particulate matter.

Such outcomes are not the primary goal of H.R. 2454, but they still provide benefits that must be considered when conducting a full economic analysis. Indeed, some past attempts to quantify ancillary benefits of various climate policies have estimated the indirect benefits at anywhere from 30% to over 100% of total compliance costs.[72] That said, ancillary benefits can often be difficult to value accurately, and so in some cases they must remain un-quantified. Nevertheless, all ancillary benefits, whether monetized or not, deserve attention when determining if the benefits of proposed legislation outweigh the costs.

Health and Economic Benefits from Co-Pollutants

As power plants begin to comply with climate legislation by becoming more efficient, switching to cleaner fuel sources (like natural gas instead of coal), or deploying controls to capture and sequester emissions, they will be reducing more than just their greenhouse gas pollution. Power plants also emit significant quantities of nitrogen dioxide, sulfur dioxide, particulate matter, and heavy metals: the pollutants responsible for producing smog and acid rain, and also for contributing to water quality deterioration, soil quality deterioration, and severe respiratory disorders. Though these co-pollutants are not the target of climate policies like H.R. 2454, such legislation will have the ancillary benefit of reducing their emission as well.[73]

EPA's models "do not incorporate the effects of changes in conventional pollutants ([sulfur dioxide, nitrogen dioxide, and mercury]) on labor productivity and public health." EPA considered this to be "an important limitation," but ultimately not a significant one, because the agency expected the actual health and economic benefits to be "small."[74] By contrast, past attempts to calculate ancillary benefits of various climate policies have predicted health effects will account for around 70-90% of the total value of ancillary benefits.[75]

Some of these ancillary benefits can be quantified using a model developed by Dallas Burtraw and other economists from Resources for the Future and the Argonne National Laboratory. In 2001, Burtraw and his colleagues released a paper on "Ancillary Benefits of Reduced Air Pollution in the United States from Moderate Greenhouse Gas Mitigation Policies in the Electricity Sector."[76] That paper makes a series of "cautious assumption[s]" to generate a "lower bound" estimate for ancillary benefits under a range of climate policies.[77] By focusing on one particular conservative scenario explored in that paper, this analysis can adapt Burtraw's model to predict some of the ancillary health benefits from H.R. 2454.

Burtraw's model estimates the ancillary benefits of applying climate policies specifically to the electricity sector. Where the climate policy is likely to lead to actual net reductions in other non-target pollutants, Burtraw's model calculates public health benefits.[78] Where the climate policy is not likely to lead to actual net reductions in other non-target pollutants, because such conventional pollutants are already subject to a strict regulatory cap, Burtraw's model predicts economic savings as the allowance price for those conventional pollutants drops.[79]

Because several significant regulatory and economic changes have occurred since 2001, ideally Burtraw's model should be updated to provide a more accurate calculation of ancillary benefits. However, the fundamental structure of Burtraw's model remains sound, and it should provide a rough estimation. Burtraw's baseline scenario assumed that, over time, some stricter regulatory controls would be developed for nitrogen dioxide and sulfur dioxide. In particular, Burtraw modeled an expanded nitrogen dioxide cap-and-trade program encompassing nineteen states and the District of Columbia.[80] In reality, the Clean Air Interstate Rule of 2005 (CAIR) now covers twenty-eight states plus D.C.[81] However, because CAIR was technically overturned by the courts and only remains in effect until EPA can replace it, and because CAIR (or its replacement) will only be phased in over time, has some seasonal components, and does not cover at least twenty-two states,[82] climate change legislation will still likely impact nationwide emissions of nitrogen dioxide, and Burtraw's model remains a good approximation.

Moreover, Burtraw's model is extremely conservative. For example, because of the difficulty in quantifying the health impacts of sulfur dioxide, ozone, and other pollutants, Burtraw only addressed the health effects of nitrogen dioxide, meaning his model's "estimates may be a lower bound of the estimates that would be achieved if a complete analysis was possible."[83] Similarly, because of the study's methodologies, the "estimate of the compliance cost savings resulting from [climate policies] would be likely to underestimate savings."[84] Finally, Burtraw's model uses a value of statistical life ($3.8 million in 1997$) much lower than EPA's current recommendation ($7.0 million in 2006$).[85]

Burtraw's model estimates a range of ancillary benefits per ton of carbon emissions avoided. This policy brief will use the lowest total estimate generated for the most analogous scenario modeled.[86] To be conservative, this analysis will assume that figure is constant and will not grow over time. EPA's ADAGE model of emissions under H.R. 2454 breaks down carbon dioxide reductions specific to electricity production.[87] By multiplying those figures and applying a 5% discount rate, ancillary benefits can be estimated.

Table 7: Ancillary Benefits in Electricity Sector

Year	CO_2 Reductions from Electricity Sector (Million Metric Tons)	Ancillary Benefits Per Ton of CO_2 (2007$)	Benefits at 0% Discount Rate (Millions of 2007$)	Benefits at 5% Discount Rate (Millions of 2007$)
2015	287.6	$4.3689	$1,256.60	$937.70
2020	673.4	$4.3689	$2,942.22	$1,720.26
2025	1,058.5	$4.3689	$4,624.50	$2,118.54
2030	1,393.9	$4.3689	$6,089.81	$2,185.89
2035	1,635.3	$4.3689	$7,144.63	$2,009.36
2040	1,922.7	$4.3689	$8,399.91	$1,851.00
2045	2,255.2	$4.3689	$9,852.60	$1,701.12
2050	2,551.6	$4.3689	$11,147.80	$1,508.09
Total from 2012-2050	**57,419.1***		**$250,858.16**	**$68,405.80**

*Note: ADAGE data is only available in five-year increments. Annual values were interpolated to derive a cumulative total.

Burtraw's model predicts that ancillary health and economic benefits from reducing co-pollutants in the electricity sector could total nearly $70 billion. This figure should be kept in mind when assessing the cost-benefit justification of H.R. 2454, but because the model is imperfect and results are available only for ADAGE data, to be conservative this total will not be added to the final direct benefits calculation.

Other sectors besides the electricity sector will also use fuel switching to comply with H.R. 2454: in particular, the transportation sector. Fuel switching in these other areas will also carry ancillary health benefits. In its recent proposed rulemaking on renewable fuels, EPA noted that switching to cleaner vehicle fuels in an attempt to reduce greenhouse gas emissions would also cut the emission of co-pollutants. Unfortunately, EPA did not attempt to monetize these benefits.[88] Without such a model to build from, it is difficult for this policy brief to attempt to quantify these ancillary benefits. Ideally, EPA should develop such a model, both for use in its renewable fuel rulemaking and to enable a complete cost-benefit analysis of climate legislation.

Ocean Acidification

In addition to acting as a greenhouse gas in the atmosphere, carbon dioxide alters ocean chemistry as it is absorbed by surface waters. The resulting acidification of water may potentially harm a wide range of marine organisms (particularly coral), as well as the food webs and valuable marine fisheries that depend on them.[89] In a recent study anticipating the economic consequences for commercial fisheries of ocean acidification, Sarah Cooley and Scott Doney note that, in the United States alone, commercial fishing contributes $34.2 billion in value to the gross national product and likely supports several hundreds of thousands of jobs; recreational fishing adds another $43 billion in total economic activity and supports around 350,000 jobs. Considering just potential losses to U.S. mollusk commercial fisheries, the economic costs of ocean acidification easily fall in the range of $0.6-$2.6 billion through the year 2060.[90] Though it is difficult to quantify what portion of such costs could be averted through policies like H.R. 2454, qualitatively the benefits of preventing ocean acidification are highly significant on a global scale.

Other Ancillary Benefits

Some of the other ancillary benefits for GHG reductions that are frequently discussed in literature—though difficult to quantify—include:[91]

- Energy security: geopolitical benefits from reduced reliance on foreign fossil fuel sources.

- Increased forest preservation: increased ecosystem service benefits from forests; increased access to recreational sites; reduced soil loss and erosion through tree farming.

- Decreased private transportation (either with shift to public options or overall decrease in miles traveled): reductions in road-related mortality; reductions in congestion and noise; cost-savings for road maintenance.

- Non-health effects of non-target pollutants: reduced nitrate loadings to marine and freshwater ecosystems; agricultural benefits from reduced ozone formation and particulate-haze effects; agricultural benefits from reduced nitrogen deposition; increased visibility.

- Possible employment gains from green collar jobs: this benefit is perhaps somewhat speculative, since possible decline in economic activity might cancel out any employment gains; EPA's current economic models do not represent effects on unemployment.[92]

A fuller analysis of and attempt to quantify all possible ancillary benefits and ancillary costs is beyond the scope of this policy brief. Ideally, Congress should request that EPA undertake such a study.

Additionally, H.R. 2454 contains particular provisions and structures unrelated to GHG reductions that may carry benefits. For example, through its distribution of revenue from the auction of emissions allowances, H.R. 2454 may provide relief to local government budgets, support for transportation and research initiatives, and improved distributional equity via tax relief to low- and middle-income families.[93] A more thorough analysis of the specific provisions of H.R. 2454 is beyond the scope of this policy brief. Such a review should be part of a comprehensive EPA cost-benefit analysis of H.R. 2454.

Comparing Costs and Benefits

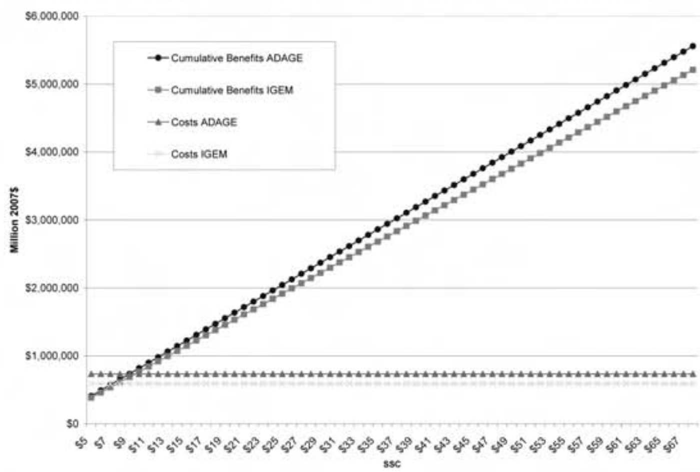
This section compares the estimated costs of complying with H.R. 2454 with estimates of the benefits as measured by the social cost of carbon and ancillary benefits. This comparison will be used to predict whether the proposed bill and possible legislative alternatives are likely to pass a more thorough cost-benefit analysis.

The Breakeven SCC

The following chart plots the estimated cumulative costs of H.R. 2454 (around $660 billion) against the projected direct benefits of the bill for a range of SCC values (from $5 per ton of carbon dioxide in 2007, up to $68 per ton). The chart continues to employ the restrictive assumptions used in the brief, and therefore does not include any ancillary benefits, and discounts costs and benefits at a 5% rate. Additionally, recall that 39-40 billion metric tons of GHG abatement are not included in the benefits analysis, because EPA excluded certain provisions from its cost estimates.

The benefits as calculated by ADAGE and IGEM increase with the SCC, but costs remain constant. Measuring benefits is more difficult than measuring costs, as SCC estimates vary widely. For that reason, it is useful to calculate the SCC that will exactly equate the benefits (excluding ancillary benefits) of the bill with the estimated cost—in other words, the "breakeven social cost of carbon." If the actual SCC is above that value, benefits of H.R. 2454 will outweigh costs, and the legislation is cost-benefit justified. For ADAGE the breakeven point is $8.97, and for IGEM it equals $7.70. The breakeven points are close, but that hides some differences in the results: ADAGE forecasts higher costs and larger emissions reductions, which cancel each other out in a cost-benefit framework. Because these values do not include (potentially large) ancillary benefits, they should be considered an upper bound on the true breakeven SCC. Notably, these figures are on the very low end of the range generated by the interagency review process, and are less than half the $19 figure preferred by the Department of Energy in its recent rulemaking.

Chart 2: Total Costs and Benefits at Different SCC Values



Maximizing Net Benefits

At the SCC values preferred by the Department of Energy, the direct benefits of H.R. 2454 are more than double the costs. Using SCC values that have a more appropriately low discount rate built in (EPA's 2% figures), direct benefits are nearly eight to nine times greater than costs. Importantly, all these benefits calculations are likely to be underestimates, due to uncertainty in forecasting the SCC values and because ancillary benefits have not been quantified and added to these numbers.

Considering how strongly benefits outweigh costs at the level of GHG emissions cap contemplated by H.R. 2454, and given the difference between the breakeven SCC calculated for the bill and projections for allowances prices under the bill,[94] it seems probable that alternate policy arranges would also be cost-benefit justified. Indeed, it is very possible that a more stringent GHG cap could even better maximize net benefits.

Limitations of This Analysis

This brief only analyzes the period for which H.R. 2454 specifies emissions targets (2012-2050). Climate change is a long-run phenomenon, with emissions today generating damages in the fairly distant future. The majority of benefits from reduced emissions are likely to accrue to future generations, while costs fall on current consumers. On the other hand, many of the ancillary benefits described in the previous section will be realized immediately. These include the health benefits from a reduction in co-pollutants and possible geopolitical benefits from reductions in energy usage.

This policy brief has not attempted to analyze whether the distribution of costs and benefits under H.R. 2454 is equitable or optimal. Many other analysts have reviewed this issue in depth and have suggested simple changes to H.R. 2454 that could improve the distributional equity of the bill. Dallas Burtraw's work on how alternate arrangements for allocating and auctioning off emissions allowances could correct some distributional imbalances is particularly instructive.[95]

Global versus Domestic Valuations

It is worth noting that the estimated costs of H.R. 2454 will be borne entirely by the United States,[96] whereas the benefits are based on a global SCC figure. The domestic SCC is typically estimated at anywhere from 2-11% of the global SCC, with the Department of

Energy preferring to approximate it at 6%.[97] While many of the ancillary benefits of H.R. 2454 not quantified in this analysis will be enjoyed by current generations of U.S. citizens, a large portion of benefits might not be felt directly or immediately within U.S. borders.

Nevertheless, as the interagency review process concluded, the global SCC is the preferred figure for comparing the costs and benefits of climate legislation.[98] To begin, many experts believe that U.S. domestic action on climate change is a prerequisite to future global climate efforts,[99] at which point Americans will see additional (and essentially free) benefits derived from international action. Greenhouse gases are global pollutants, meaning that emissions anywhere in the world generate damages everywhere. In other words, each ton of reduced emissions in the United States will generate benefits to every other nation, and visa-versa. There is currently no mechanism for the United States to capture benefits exclusively for ourselves.[100] But once other countries take reciprocal action on climate change, they will likewise generate global benefits that will in part be reaped by the United States.

Second, current models for estimating the SCC typically do not consider domestic valuations of international impacts. For example, foreign physical damages from climate change could have domestic economic costs: the worldwide disruption of agricultural production and water resources, and the potential for social unrest—including violent conflicts—as countries react to such disasters, could pose threats to the U.S. national security and economy.[101] Freeman and Guzman detail the five "spillover" effects through which international climate impacts could indirectly—but significantly—affect U.S. interests: national security threats; economic spillovers, such as higher prices on oil and other commodities, supply and demand shocks, and market disruptions; the spread of infectious diseases; climate-induced human migration; and the risks of food and water shortages, and biodiversity loss.[102] Similarly, a recent UN report suggests that a failure to act on climate change could result in a permanent loss of as much as 20% of world gross product:[103] a potentially catastrophic impact that would undeniably be felt deeply within the United States. If all cross-sectoral, indirect, cumulative, and spillover effects were captured by the economic models, the global SCC would be higher, the domestic share of the global SCC would be higher, and the clear case for aggressive U.S. action would be easier to demonstrate qualitatively.[104]

Finally, the portion of benefits falling outside the United States could be viewed as a highly effective, highly leveraged form of foreign aid. If the global SCC is assumed to be $19, then for every dollar the United States spends complying with H.R. 2454, about $2.29 in direct benefits is produced.[105] According to the conservative domestic SCC approximation of 6%, at least fourteen cents immediately comes back to the United States in direct benefits, along with currently un-quantified but potentially large ancillary benefits. The rest is distributed to foreign countries, especially to those developing nations most vulnerable to climate change, such as Bangladesh.[106] Poorer nations are likely to be hit the hardest by climate change, because they do not have the same adaptive capacity as wealthier nations; they depend more heavily on agriculture, a climate-vulnerable sector; and they tend to be located in warmer, lower latitudes.[107]

Unlike monetary foreign aid, which is susceptible to corruption and mismanagement, these climate benefits go directly to the citizens of foreign countries, who would otherwise face floods, extreme weather, increased disease, and interrupted food and water supplies. Moreover, at some point in the near future, the United States will largely be paid back. Not only is domestic action on climate change a necessary prerequisite for future international efforts that will benefit the United States, but the international offsets and other provisions contained in H.R. 2454 will help spur the kind of technological innovation and global deployment necessary for such future international efforts to succeed.[108]

In short, from almost any perspective and under almost any assumption, H.R. 2454 is a good investment for the United States to make in our own economic future and in the future of the planet.

Conclusion and Policy Recommendations

This policy brief has considered the costs and benefits of provisions of H.R. 2454, the American Clean Energy and Security Act of 2009. EPA has conducted a careful analysis of the costs of the proposed legislation, but has not considered the benefits. Using information from that cost analysis, and estimates of the social cost of carbon generated by an interagency review process, this brief was able to conduct an exploratory benefits analysis and compare those benefits to the costs previously estimated by EPA. Analysis supports the passage of climate change legislation as cost-benefit justified under most reasonable assumptions about the likely "social cost of carbon." Indeed, using conservative assumptions and excluding ancillary benefits, the benefits of H.R. 2454 could likely exceed the costs by as much as nine-to-one or more.

The Institute for Policy Integrity (IPI) supports the continuation of the federal interagency review process to refine the likely range of SCC estimates. IPI also recommends that such interagency process rethink its approach to discounting.

This brief represents a preliminary and informal analysis, but EPA has the capacity to conduct a more thorough analysis. EPA can help ensure that Congress pursues a rational approach to climate change legislation by analyzing the likely benefits of such legislation and releasing a thorough report both to Congress and to the public. The report should first explore the potential direct benefits of mitigating the speed and severity of climate change effects, including the myriad impacts on the environment, the economy, public health, and national security. Additionally, the report should reflect the many potential indirect benefits of cutting greenhouse gas emissions, such as the environmental benefits of slowing ocean acidification, and the ancillary economic and health benefits of reducing the emission of co-pollutants. EPA should follow best practices for economic analysis when reporting the estimated valuation of these benefits.[109] EPA should begin with an analysis of the current legislative proposal (namely, H.R. 2454), but ideally a full cost-benefit analysis should look at alternative policy options as well, especially more stringent options. Finally, EPA should conduct a distributional analysis of the costs and benefits for a range of policy options.

More than ever, Congress will need a clear and comprehensive summary of all the consequences of climate change legislation, to guide its decisions over the next few months. IPI asks that EPA use its extensive expertise on climate change to act as such a guide for Congress.

Notes

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[1] *See, e.g.*, Letter from Senator Joseph Lieberman & Senator John Warner, to Hon. Stephen Johnson, EPA Administrator (Nov. 9, 2007) (requesting analysis of S. 2191, America's Climate Security Act of 2007) (*available at* http://www.epa.gov/climatechange/downloads/L-W_Request_to_EPA.pdf); *see generally* EPA, Climate Change—Climate Economics, http://www.epa.gov/climatechange/economics/economicanalyses.html (last visited August 31, 2009).

[2] Letter from Rep. Henry Waxman & Rep. Edward Markey, to Hon. Lisa Jackson, EPA Administrator (Feb. 27, 2009) (requesting analysis of draft legislation) (*available at* http://www.epa.gov/climatechange/economics/pdfs/WM-Analysis.pdf); *accord.* Letter from Rep. Henry Waxman & Rep. Edward Markey, to Hon. Lisa Jackson, EPA Administrator (May 14, 2009) (requesting update of analysis) (*available at* http://www.epa.gov/climatechange/economics/pdfs/HR2454_Analysis.pdf).

[3] Letter from Rep. Henry Waxman & Rep. Edward Markey, to Howard K. Gruenspecht, acting EIA Administrator (Mar. 17, 2009) (*available at* http://www.eia.doe.gov/oiaf/servicerpt/hr2454/pdf/appa.pdf); CONG. BUDGET OFFICE, COST ESTIMATE—H.R. 2454: AMERICAN CLEAN ENERGY AND SECURITY ACT OF 2009 (2009), *available at* http://www.cbo.gov/ftpdocs/102xx/doc10262/hr2454.pdf (summarizing the cost estimate, in response to a request from Rep. Henry Waxman and Rep. Edward Markey of the House Committee on Energy and Commerce).

[4] EPA, ANALYSIS OF THE AMERICAN CLEAN ENERGY AND SECURITY ACT OF 2009: APPENDIX 12 (2009), *available at* http://www.epa.gov/climatechange/economics/pdfs/HR2454_Analysis_Appendix.pdf (hereinafter Appendix).

[5] *Id.* at 63.

[6] *See* ENERGY INFO. ADMIN., DEP'T OF ENERGY, ENERGY MARKET AND ECONOMIC IMPACTS OF H.R. 2454 (2009), *available at* http://www.eia.doe.gov/oiaf/servicerpt/hr2454/pdf/sroiaf(2009)05.pdf;CONG. BUDGET OFFICE, *supra* note 3.

[7] *See, e.g.*, EPA, TECHNICAL SUPPORT DOCUMENT ON BENEFITS OF REDUCING GHG EMISSIONS (2008) (developing a range of SCC estimates, for the agency's own use and as possible guidance for other federal agencies); Average Fuel Economy Standards, Passenger Cars and Light Trucks; Model Years 2011-2015, 73 Fed. Reg. 24351, 24413 (proposed May 2, 2008) (presenting independent SCC calculations by the

National Highway Traffic Safety Administration, Department of Transportation); Average Fuel Economy Standards, Passenger Cards and Light Trucks Model Year 2011, 74 Fed. Reg. 14195, 14337 (Mar. 30, 2009) (to be codified at 49 C.F.R. pts. 523, 531, 533, 534, 536, 537) (presenting new SCC calculations by the National Highway Traffic Safety Administration, Department of Transportation); Energy Conservation Program for Commercial and Industrial Equipment, 74 Fed. Reg. 1091, 1133 (Jan. 9, 2009) (to be codified at 10 C.F.R. pt. 431) (presenting independent SCC calculations by the Department of Energy); Energy Conservation Program for Certain Industrial Equipment: Energy Conservation Standards and Test Procedures for Commercial Heating, Air-Conditioning, and Water-Heating Equipment 74 Fed. Reg. 36312, 36342 (July 22, 2009) (to be codified at 10 C.F.R. pt. 431) (relying on the Department of Transportation's calculations of the SCC, in a Department of Energy rulemaking).

[8] Energy Conservation Program: Energy Conservation Standards for Refrigerated Bottled or Canned Beverage Vending Machines, 74 Fed. Reg. 44913, 44947 (Aug. 31, 2009) (to be codified at 10 C.F.R. pt. 431) (hereinafter BVM Rule).

[9] *See* ENERGY INFO. ADMIN., DEP'T OF ENERGY, ENERGY MARKET AND ECONOMIC IMPACTS OF H.R. 2454 (2009), *available at* http://www.eia.doe.gov/oiaf/servicerpt/hr2454/pdf/sroiaf(2009)05.pdf (raw data available at http://www.eia.doe.gov/oiaf/servicerpt/hr2454/index.html).

[10] *See* STAFF OF H. COMM. ON ENERGY & COMMERCE, 111TH CONG., SUMMARY OF THE AMERICAN CLEAN ENERGY AND SECURITY ACT (2009), *available at* http://energycommerce.house.gov/Press_111/20090724/hr2454_housesummary.pdf ("[C]arbon pollution from large sources must be reduced by 17% below 2005 levels by 2020 and 83% below 2005 levels by 2050.").

[11] *See* CONG. BUDGET OFFICE, *supra* note 3.

[12] EPA, Data Annex for June 2009 Economic Analysis of H.R. 2454, http://www.epa.gov/climatechange/economics/downloads/HR2454Analysis-DataAnnex.zip (last visited Aug. 31, 2009).

[13] *See* Appendix, *supra* note 4, at 8 (noting the inclusion of the Energy Independence and Security Act and the use of the 2009 Annual Energy Outlook). EPA's reference case does not include the impacts of the American Recovery and Reinvestment Act of 2009, also known as the federal stimulus package. *Id.*

[14] See *id.* at 59 for a demonstration of the importance of updating the baseline scenario. Under the provisions of H.R. 2454, cumulative GHG emissions over the 2012-2050 period (before domestic or international offsets) must be cut to 235-244 billion metric tons (depending on the economic model). In the old baseline, "business as usual" would have generated 354-371 billion metric tons during that 39-year period; in EPA's updated reference case, baseline emissions fall to 303-304 billion metric tons. In other words, because of the economic downturn and independent federal energy efficiency standards, the level of emissions reduction

necessary to comply with H.R. 2454 has dropped from 119-127 billion metric tons down to 60-68 billion metric tons.

15 *Id.* at 8.

16 *Id.* (referencing the Notice of Upcoming Joint Rulemaking to Establish Vehicle GHG Emissions and CAFE Standards, 74 Fed. Reg. 24007 (May 22, 2009)). Under the order of a recent Supreme Court case, EPA is obligation to regulate the greenhouse gas emissions from motor vehicles, but the form of such regulation is not yet certain. *See* IPI, THE ROAD AHEAD: EPA'S OPTIONS AND OBLIGATIONS FOR REGULATING GREENHOUSE GASES (2009).

17 Current international obligations to control GHG emissions under the Kyoto Protocol do not extend beyond the year 2012. Negotiations scheduled for December 2009 in Copenhagen are intended to develop a successor treaty, but neither the form of such an agreement nor the likelihood of its passage is certain. *See* Jean-Marie Macabrey, *Concern Grows that Kyoto Successor May Not Be Finished in Copenhagen*, CLIMATEWIRE, June 12, 2009.

18 *See* Appendix, *supra* note 4, at 9. For example, Scenario 3 analyzes H.R. 2454 without its energy efficiency provision, and Scenario 5 alters the assumptions about nuclear electricity generation capacity.

19 *See id.* at 8.

20 *Id.* at 10-17.

21 *Id.* at 14 ("Emissions leakage occurs when a domestic GHG policy causes a relative price differential between domestically produced and imported goods. This causes domestic production, which embodies the GHG allowance price[,] to shift abroad, and thus [results in] an increase in GHG emissions in other countries. Additionally, emissions leakage not associated with trade effects may occur when a GHG policy reduces domestic consumption of oil[;] lower demand for oil lowers the world oil price, which increases oil consumption in countries without a GHG policy[,] thus increasing emissions.").

22 For example, ADAGE includes capital adjustment costs, whereas IGEM does not. *Id.* at 13.

23 *See* Data Annex, *supra* note 12.

24 See EPA, Climate Economic Modeling, http://www.epa.gov/climatechange/economics/modeling.html (last visited Aug. 31, 2009) for a more information on the models and their relative strengths and weakness.

25 *See* STAFF OF H. COMM. ON ENERGY & COMMERCE, *supra* note 10.

26 Some of EPA's figures, notably the average cost estimates, analyze data starting in 2010, before most of H.R. 2454's provisions take effect. *See* Appendix, *supra* note 4, at 56 ("The average annual cost per household is the 2010 through 2050 average of the net present value of the per household consumption loss.").

[27] *See* EIA, *supra* note 9, *available at* http://www.eia.doe.gov/oiaf/servicerpt/hr2454/background.html ("H.R. 2454 is projected to lead to higher electricity prices and lower electricity demand, though most of the price impacts are expected after 2025, as the allowances allocated to retail electricity providers are phased out.").

[28] *See* RICHARD L. REVESZ & MICHAEL A. LIVERMORE, RETAKING RATIONALITY: HOW COST-BENEFIT ANALYSIS CAN BETTER PROTECT THE ENVIRONMENT AND OUR HEALTH 131-43 (2008). For example, the actual cost of phasing out leaded gasoline in the United States proved to be 95% lower than industry had expected. ROBERT V. PERCIVAL ET AL., ENVIRONMENTAL REGULATION 561 fig.4.8 (2d ed. 1996).

[29] BVM Rule, *supra* note 8, at 44949.

[30] In its recent rulemaking that reports on the results of the interagency SCC review process, the Department of Energy uses a variety of discount rates (3%, 5%, and 7%) and mostly uses 2007$ (though a few tables claim to be presented in 2006$). *See generally id.* EPA's economic analysis of H.R. 2454 uses a 5% discount rate fairly consistently, *see* Appendix, *supra* note 4, at 61 ("The economic discount rate (5%) is applied to find the net present value (NPV) of the cost in each year in the future"), though its raw data sometimes presents figures in 2000$ and other times in 2005$, *see* Data Annex, *supra* note 12.

[31] *See* Letter from IPI, to EPA's Environmental Economics Advisory Committee (Nov. 25, 2008) (critiquing EPA's 2008 draft *Guidelines for Preparing Economic Analyses*, including its recommendations on inter-generational discounting) (*available at* http://policyintegrity.org/projects/documents/CommentsonDraftEPAGuidelines11-25.pdf).

[32] IPI, Other Side of the Coin Data, http://www.policyintegrity.org/documents/OtherSideoftheCoinDataAppendix.xls

[33] *See* Appendix, *supra* note 4, at 61. Because these figures are in 2005$ and take into account the costs in years 2010 and 2011 (which will actually be negative, because H.R. 2454's cap is not yet in effect), EPA's cost estimates are slightly deflated compared to those calculated in this analysis.

[34] *Id.*

[35] EPA, ANALYSIS OF THE AMERICAN CLEAN ENERGY AND SECURITY ACT OF 2009, 4 (2009), *available at* http://www.epa.gov/climatechange/economics/pdfs/HR2454_Analysis.pdf.

[36] Appendix, *supra* note 4, at 13.

[37] *See, e.g.*, *id.* at 84 (discussing the pre-2012 deployment of financial incentives like renewable energy production and investment tax credits).

[38] *See id.* at 56 ("The average annual cost per household is the 2010 through 2050 average of the net present value of the per household consumption loss.").

[39] EPA, ANALYSIS OF THE AMERICAN CLEAN ENERGY AND SECURITY ACT OF 2009, *supra* note 35, at 14.

[40] *See* Appendix, *supra* note 4, at 59 (calculating approximately 24 billion metric tons of carbon dioxide-equivalent units in avoided emissions from these two provisions).

[41] Carbon dioxide equivalence make it possible to compare emissions of GHG compounds that have different impacts on climate change, by translating emissions of other gases into the amount of carbon dioxide necessary to generate the same impact on the global climate. For example 1 ton of methane emissions has a carbon dioxide equivalence of about 25 tons.

[42] International offset by year were approximated for the ADAGE model figures using the reported level of domestic offsets and the overall ratio of domestic to international offsets. See Appendix, *supra* note 4, at 59 for more details, and see IPI, Other Side of the Coin Data, http://www.policyintegrity.org/OtherSideOfTheCoinData.xls for calculations. This relies on the assumption that the ratio of domestic to international offsets should remain constant over time, which is consistent with the IGEM model but not reported for ADAGE.

[43] *See* Appendix, *supra* note 4, at 59. It is also not clear whether EPA's figures include possible energy efficiency gains (and related GHG reductions) made in otherwise uncovered sectors, either as a direct or indirect result of the policies of H.R. 2454.

[44] At least some climate effects in the following areas are modeled by a key economic model (FUND) often used to calculate the SCC: agricultural production; forestry production; water resources; energy consumption for space cooling and heating; sea level rise, dry land loss, wetland loss, and coastal protection costs; forced migration due to dry land loss; changes in human health (mortality, morbidity) associated with diarrhea incidence, vector-borne diseases, cardiovascular disorders, and respiratory disorders; hurricane damage; and loss of ecosystems/biodiversity. *See* EPA, 420-D-09-001, DRAFT REGULATORY IMPACT ANALYSIS: CHANGES TO RENEWABLE FUEL STANDARD PROGRAM 690 tbl. 5.3-3 (2009).

[45] *Id.* at 689.

[46] EPA, TECHNICAL SUPPORT DOCUMENT, *supra* note 7, at 15.

[47] Jody Freeman & Andrew Guzman, *Seawalls Are Not Enough: Climate Change and U.S. Interests* 18 (U.C. Berkeley Pub. L. Res. Paper No. 1357690, 2009).

[48] Information and format for table based on EPA, TECHNICAL SUPPORT DOCUMENT, *supra* note 7, at 16-17, and EPA, DRAFT REGULATORY IMPACT ANALYSIS, *supra* note 44, at 691 tbl. 5.3-4.

[49] Average Fuel Economy Standards, Passenger Cars and Light Trucks; Model Years 2011-2015, 73 Fed. Reg. 24351, 24414 (proposed May 2, 2008) (selecting $7 as the midpoint of a possible $0-$14 range).

[50] Average Fuel Economy Standards, Passenger Cards and Light Trucks Model Year 2011, 74 Fed. Reg. 14195, 14350 (Mar. 30, 2009) (to be codified at 49 C.F.R. pts. 523,

531, 533, 534, 536, 537) (revising its SCC calculations, in light of substantial public comments).

[51] E.g., Energy Conservation Program for Commercial and Industrial Equipment, 74 Fed. Reg. 1091, 1133 (Jan. 9, 2009) (to be codified at 10 C.F.R. pt. 431) (presenting independent SCC calculations by the Department of Energy);

[52] E.g., Energy Conservation Program for Certain Industrial Equipment: Energy Conservation Standards and Test Procedures for Commercial Heating, Air-Conditioning, and Water-Heating Equipment 74 Fed. Reg. 36312, 36342 (July 22, 2009) (to be codified at 10 C.F.R. pt. 431) (relying on the Department of Transportation's calculations of the SCC, in a Department of Energy rulemaking).

[53] EPA, TECHNICAL SUPPORT DOCUMENT, *supra* note 6, at 12.

[54] EPA, DRAFT REGULATORY IMPACT ANALYSIS, *supra* note 44, at 682.

[55] E.g., *id.* at 695-96.

[56] *See* BVM Rule, *supra note* 8, at 44947. Presumably, the interagency task force includes at least EPA, the Department of Energy, and the Department of Transportation.

[57] *See generally id.*

[58] *Id.* at 44948.

[59] *See* Average Fuel Economy Standards, Passenger Cars and Light Trucks; Model Years 2011-2015, 73 Fed. Reg. at 24414. The Department of Transportation contended this restriction was dictated by consistency, since no other non-domestic costs or benefits were measured. *Id.* However, even the Office of Management and Budget (OMB)—the federal agency charged with overseeing cost-benefit analyses—specifically permits consideration of significant international costs and benefits. U.S. OFFICE OF MGMT. & BUDGET, CIRCULAR A-4, 15 (2003) ("When you choose to evaluate a regulation that is likely to have effects beyond the borders of the United States, these effects *should be reported* separately.") (emphasis added).

[60] WILLIAM NORDHAUS & JOSEPH BOYER, WARMING THE WORLD 96-97 (2000).

[61] *See* EPA, TECHNICAL SUPPORT DOCUMENT, *supra* note 7, at 11; *see also* Freeman & Guzman, *supra* note 47 (discussing spillover effects from the international arena into the United States).

[62] BVM Rule, *supra* note 8, at 44948.

[63] *Id.* at 44948-49.

[64] *Id.* at 44949.

[65] EPA, TECHNICAL SUPPORT DOCUMENT, *supra* note 7, at 12 n.25 (noting the international recommendation is a 2-4% growth rate).

[66] *See* Letter from IPI, to EPA's Environmental Economics Advisory Committee (Nov. 25, 2008) (critiquing EPA's 2008 draft *Guidelines for Preparing Economic Analyses*, including its recommendations on inter-generational discounting) (*available at*

http://policyintegrity.org/projects/documents/CommentsonDraftEPAGuidelines11-25.pdf).

[67] BVM Rule, *supra* note 8, at 44949.

[68] *Id.* at 44949-44951.

[69] EPA, TECHNICAL SUPPORT DOCUMENT, *supra* note 7, at 12; *id.* at 9 ("A review of the literature indicates that rates of three percent *or lower* are more consistent with conditions associated with long-run uncertainty in economic growth and interest rates, inter-generational considerations, and the risk of high impact climate damages (which could reduce or reverse economic growth).") (emphasis added).

[70] These benefit numbers do not take into account the uncertainty regarding the timing or effects of climate change. Computable General Equilibrium models like ADAGE and IGEM are not capable of producing confidence intervals. Reported ranges are generated by varying the inputs to the model and do not represent uncertainty in the model.

[71] *See* EPA, No. 240-R-00-003, GUIDELINES FOR PREPARING ECONOMIC ANALYSIS 48 (2000) ("In addition, all analyses should present the undiscounted streams of benefits and costs. This is not equivalent to calculating a present value using a discount rate of zero. In other words, the flow of benefits and costs should be displayed rather than a summation of values.").

[72] *See* ENV'T POL'Y COMM., ORG. FOR ECON. COOPERATION & DEV. (OECD), ENV/EPOC/GSP(2001)13/FINAL, ANCILLARY BENEFITS AND COSTS OF GHG MITIGATION: POLICY CONCLUSIONS 6 (2001), *available at* http://www.olis.oecd.org/olis/2001doc.nsf/LinkTo/NT00000ABA/$FILE/JT00124610.PDF.

[73] Power plants can achieve direct greenhouse gas reductions to comply with climate legislation in one of three ways. (Power plants can also reduce emissions indirectly by investing in "offset" projects, such as the capture of methane from agricultural facilities.) First, they can improve efficiency in the generation and distribution of electricity: according to the Department of Energy, if the nation's electricity production and distribution grid "were just 5% more efficient, the energy savings would equate to permanently eliminating the fuel and greenhouse gas emissions from 53 million cars." DEP'T OF ENERGY, THE SMART GRID: AN INTRODUCTION 6 (2008). Second, they can switch to cleaner fuels. Natural gas, for instance, generates about half as much carbon dioxide as coal. *See* U.S. Gov't Accountability Office, GAO-08-601R, ECONOMIC AND OTHER IMPLICATIONS OF SWITCHING FROM COAL TO NATURAL GAS AT THE CAPITOL POWER PLANT AND AT ELECTRICITY-GENERATING UNITS NATIONWIDE 2 (2008). Third, they can deploy pre- or post-combustion controls to capture and sequester emissions before they leave the smokestacks. *See* OFFICE OF FOSSIL ENERGY, DEP'T OF ENERGY, CARBON SEQUESTRATION TECHNOLOGY ROADMAP AND PROGRAM PLAN 17-18 (2007).

But those techniques work not only to reduce greenhouse gas emissions. Improving energy efficiency means decreasing the total amount of fuel needed, which in turn decreases total emissions of all air pollutants from fossil fuels, not just the greenhouses gases. Switching to cleaner fossil fuels will reduce the emissions of many other air pollutants as well: EPA calculates that "[c]ompared to the average air emissions from coal-fired generation, natural gas produces…less than a third as much nitrogen oxides, and *one percent as much* sulfur oxides at the power plant." EPA, Clean Energy: Air Emissions, http://www.epa.gov/RDEE/energy-and-you/affect/air-emissions.html. Even certain pre- or post-combustion carbon controls will reduce air pollutants as well as greenhouse gases: one innovative carbon capture technology being funded by the U.S. Department of Energy claims to "have the potential to capture all carbon dioxide emissions, while also exceeding all current environmental regulations (e.g. nitrogen oxides, sulfur oxides, etc.)." NAT'L ENERGY TECH. LAB., U.S. DEP'T OF ENERGY, PROJECT FACTS: HYBRID COMBUSTION-GASIFICATION CHEMICAL LOOPING COAL POWER TECHNOLOGY DEVELOPMENT (2006), *available at* http://www.netl.doe.gov/publications/factsheets/project/Proj329.pdf.

[74] Appendix, *supra* note 4, at 3.

[75] *See* ENV'T POL'Y COMM., OECD, *supra* note 72, at 6.

[76] *See, e.g.*, Dallas Burtraw et al., *Ancillary Benefits of Reduced Air Pollution in the United States from Moderate Greenhouse Gas Mitigation Policies in the Electricity Sector* (Resources for the Future Discussion Paper No. 01-61, 2001).

[77] *Id.* at 4-5.

[78] *Id.* at 4, 12-14 (listing the health benefits of ancillary nitrogen oxide reductions as reduced respiratory symptom days, eye irritation days, asthma attacks, adult and child chronic bronchitis cases, chronic cough cases, emergency room visits, restricted activity days, and hospital admissions).

[79] *Id.* at 8-9, 20-21. For example, sulfur dioxide emissions are already limited by a nationwide cap: companies need to purchase "allowances" in order to emit sulfur dioxide, and only so many allowances are sold. If a power plant achieves ancillary sulfur dioxide reductions while responding to climate legislation, it will need fewer allowances. The leftover allowances will become available for another company to purchase, allowing it to emit extra sulfur dioxide. Therefore, total emissions of sulfur dioxide are not necessarily reduced. However, that second company now can comply with the sulfur dioxide cap by purchasing extra allowances rather than investing in expensive emissions control technologies. *Id.* at 9 ("Under the [sulfur dioxide] cap, a facility that reduces its sulfur dioxide emissions makes emissions allowances available for another facility, displacing the need for abatement investment at that facility."). Investment in nitrogen oxide controls may similarly decrease. Moreover, at some point, "[t]here will be a threshold…where greenhouse gas control has made the sulfur dioxide cap no longer binding [i.e., when nobody needs to buy the extra allowances, since they are not emitting that much]. Beyond this point, health benefits from additional net reductions in sulfur dioxide will accrue….The Clinton Administration's unpublished analysis of the impacts of

stabilizing greenhouse gas emissions at 1990 levels in 2010 calculates even larger sulfur dioxide emissions reductions (on the order of four million tons)." *Id.* at 34.

[80] *Id.* at 8.

[81] *See* EPA, Clean Air Interstate Rule, http://www.epa.gov/cair/ (last visited Aug. 31, 2009).

[82] *See id.*

[83] Burtraw et al., *supra* note 73, at 3-4.

[84] *Id.* at 10.

[85] *See* EPA, GUIDELINES FOR PREPARING ECONOMIC ANALYSES 7-6 (2008 draft).

[86] Specifically, this analysis looks at Burtraw's model using "the SIP Call Baseline," which does include an expanded nitrogen oxide cap-and-trade system (and unlike an alternate baseline scenario, does not assume electricity restructuring at the national level). Burtraw's hypothetical climate policy was a carbon tax, modeled at two different stringencies. Since Burtraw found roughly equivalent ancillary benefits per ton of carbon regardless of the tax's stringency, this analysis will assume that stringency—and indeed the form of regulation—is mostly irrelevant to the per carbon generation of ancillary benefits, and therefore Burtraw's estimates are applied to H.R. 2454 (even though that legislation creates a cap-and-trade system rather than a carbon tax). To be conservative, the lower of Burtraw's estimates for this scenario was selected ($12.4 per ton of carbon in 1997$, *id.* at 22). Burtraw's estimates are converted into 2007$ and calculated per ton of carbon dioxide, rather than per ton of carbon.

[87] *See* Data Annex, *supra* note 12.

[88] EPA, DRAFT REGULATORY IMPACT ANALYSIS, *supra* note 44, at 696.

[89] *See* Sarah R. Cooley & Scott C. Doney, *Anticipating Ocean Acidification's Economic Consequences for Commercial Fishers*, 4 ENVTL. RES. LETTERS 1, 4 (2009).

[90] *Id.* at 5.

[91] *See* ENV'T POL'Y COMM., OECD, *supra* note 72, at 10-15.

[92] Appendix, *supra* note 4, at 13.

[93] *See* STAFF OF H. COMM. ON ENERGY & COMMERCE, *supra* note 9.

[94] *See* EPA, ANALYSIS OF THE AMERICAN CLEAN ENERGY AND SECURITY ACT OF 2009, *supra* note 35, at 3 (estimating allowance prices at $13 per ton of carbon dioxide in 2015).

[95] *See Climate Change Legislation: Allowance and Revenue Distribution: Hearing Before the S. Comm. on Finance*, 111th Cong. (2009) (written statement of Dallas Burtraw), *available at* http://finance.senate.gov/hearings/testimony/2009test/080409dbtest.pdf.

[96] There may be some international trade effects, especially if H.R. 2454 includes a provision attaching tariffs to imports from countries that have not enacted

reciprocal climate policies, but EPA has calculated costs in terms of per U.S. household loss of consumption.

[97] BVM Rule, *supra* note 8, at 44948.

[98] *Id.*

[99] *See* Interview by Monica Trauzzi, Managing Editor, E&E TV, with Yvo de Boer, executive secretary of the United Nations Framework Convention on Climate Change (Mar. 30, 2009) ("[W]e're really happy to see the United States back into the international climate change process....[W]e need that U.S. engagement...to come to really a global deal at the end of this year to move action on climate change forward.").

[100] *See* Brian Copeland and M. Scott Taylor, *Trade and Transboundary Pollution*, 95 AM. ECON. REV. 716-737 (1995); Hilary Sigman, *International Spillovers and Water Quality in Rivers: Do Countries Free Ride?*, 92 AM. ECON. REV. (1992).

[101] *See* EPA, TECHNICAL SUPPORT DOCUMENT, *supra* note 7, at 11 (also noting that Americans have a willingness to pay to avoid international damages caused by U.S. emissions).

[102] Freeman & Guzman, *supra* note 47, at 7 ("We do not claim that all of these things will happen at catastrophic levels, or that the United States will necessarily be dragged into every climate-related conflict around the world, but simply that the United States cannot sequester itself from all such spillovers.").

[103] DEP'T OF ECON. & SOCIAL AFFAIRS, UNITED NATIONS, E/2009/50/REV.1 ST/ESA 319, WORLD ECONOMIC AND SOCIAL SURVEY 2009: PROMOTING DEVELOPMENT, SAVING THE PLANET 154 (2009), *available at* http://www.un.org/esa/policy/wess/wess2009files/wess09/wess2009.pdf.

[104] Freeman & Guzman, *supra* note 47, at 10 ("[L]arge players may internalize enough of the benefits from the production of collective goods (here, mitigated climate change) to make it worthwhile to invest in those goods"); *id.* at 62 ("Based on a fuller accounting of what the United States stands to lose in a warmer world, investing in mitigation, even at the risk of other nations' free-riding, is the most rational course.").

[105] Average of direct benefits divided by costs for the IGEM and ADAGE models.

[106] *See* Joseph E. Stiglitz, *A New Agenda for Global Warming*, ECONOMISTS' VOICES (2004) (noting, among the principal climate change consequences, "The Maldives will within 50 years be our own 21st century Atlantis, disappearing beneath the ocean; a third of Bangladesh will be submerged, and with that country's poor people crowded closer together, incomes already close to subsistence level will be further submerged").

[107] *See* Freeman & Guzman, *supra* note 47, at 4.

[108] *See* STAFF OF H. COMM. ON ENERGY & COMMERCE, *supra* note 10 (noting H.R. 2454's provisions for international technology transfer and international capacity-building). *See* DEP'T OF ECON. & SOCIAL AFFAIRS, UNITED NATIONS, *supra* note 103.

[109] Generally, EPA should follow its own Guidelines on Economic Analysis. *See* EPA, NO. 240-R-00-003, GUIDELINES FOR PREPARING ECONOMIC ANALYSES (2000). But IPI believes the guidelines would benefit from some modification. *See* Letter from IPI, to EPA's Environmental Economics Advisory Committee (Nov. 25, 2008) (commenting on the 2008 draft of *Guidelines for Preparing Economic Analysis*). In particular, EPA should avoid inter-generational discounting of future costs and benefits relating to climate change, and EPA should avoid using the life-years or quality-adjusted life-years models for measuring health benefits.

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AFPC Research Paper 09-2

August 2009

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Economic Implications of the EPA Analysis of the CAP and Trade Provisions of H.R. 2454 for U.S. Representative Farms[1]

At the request of Senator Saxby Chambliss, the Agricultural and Food Policy Center (AFPC) at Texas A&M University conducted an analysis of the economic impacts of "The American Clean Energy and Security Act of 2009" (H.R. 2454) on the AFPC database of U.S. representative farms. This report assesses the impacts of H.R. 2454 by including:

- The anticipated energy related cost increases directly experienced by agricultural producers for inputs such as fuel and electricity and indirectly experienced, such as, higher chemical prices resulting from higher energy prices. As discussed, in detail, later in the report, nitrogen fertilizer costs were treated differently as a result of the energy-intensive trade-exposed entities (EITE) provisions in the legislation.
- The expected commodity price changes resulting from producers switching among agricultural commodities and afforestation of land previously employed in agricultural commodity production.
- The estimated benefits to agricultural producers from selling carbon credits.

AFPC currently does not maintain sector level economic models with the amount of detail required to develop estimates of all of the impacts listed above along with their feedback effects. Therefore, we turned to recently published aggregate estimates to use in evaluating the farm level effects. Two analyses (U.S. Environmental Protection Agency (EPA) and Charles River Associates (CRA International)) were evaluated to determine which one provided the most complete data needed to perform the farm level analysis. The estimated energy price changes for the two analyses are not significantly different (Table 1). The CRA International analysis (http://www.nationalbcc.org/images/stories/documents/CRA_Waxman-Markey_%205-20-09_v8.pdf)) did not provide all of the input data required to conduct the farm level analysis. Therefore, AFPC utilized the EPA estimated energy price changes, as well as, estimates of carbon and agricultural commodity prices to evaluate the farm level impacts of H.R. 2454. **The results of this analysis are dependent on the estimated outcomes contained in the EPA analysis of H.R. 2454.**[2] As additional sector level analyses are conducted and estimates are refined, AFPC will update the farm level analysis.

Table 1. Estimated Changes in Inflation Rates Relative to the Base Situation for Motor Fuel, Natural Gas, and Electricity Reported by EPA and CRA International by 2020.

	EPA	CRA International
Motor Fuel	0.04	0.04
Natural Gas	0.085	0.14
Electricity	0.127	0.16

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[1] AFPC thanks Dave Miller with Iowa Farm Bureau and Pat Westhoff with FAPRI-Missouri for their review of this manuscript. All errors or omissions are the responsibility of AFPC.

[2] EPA's analysis is the product of several different quantitative models. Carbon price and energy prices employed in this analysis are from EPA's economy-wide modeling (ADAGE and IGEM models), while agricultural commodity prices and land prices are from EPA's ag and forestry sector modeling (FASOM-GHG model). Further, the differences between natural gas prices inclusive and exclusive of carbon allowance costs were inferred from EPA's near-term electricity sector modeling (IPM model) output.

Background on Representative Farms and Process

AFPC has a 26 year history of maintaining a unique dataset of representative farms and utilizing them to evaluate the economic impacts of agricultural policy changes. This analysis was conducted over the 2007-2016 planning horizon using FLIPSIM, AFPC's risk-based whole farm simulation model. Data to simulate farming operations in the nation's major production regions came from producer panel interviews to gather, develop, and validate the economic and production information required to describe and simulate representative crop, livestock, and dairy farms. The FLIPSIM policy simulation model incorporates the historical risk faced by farmers for prices and production.

Panel Process

AFPC has developed and maintains data to simulate 98 representative crop farms, dairies, and livestock operations chosen from major production areas across the United States (Figure 1). Characteristics for each of the operations in terms of location, size, crop mix, assets, and average receipts are summarized in Appendix A. The location of these farms is primarily the result of discussions with staffers for the U.S. House and Senate Agriculture Committees. Information necessary to simulate the economic activity on these representative farms is developed from panels of producers using a consensus-building interview process. Normally two farms are developed in each region using separate panels of producers: one is representative of moderate size full-time farm operations, and the second panel usually represents a farm two to three times larger.

The data collected from the panel farms are analyzed in the whole farm simulation model (FLIPSIM) developed by AFPC. The producer panels are provided pro-forma financial statements for their representative farm and are asked to verify the accuracy of simulated results for the past year and the reasonableness of a seven-year projection. Each panel must approve the model's ability to reasonably reflect the economic activity on their representative farm prior to using the farm for policy analyses.

All of the crop farms are assumed to begin 2007 with 20 percent intermediate-term and long-term debt. Initial debt levels in 2007 for dairy farms were set at 30 percent and initial debt levels for beef cattle ranches were 1 percent for land and 5 percent for cattle and machinery. The representative farms' debt levels at the outset of 2007, the first year of the simulation period, are based on a stratified tabulation of the ERS-USDA Farm Cost and Returns Survey for 2004 (using the survey data for moderate to large size farms in states where AFPC has representative farms), and panel member input.

Scenarios Analyzed

- **Baseline** – Projected prices, policy variables, and input inflation rates from the Food and Agricultural Policy Research Institute (FAPRI) January 2009 Baseline.

- **C&T[3] without Ag Carbon Credits** – Assumes H.R. 2454 becomes effective in 2010. Imposes EPA commodity price forecasts along with estimated energy cost inflation on representative farm inputs.

- **C&T with Ag Carbon Credits** – Assumes H.R. 2454 becomes effective in 2010. Imposes EPA commodity price forecasts along with estimated energy cost inflation on farm inputs, converts farms to no-till production (if applicable) and/or installs a methane digester on dairies over 500 head and sells carbon credits at EPA estimated market prices.

[3] Cap and Trade is abbreviated as C&T throughout this report.

Figure 1. Representative Farms, Dairies, and Ranches Maintained by AFPC

Farms in green are able to sell CO_2e credits.

Farms in red are unable to sell CO_2e credits.

Farms in **black** represent a pair of farms where one is able to sell CO_2e credits and one is unable.

- **C&T with Ag Carbon Credits and Saturation** – Assumes the farmland reaches carbon saturation in 2014. This scenario represents the loss of revenues that will be experienced by farms at some point due to carbon saturation of the soil. This scenario is not relevant for the analysis of methane digesters on the dairies since saturation is not an issue.

No-till and Methane Digester Assumptions

Cropland requirements for carbon dioxide sequestration specify that land must be engaged in a minimum or no-till cropping program. Higher fuel and input costs have driven the majority of AFPC representative crop farms to participate in some form of reduced tillage; however, very few are truly no-till operations. Extension budgets were examined for states in which representative farms are located. Some states lacked sufficient budgets for no-till practices, so nearby state budgets were used as a proxy. These budgets were used to determine changes in input and overhead costs typically experienced in converting from conventional tillage practices to no-till farming. All AFPC farms with the potential to sequester carbon dioxide (based on Conservation tillage soil offset map available from the Chicago Climate Exchange) were converted to no-till operations using the state budgets as a template. There are also four wheat farms and one cotton farm that do not have the opportunity to participate based on this map. With the exception of one farm in Southeast Arkansas, the AFPC representative rice farms either only produce rice or lack necessary crop rotations to allow conversion to no-till practices. Figure 1 shows the farms that are able to sell carbon dioxide equivalent (CO_2e) credits (green) and those that cannot sell CO_2e credits (red). Variable costs were adjusted individually for corn, soybeans, grain sorghum, wheat, cotton, barley, and millet. Costs for seed, fertilizer, herbicide, custom application, and insecticide (for some crops) were increased for crops converted to no-till on the representative farms. Fuel costs were reduced for farms converted to no-till. Overhead costs were modified based on overall farm classification determined by enterprises earning the majority of receipts for a farm. Conversion to no-till on the farms involved reducing overhead costs including labor, repairs, and fixed machinery costs. Crop yields were not changed when the switch to no-till was made.

Methane digesters may be beneficial to some confinement dairies, allowing them to generate electricity and reduce greenhouse gases (GHG). The destruction of GHGs makes the dairies eligible to receive carbon credits for their efforts. This study assumed a dairy size of 500 cows or more is necessary to make erecting a methane digester a viable economic option. Sixteen of 22 AFPC representative dairies have sufficient cow numbers to justify a digester based on this assumption. Based on information from Lazarus (2009), a fixed construction cost of $678,064 plus a variable component of $563/cow was assumed for building a digester on those sixteen dairies. Grants were assumed to offset 25 percent of the initial investment cost, and the remainder was financed over a 20 year period at a fixed annual interest rate of 6 percent. Annual maintenance costs for the dairies were increased by five percent of the total investment. Electricity generation was assumed at 1,000 KWH/cow, and electricity costs were offset at the rate of $0.09/KWH. Carbon credits were earned based on carbon dioxide equivalents and regional climatic differences.

For this study, AFPC's representative cattle ranches and rice farms were the only two categories of farms that were assumed not to participate in carbon sequestration activities. In order to participate in the grassland or pastureland carbon sequestration, the ranches would need to reduce their stocking rates substantially which would have substantially changed the economics of the farms. Therefore, we decided they would likely not participate for the purposes of this study. The Chicago Climate Exchange does not currently have a protocol in effect for rice farms therefore we assumed they would be unable to participate.

Commodity Prices, Inflation Rates, and Interest Rates Assumed in the Analysis

Tables 2-4 contain the estimated commodity prices, inflation rates and interest rates for the January 2009 FAPRI Baseline and the prices inferred by AFPC from the EPA H.R. 2454 analysis. The EPA analysis presented estimates for five year time periods (i.e., 2010, 2015 and 2020…) for several carbon price scenarios. AFPC developed annual estimates by interpolating between the five year time periods and alternative carbon price scenarios (as necessary), and applying the percentage changes in the estimated economic variables from the EPA scenario estimates and EPA Baseline to the January 2009 FAPRI Baseline.[4]

The estimated gross and net-to-farmer carbon prices per ton utilized in this study are summarized in Table 5. AFPC assumed that a fee structure similar to that used by the Chicago Climate Exchange (CCX) would likely be imposed under H.R. 2454.

Table 5. Gross and Net-to-Farmer Carbon Prices Utilized in Representative Farm Analysis, 2010 to 2016.[5]

Year	2010	2011	2012	2013	2014	2015	2016
Gross ($/ton)	8.97	9.704	10.438	11.172	11.906	12.64	13.374
Net-to-farmer ($/ton)	7.75	8.41	9.07	9.73	10.40	11.06	11.72

Natural gas prices, inclusive of commensurate allowance costs, were taken from EPA's economy-wide modeling (ADAGE and IGEM models) output. Specifically, prices from EPA's reference scenario (scenario 1) and their basic H.R. 2454 scenario (scenario 2) were used. The changes in the H.R. 2454 scenario prices, relative to the reference scenario, represent an amalgam of price changes due to the inclusion of the new allowance costs and changes in equilibrium market prices (exclusive of the allowance cost). These prices cannot be used in isolation to determine the net effects of H.R. 2454 on production costs for energy-intensive, trade-exposed (EITE) industries (such as nitrogenous fertilizer production) that will be given varying proportions of their needed allowances each year. EPA's economy-wide modeling output did not include natural gas prices exclusive of allowance costs. EPA's near-term electricity sector modeling (IPM model) did contain such prices, however.[6] The percentage changes in non-allowance natural gas prices emanating from IPM were therefore used to decompose the aggregate (allowance cost imposition plus market equilibrium changes) percentage price changes taken

[4] Carbon and energy price changes in the H.R. 2454 scenario, relative to the base scenario, were interpolated between 5-year time periods from EPA's economy-wide modeling (ADAGE/IGEM). EPA's agricultural and forestry sector model (FASOM-GHG) runs were based on fixed carbon price scenarios that do not track the carbon price trajectory from their economy-wide modeling. Therefore, for agricultural commodity prices and land prices, 2-dimensional interpolation between 5-year time periods and carbon price scenarios was employed to infer FASOM-GHG output that is consistent with the economy-wide modeling output. Detailed FASOM-GHG output used for this interpolation emanated from July FASOM-GHG runs, while EPA's agricultural and forestry sector analysis was based on April model runs. The FASOM-GHG modelers report that differences between these two model runs are minimal.

[5] These prices were derived from EPA estimates for 2015 and 2020 and extrapolated and interpolated to provide annual estimates.

[6] The IPM reference case natural gas prices were determined endogenously in IPM, and do not correspond exactly to the reference case natural gas prices from ADAGE/IGEM. The IPM prices only reflect changes in natural gas supply and demand due to changes in electricity sector behavior. EPA notes, however, that demand for natural gas from outside the electricity generation sector does not change significantly in ADAGE.

Table 2. Crop Prices for the January 2009 FAPRI Baseline and the EPA Cap and Trade Scenarios.

		2010	2011	2012	2013	2014	2015	2016
Cotton ($/lb.)	Baseline	0.5585	0.5709	0.5792	0.5912	0.6013	0.6069	0.6137
	EPA H.R. 2454	0.5699	0.5876	0.6022	0.6217	0.6403	0.6553	0.6632
Wheat ($/bu.)	Baseline	5.26	5.41	5.51	5.65	5.78	5.86	5.88
	EPA H.R. 2454	5.30	5.46	5.57	5.71	5.85	5.94	5.91
Sorghum ($/bu.)	Baseline	5.75	6.04	6.18	6.43	6.59	6.69	6.72
	EPA H.R. 2454	5.85	6.18	6.36	6.68	6.90	7.09	7.15
Corn ($/bu.)	Baseline	3.69	3.85	3.88	4.02	4.09	4.14	4.11
	EPA H.R. 2454	3.78	3.97	4.03	4.22	4.33	4.41	4.42
Barley ($/bu.)	Baseline	4.03	4.15	4.18	4.31	4.36	4.39	4.35
	EPA H.R. 2454	4.24	4.38	4.42	4.56	4.63	4.66	4.67
Oats ($/bu.)	Baseline	2.54	2.58	2.60	2.67	2.72	2.75	2.76
	EPA H.R. 2454	2.61	2.66	2.69	2.77	2.82	2.87	2.93
Soybeans ($/bu.)	Baseline	8.78	9.08	9.30	9.55	9.78	9.94	9.99
	EPA H.R. 2454	9.01	9.33	9.58	9.86	10.13	10.33	10.41
Rice ($/cwt.)	Baseline	11.87	12.05	12.53	13.02	13.27	13.68	13.64
	EPA H.R. 2454	11.97	12.17	12.68	13.20	13.47	13.92	13.90
Soybean Meal ($/ton)	Baseline	242.97	239.41	241.20	245.51	250.19	252.78	252.00
	EPA H.R. 2454	241.69	238.48	240.60	245.24	250.27	253.21	255.46
All Hay ($/ton)	Baseline	130.94	128.88	128.46	129.58	131.30	133.84	136.05
	EPA H.R. 2454	134.12	133.77	135.40	138.98	143.61	149.57	151.75

Table 3. Livestock and Milk Prices for the January 2009 FAPRI Baseline and the EPA Cap and Trade Scenarios.

		2010	2011	2012	2013	2014	2015	2016
Culled Cows ($/cwt.)	Baseline	0.5736	0.5847	0.5928	0.5944	0.6093	0.6093	0.6096
	EPA H.R. 2454	0.5786	0.5907	0.5999	0.6025	0.6186	0.6196	0.6210
Feeder Cattle ($/cwt.)	Baseline	1.1402	1.2240	1.2805	1.3127	1.3260	1.3255	1.3287
	EPA H.R. 2454	1.1091	1.1864	1.2361	1.2616	1.2683	1.2611	1.2536
Fed Cattle ($/cwt.)	Baseline	0.9497	0.9848	1.0079	1.0175	1.0240	1.0239	1.0258
	EPA H.R. 2454	0.9176	0.9515	0.9739	0.9832	0.9895	0.9894	1.0001
Culled Sows ($/cwt.)	Baseline	0.3991	0.4209	0.4344	0.4178	0.4055	0.3970	0.3873
	EPA H.R. 2454	0.4125	0.4363	0.4517	0.4358	0.4244	0.4169	0.4090
Market Hogs ($/cwt.)	Baseline	0.5302	0.5502	0.5625	0.5477	0.5397	0.5368	0.5333
	EPA H.R. 2454	0.5443	0.5663	0.5804	0.5666	0.5598	0.5583	0.5571
All Milk ($/cwt.)	Baseline	14.23	16.00	16.52	16.70	16.88	17.16	17.45
	EPA H.R. 2454	14.49	16.36	16.98	17.26	17.54	17.95	18.29
California Milk ($/cwt.)	Baseline	12.82	14.45	14.90	15.01	15.20	15.48	15.78
	EPA H.R. 2454	13.05	14.78	15.31	15.51	15.80	16.20	16.54
Florida Milk ($/cwt.)	Baseline	18.37	20.21	20.75	20.93	21.09	21.37	21.68
	EPA H.R. 2454	18.71	20.67	21.33	21.63	21.93	22.36	22.72
Idaho Milk ($/cwt.)	Baseline	12.97	14.78	15.36	15.60	15.81	16.11	16.43
	EPA H.R. 2454	13.21	15.12	15.79	16.12	16.43	16.85	17.22
Missouri Milk ($/cwt.)	Baseline	14.61	16.44	17.00	17.19	17.38	17.66	17.97
	EPA H.R. 2454	14.88	16.81	17.47	17.77	18.06	18.48	18.84
New York Milk ($/cwt.)	Baseline	14.34	16.16	16.73	16.95	17.15	17.45	17.76
	EPA H.R. 2454	14.60	16.53	17.19	17.51	17.82	18.25	18.62
Texas Milk ($/cwt.)	Baseline	14.72	16.54	17.11	17.32	17.52	17.81	18.13
	EPA H.R. 2454	14.99	16.92	17.58	17.90	18.21	18.63	19.00
Vermont Milk ($/cwt.)	Baseline	15.28	17.09	17.66	17.88	18.09	18.38	18.70
	EPA H.R. 2454	15.55	17.48	18.15	18.48	18.80	19.23	19.60
Washington Milk ($/cwt.)	Baseline	13.44	15.24	15.82	16.07	16.28	16.59	16.91
	EPA H.R. 2454	13.68	15.59	16.26	16.60	16.92	17.35	17.72
Wisconsin Milk ($/cwt.)	Baseline	15.04	16.88	17.42	17.59	17.75	18.03	18.33
	EPA H.R. 2454	15.32	17.27	17.91	18.18	18.45	18.86	19.21

Table 4. Inflation Rates for the January 2009 FAPRI Baseline and the EPA Cap and Trade Scenarios.

		2010	2011	2012	2013	2014	2015	2016
Seed	Baseline	0.0053	0.0429	0.0324	0.0398	0.0290	0.0138	0.0177
	EPA H.R. 2454	0.0058	0.0432	0.0327	0.0401	0.0293	0.0141	0.0181
Nitrogen Fertilizer	Baseline	-0.0678	0.0695	0.0329	0.0500	0.0300	-0.0050	0.0068
	EPA H.R. 2454	-0.0678	0.0608	0.0202	0.0330	-0.0139	-0.0388	-0.1170
P & K Fertilizer	Baseline	0.0036	0.0690	0.0401	0.0314	0.0213	0.0067	0.0097
	EPA H.R. 2454	-0.0429	0.0841	0.0483	0.0662	0.0470	0.0128	0.0254
Herbicide	Baseline	-0.0277	0.0087	0.0046	0.0112	0.0059	0.0001	0.0082
	EPA H.R. 2454	-0.0262	0.0095	0.0055	0.0122	0.0069	0.0011	0.0093
Insecticide	Baseline	-0.0005	0.0232	0.0058	0.0103	0.0086	0.0083	0.0184
	EPA H.R. 2454	0.0009	0.0240	0.0067	0.0112	0.0096	0.0093	0.0194
Fuel and Lube	Baseline	-0.0427	0.0906	0.0758	0.0538	0.0072	-0.0315	-0.0042
	EPA H.R. 2454	0.0078	0.1198	0.1066	0.0862	0.0412	0.0040	0.0329
Machinery	Baseline	0.0087	0.0227	0.0106	0.0222	0.0221	0.0209	0.0289
	EPA H.R. 2454	0.0097	0.0232	0.0112	0.0228	0.0227	0.0216	0.0296
Wages	Baseline	0.0125	0.0047	0.0142	0.0198	0.0235	0.0262	0.0257
	EPA H.R. 2454	0.0366	0.0183	0.0286	0.0350	0.0395	0.0430	0.0433
Supplies	Baseline	0.0110	0.0377	0.0174	0.0207	0.0089	-0.0050	0.0009
	EPA H.R. 2454	0.0119	0.0382	0.0180	0.0213	0.0095	-0.0043	0.0016
Repairs	Baseline	0.0031	0.0100	0.0123	0.0166	0.0157	0.0116	0.0091
	EPA H.R. 2454	0.0041	0.0106	0.0129	0.0172	0.0164	0.0123	0.0098
Services	Baseline	-0.0066	0.0096	-0.0068	0.0021	0.0000	-0.0016	0.0121
	EPA H.R. 2454	0.0173	0.0232	0.0076	0.0173	0.0160	0.0152	0.0297
Long-Term Interest Rate	Baseline	0.0773	0.0904	0.0977	0.1017	0.1047	0.1061	0.1069
	EPA H.R. 2454	0.0797	0.0946	0.1040	0.1104	0.1160	0.1201	0.1240
Intermediate-Term Interest Rate	Baseline	0.0626	0.0732	0.0791	0.0824	0.0847	0.0859	0.0866
	EPA H.R. 2454	0.0645	0.0766	0.0842	0.0894	0.0939	0.0973	0.1003
Savings Account Interest Rate	Baseline	0.0214	0.0251	0.0271	0.0282	0.0290	0.0294	0.0297
	EPA H.R. 2454	0.0221	0.0262	0.0289	0.0306	0.0322	0.0333	0.0344
Land Prices	Baseline	0.0241	0.0209	0.0097	0.0163	0.0314	0.0397	0.0390
	EPA H.R. 2454	0.0960	0.0383	0.0246	0.0291	0.0422	0.0485	0.0433

from EPA's economy-wide modeling. These forecast prices are available from EPA each five years, and intermediate years are interpolated.

Total emissions allowances under H.R. 2454 grow through 2016 to 5,482 million tons of CO2e, and decline thereafter (H.R. 2454 section 721). A varying proportion of these allowances are given freely to EITE industries (H.R. 2454 section 782). The EITE allowances are contained in Table 6. Two percent of total allowances are given to EITE industries in 2012 and 2013. Fifteen percent of total allowances are provided in 2014, and this percentage declines slowly thereafter. The variation in these two quantities results in a varying number of allocations being provided to EITE industries. The large increase in allowances provided to EITE industries in 2014 corresponds to most of these industries, including nitrogenous fertilizer producers, being phased in under section 722 of the bill as entities whose emissions are regulated.

Table 6. Total Allowances Given to EITE Industries

Year	Total Allowances
2012	92.5
2013	90.9
2014	764.9
2015	736.3
2016	791.6

Industries eligible for EITE status and benefits are not explicitly specified, making it difficult to determine the extent to which EITE allocations will cover EITE industries' emissions under existing production levels and technologies. To estimate this, we employ the analysis provided by the Peterson Institute for International Economics.[7] That analysis finds that the set of presumed EITE-eligible industries emit an estimated 665.4 million tons of CO2e annually. EITE industries are thus somewhat over-compensated. Using the proportions of EITE allowance coverage (assuming constant emissions of 665.4 million tons CO2e) for each year, we interpolated and extrapolated, as appropriate, from the allocation-inclusive and -exclusive natural gas prices to arrive at final net natural gas input cost changes (relative to the reference scenario) that will be realized by nitrogenous fertilizer producers under H.R. 2454 in 2014 through 2016. Before 2014, nitrogenous fertilizer producers are not covered entities, and simply pay for natural gas exclusive of allowance costs.

Measures of Economic Performance

Five alternative measures of economic performance are provided for each of the farms. These are:

- **Average Annual Total Cash Receipts** – Average annual cash receipts in 2010 - 2016 from all sources, including market sales, counter-cyclical/ACRE, direct payments, marketing loan gains/loan deficiency payments, crop insurance indemnities, and other farm related receipts.

- **Average Annual Total Cash Costs** – Average annual cash costs in 2010 - 2016 from all sources including variable, overhead, and interest expenses.

[7] "Ensuring US Competitiveness and International Participation"; testimony by Trevor Houser before the US House of Representatives Committee on Energy and Commerce, April 23, 2009.

- **Average Annual Net Cash Farm Income** – Equals average annual total cash receipts minus average annual cash expenses in 2010 - 2016. Net cash farm income is used to pay family living expenses, principal payments, income taxes, self employment taxes, and machinery replacement costs.

- **Average Ending Cash Reserves in 2016** – Equals total cash on hand at the end of the year in 2016. Ending cash equals beginning cash reserves plus net cash farm income and interest earned on cash reserves less principal payments, federal taxes (income and self employment), state income taxes, family living withdrawals, and actual machinery replacement costs (not depreciation).

- **Average Ending Real Net Worth** – Real Equity (inflation adjusted) at the end of the year in 2016. Equals total assets including land minus total debt from all sources.

Results

The farm level results are presented in Tables 7-13. The results section will provide a brief summary by measure of economic performance. Average ending cash reserves in 2016 will be highlighted as the most appropriate measure to evaluate this type of long-run decision. In other words, will the farm be better off or worse off at the end of the period based on cash on hand at the end of the year.

The general naming convention for the representative farms follows the pattern described below. The first two letters of a farm name indicate the state where it is located. If a farm has four letters, the third is generally a regional indicator. The last letter of a farm name indicates the type of operation (i.e., G for Feedgrain/Oilseed, W for Wheat, C for Cotton, R for Rice, D for Dairy, and B for Beef Ranches). A few exceptions exist where states contain multiple farms and the third and fourth letters of the farm name are both regional indicators. Numbers on crop farms indicate acres of cropland and numbers on dairies and ranches indicate numbers of cows.

For a detailed analysis of the representative farms under the Baseline scenario, refer to AFPC Working Paper 09-1, Representative Farms Economic Outlook for the January 2009 FAPRI/AFPC Baseline.

<u>Average Annual Total Cash Receipts</u>

All of the crop farms and dairies are expected to realize slightly higher average annual cash receipts under the C&T without Ag Carbon Credits scenario due to slightly higher crop and milk prices resulting from instituting cap and trade (Table 7). The lone exception is the 12 cattle ranches that realize slightly lower receipts due to lower calf prices. As mentioned earlier, some of the price increase is expected to result from shifting between crops as one becomes relatively more expensive to produce, but there is also the price increasing effect of shifting land out of commodity production to forestry.

As one would expect, the C&T with Ag Carbon Credits scenario results in slightly higher cash receipts than the Baseline and C&T without Ag Carbon Credits scenario. The amount of the carbon credits is relatively small with many farms averaging less than $10,000 per year higher receipts (Appendix B). Again, the exceptions are rice farms and the cattle ranches. AFPC knows of no mechanism for rice farms to sell carbon credits. The lone rice farm that is expected to benefit from selling carbon credits is the ARMR7500 farm which has a significant amount of land dedicated to the production of other commodities. Carbon credits are assumed to be earned on the land not in the rotation for rice production.

The last scenario (C&T with Ag Carbon Credits and Saturation) was analyzed to provide an indication of farms no longer being able to sell carbon credits because their land has become saturated for carbon sequestration purposes. Losing the revenue from selling carbon credits in 2015 and 2016 has a relatively small effect on the annual average cash receipts on the farms who were selling carbon credits.

Table 7. Average Annual Total Cash Receipts for AFPC Representative Feedgrain/Oilseed and Wheat Farms, 2010-2016.

	Baseline --$1,000--	C&T with No Ag Carbon Credits --$1,000--	C&T with Ag Carbon Credits --$1,000--	C&T with Ag Carbon Credits and Saturation --$1,000--
Feedgrain/Oilseed				
IAG1350	820.9	854.2	862.1	859.5
IAG3400	2,021.2	2,102.6	2,122.4	2,115.8
NEG1960	1,518.0	1,583.5	1,593.8	1,590.3
NEG4300	3,077.8	3,213.3	3,234.6	3,227.2
MOCG2050	1,010.9	1,049.6	1,061.5	1,057.5
MOCG4000	1,981.8	2,056.1	2,078.2	2,070.4
MONG1850	1,065.1	1,096.1	1,106.6	1,103.1
ING1000	546.0	566.5	572.3	570.4
ING2200	1,278.5	1,324.5	1,337.3	1,333.0
NDG2180	709.4	730.8	738.9	736.2
NDG7500	2,919.5	3,015.0	3,037.0	3,027.6
TXNP3000	1,564.5	1,611.8	1,627.0	1,621.9
TXNP8000	4,293.6	4,443.0	4,488.5	4,474.5
TXHG2000	528.8	546.4	554.2	551.6
TXPG2500	1,536.2	1,570.0	1,582.5	1,578.3
TXMG1800	689.6	709.7	716.7	714.4
TXPG3760	3,092.5	3,221.2	3,239.0	3,233.0
TXWG1600	504.1	518.7	521.8	520.8
TXUG1200	753.1	775.9	778.3	777.5
TNG900	408.3	423.6	428.8	427.1
TNG2750	1,345.4	1,389.4	1,405.5	1,400.1
LANG2500	1,958.8	2,009.1	2,020.8	2,016.9
LAG2640	1,749.7	1,796.0	1,811.4	1,806.3
SCG1500	939.0	962.0	968.5	966.3
SCG3500	1,880.9	1,938.9	1,959.1	1,952.3
Wheat				
WAW1725	658.4	664.5	664.5	664.5
WAW5500	1,968.6	1,990.5	1,990.5	1,990.5
WAAW3500	391.2	393.8	393.8	393.8
KSCW2000	518.1	529.0	536.7	534.1
KSCW4500	1,100.2	1,124.4	1,141.7	1,135.9
KSNW2800	518.7	526.3	530.4	529.0
KSNW5000	1,274.0	1,303.3	1,311.6	1,308.8
COW3000	418.1	426.2	431.5	429.7
COW5640	788.8	798.5	808.6	805.3
MTW4500	551.6	556.3	570.2	565.6
ORW3600	485.6	488.9	488.9	488.9

Table 7 (continued). Average Annual Total Cash Receipts for AFPC Representative Cotton and Rice Farms, 2010-2016.

	Baseline --$1,000--	C&T with No Ag Carbon Credits --$1,000--	C&T with Ag Carbon Credits --$1,000--	C&T with Ag Carbon Credits and Saturation --$1,000--
Cotton				
CAC4000	6,690.1	6,891.7	6,891.7	6,891.7
TXSP2500	684.2	699.4	705.8	703.7
TXSP3745	1,132.4	1,160.3	1,169.2	1,166.2
TXRP2500	377.0	383.1	388.0	386.4
TXCB2250	788.2	808.5	817.3	814.4
TXCB8000	2,928.7	3,005.5	3,039.6	3,029.2
TXVC4500	1,636.8	1,668.5	1,676.7	1,673.9
TXEC5000	2,053.6	2,101.9	2,122.9	2,115.9
GAC2300	1,910.6	1,966.5	1,976.6	1,973.2
TNC1900	1,107.1	1,136.0	1,146.9	1,143.3
TNC4050	1,932.8	1,972.9	1,996.5	1,988.6
ARNC5000	3,808.4	3,893.8	3,923.6	3,913.8
ALC3000	1,363.3	1,397.9	1,415.4	1,409.5
NCC1500	909.7	926.0	934.8	931.8
Rice				
CAR550	668.4	675.0	675.0	675.0
CAR2365	2,974.0	3,006.2	3,006.2	3,006.2
CABR1300	1,652.0	1,668.7	1,668.7	1,668.7
CACR715	945.5	954.8	954.8	954.8
TXR1350	522.7	528.1	528.1	528.1
TXR3000	1,279.9	1,293.5	1,293.5	1,293.5
TXBR1800	931.2	941.3	941.3	941.3
TXER3200	1,495.9	1,518.1	1,518.1	1,518.1
LASR1200	783.1	791.4	791.4	791.4
ARMR7500	5,052.9	5,168.9	5,204.7	5,193.7
ARSR3240	1,898.7	1,930.3	1,930.3	1,930.3
ARWR1200	773.5	787.4	787.4	787.4
ARHR3000	1,986.5	2,025.9	2,025.9	2,025.9
MOWR4000	2,705.8	2,755.6	2,755.6	2,755.6

Table 7 (continued). Average Annual Total Cash Receipts for AFPC Representative Dairies and Ranches, 2010-2016.

	Baseline --$1,000--	C&T with No Ag Carbon Credits --$1,000--	C&T with Ag Carbon Credits --$1,000--	C&T with Ag Carbon Credits and Saturation --$1,000--
Dairies				
CAD1710	6,950.8	7,178.8	7,391.7	7,391.7
WAD250	1,121.3	1,157.9	1,157.9	1,157.9
WAD850	3,732.1	3,861.2	3,960.7	3,960.7
IDD1000	4,655.2	4,806.1	4,923.2	4,923.2
IDD3000	13,633.5	14,087.2	14,438.4	14,438.4
TXCD550	2,092.4	2,161.6	2,230.1	2,230.1
TXCD1300	5,131.5	5,296.2	5,458.0	5,458.0
TXED450	1,686.0	1,738.5	1,738.5	1,738.5
TXED1000	4,089.9	4,228.6	4,353.1	4,353.1
TXND3000	12,093.9	12,511.6	12,885.1	12,885.1
WID145	811.4	837.0	837.0	837.0
WID775	4,096.4	4,229.6	4,316.7	4,316.7
NYWD1200	5,468.6	5,643.5	5,778.4	5,778.4
NYWD600	2,678.4	2,763.8	2,831.3	2,831.3
NYCD110	532.9	549.2	549.2	549.2
NYCD550	2,795.5	2,881.1	2,942.9	2,942.9
VTD140	631.6	651.4	651.4	651.4
VTD400	1,923.4	1,986.7	1,986.7	1,986.7
MOCD500	2,210.2	2,282.9	2,341.4	2,341.4
MOGD500	1,268.9	1,309.5	1,368.0	1,368.0
FLND550	2,562.5	2,643.6	2,712.1	2,712.1
FLSD1500	7,041.9	7,260.2	7,446.9	7,446.9
Ranches				
MTB500	330.5	321.1	321.1	321.1
WYB335	298.4	295.7	295.7	295.7
COB250	234.8	233.3	233.3	233.3
MOB250	312.5	311.4	311.4	311.4
MOCB400	297.3	289.5	289.5	289.5
NMB240	185.1	180.2	180.2	180.2
FLB1155	723.1	703.9	703.9	703.9
NVB700	409.2	396.7	396.7	396.7
CAB500	328.8	316.4	316.4	316.4
SDB375	257.4	249.6	249.6	249.6
TXSB200	167.8	163.9	163.9	163.9
TXRB500	465.7	452.8	452.8	452.8

Average Annual Total Cash Costs

Average annual total cash costs differ from the Baseline under all three alternative scenarios (Table 8). Costs under the C&T without Ag Carbon Credits scenario differ from the Baseline due to different rates of change for input prices resulting from cap and trade legislation. Costs differ from the base under C&T with Ag Carbon Credits due to imposition of those same higher costs; however, this scenario also incurs different costs as a result of conversion to no-till on farms eligible for carbon credits and construction of methane digesters on eligible dairy farms. Slightly different average annual costs are experienced by some farms between the C&T with Ag Carbon Credits and C&T with Ag Carbon Credits and Saturation resulting from higher operating interest costs in the Saturation scenario.

Average Annual Net Cash Farm Income

Average annual net cash farm income is defined in this study as average annual total cash receipts minus average annual total cash costs. As a result of this formula, the average annual net cash farm income differs between scenarios in the same ways that average annual total receipts and average annual total cash costs differ (explained above). In general, the feedgrain/oilseed farms located in or near the Corn Belt and the wheat farms located in the Great Plains, have higher average annual net cash farm income under the three cap and trade alternatives (Table 9). Most cotton and dairy farms and all of the rice farms and ranches are experiencing lower net cash farm incomes under the cap and trade alternatives. The rice farms and cattle ranches, are assumed to not participate in carbon sequestration activities so they experience higher costs, without carbon revenue and their commodity prices do not increase enough to offset higher costs so they experience lower average annual net cash farm incomes.

Average Ending Cash Reserves in 2016

Ending cash reserves in 2016 is the cumulative effect of average annual net cash farm income with the additional impacts of principal payments on loans, income taxes, and family living expenses. As revenues and costs change, income taxes and principal payments on loans will differ. AFPC has chosen this measure to highlight some of the farm level results. As indicated in Table 10, most (17 of 25) of the feedgrain farms have higher average ending cash reserves under either of the C&T without Ag Carbon Credits or C&T with Ag Carbon Credits scenarios. In addition, all but a few of the feedgrain/oilseed farms end the analysis period with higher cash reserves even under the saturation scenario. Eight of 11 wheat farms are better off under the C&T with Ag Carbon Credits scenario relative to the Baseline, while one cotton and no rice farms or cattle ranches are better off. One dairy (WID145) is better off because it produces and sells excess corn and soybeans which are projected to see much higher prices as a result of cap and trade.

Table 11 provides a summary of the farms with higher and lower (relative to the Baseline) average ending cash reserves in 2016. Twenty-seven out of 98 representative farms are expected to be better off at the end of the period in terms of their ending cash reserves.

Figure 2 shows the locations of the representative farms that, based on average ending cash reserves in 2016, are better off in green and worse off in red. Clearly it is easy to see that in general, the only real winners assuming EPA's analysis of cap and trade would be feedgrain/oilseed and plains wheat farms.

Table 8. Average Annual Total Cash Costs for AFPC Representative Feedgrain/Oilseed and Wheat Farms, 2010-2016.

	Baseline --$1,000--	C&T with No Ag Carbon Credits --$1,000--	C&T with Ag Carbon Credits --$1,000--	C&T with Ag Carbon Credits and Saturation --$1,000--
Feedgrain/Oilseed				
IAG1350	612.0	623.2	623.6	623.7
IAG3400	1,415.9	1,443.9	1,440.1	1,440.2
NEG1960	1,010.3	1,038.8	1,031.1	1,031.1
NEG4300	2,061.4	2,121.1	2,102.1	2,102.1
MOCG2050	522.6	533.6	526.2	526.2
MOCG4000	841.3	862.8	839.0	839.0
MONG1850	834.2	854.3	846.6	846.7
ING1000	433.7	442.4	440.9	441.0
ING2200	910.8	931.9	920.8	920.8
NDG2180	440.9	453.5	430.7	430.7
NDG7500	1,705.2	1,739.9	1,640.1	1,640.1
TXNP3000	1,390.0	1,487.5	1,518.8	1,519.0
TXNP8000	3,709.1	3,942.6	4,045.9	4,046.4
TXHG2000	459.8	466.0	465.7	465.7
TXPG2500	1,298.3	1,382.3	1,370.0	1,370.1
TXMG1800	583.9	601.9	626.2	626.3
TXPG3760	3,566.5	3,748.4	3,817.8	3,818.1
TXWG1600	446.8	457.9	438.6	438.7
TXUG1200	768.1	803.0	807.1	807.1
TNG900	435.2	444.0	450.1	450.2
TNG2750	929.2	936.0	933.8	933.9
LANG2500	1,427.1	1,483.3	1,482.9	1,482.9
LAG2640	1,492.3	1,537.1	1,587.1	1,587.2
SCG1500	913.4	941.8	952.2	952.3
SCG3500	1,463.9	1,489.0	1,473.4	1,473.5
Wheat				
WAW1725	344.4	349.8	349.8	349.8
WAW5500	1,322.8	1,360.8	1,360.8	1,360.8
WAAW3500	227.3	238.4	238.4	238.4
KSCW2000	328.0	337.2	331.9	331.9
KSCW4500	625.1	643.6	624.7	624.7
KSNW2800	389.8	398.8	395.8	395.8
KSNW5000	914.5	934.8	949.6	949.6
COW3000	228.1	231.0	233.3	233.3
COW5640	468.7	479.3	480.2	480.3
MTW4500	363.3	367.8	365.7	365.7
ORW3600	201.1	213.3	213.3	213.3

Table 8 (continued). Average Annual Total Cash Costs for AFPC Representative Cotton and Rice Farms, 2010-2016.

	Baseline --$1,000--	C&T with No Ag Carbon Credits --$1,000--	C&T with Ag Carbon Credits --$1,000--	C&T with Ag Carbon Credits and Saturation --$1,000--
Cotton				
CAC4000	5,184.7	5,481.8	5,481.8	5,481.8
TXSP2500	762.1	819.4	851.8	851.9
TXSP3745	1,189.4	1,273.2	1,306.4	1,306.5
TXRP2500	348.1	371.8	370.0	370.1
TXCB2250	669.1	688.2	717.9	717.9
TXCB8000	2,565.0	2,632.0	2,716.4	2,716.7
TXVC4500	1,286.2	1,339.9	1,326.1	1,326.1
TXEC5000	1,689.8	1,792.3	1,897.8	1,897.9
GAC2300	1,824.8	1,902.8	1,968.9	1,969.1
TNC1900	851.9	871.4	932.9	933.0
TNC4050	3,098.8	3,223.9	3,606.1	3,606.6
ARNC5000	3,334.0	3,431.3	3,736.9	3,737.3
ALC3000	1,163.6	1,194.4	1,259.9	1,260.3
NCC1500	808.5	826.9	865.1	865.3
Rice				
CAR550	641.2	700.6	700.6	700.6
CAR2365	2,758.0	2,963.8	2,963.8	2,963.8
CABR1300	1,417.0	1,495.5	1,495.5	1,495.5
CACR715	839.9	900.8	900.8	900.8
TXR1350	513.3	551.4	551.4	551.4
TXR3000	1,046.5	1,113.9	1,113.9	1,113.9
TXBR1800	1,002.1	1,085.6	1,085.6	1,085.6
TXER3200	1,601.8	1,708.0	1,708.0	1,708.0
LASR1200	628.1	670.5	670.5	670.5
ARMR7500	4,548.3	4,781.7	4,896.0	4,896.5
ARSR3240	1,554.5	1,641.6	1,641.6	1,641.6
ARWR1200	1,214.7	1,314.4	1,314.4	1,314.4
ARHR3000	1,978.1	2,102.0	2,102.0	2,102.0
MOWR4000	2,051.1	2,152.3	2,152.3	2,152.3

Table 8 (continued). Average Annual Total Cash Costs for AFPC Representative Dairies and Ranches, 2010-2016.

	Baseline --$1,000--	C&T with No Ag Carbon Credits --$1,000--	C&T with Ag Carbon Credits --$1,000--	C&T with Ag Carbon Credits and Saturation --$1,000--
Dairies				
CAD1710	6,188.8	6,472.3	6,625.1	6,625.1
WAD250	900.9	936.2	936.2	936.2
WAD850	3,162.8	3,280.4	3,397.5	3,397.5
IDD1000	3,841.0	4,049.8	4,171.6	4,171.6
IDD3000	11,087.2	11,678.3	11,895.7	11,895.7
TXCD550	1,750.4	1,821.1	1,916.3	1,916.3
TXCD1300	4,707.0	4,948.5	5,087.9	5,087.9
TXED450	1,554.2	1,634.1	1,634.1	1,634.1
TXED1000	3,723.8	3,897.5	4,027.9	4,027.9
TXND3000	10,592.6	11,168.7	11,382.8	11,382.8
WID145	526.8	549.7	549.7	549.7
WID775	2,779.5	2,908.2	3,011.7	3,011.7
NYWD1200	4,614.2	4,841.3	4,971.9	4,971.9
NYWD600	2,660.9	2,805.0	2,931.1	2,931.1
NYCD110	340.0	357.2	357.2	357.2
NYCD550	2,518.2	2,669.3	2,788.0	2,788.0
VTD140	562.9	588.5	588.5	588.5
VTD400	1,688.1	1,752.8	1,752.8	1,752.8
MOCD500	1,983.2	2,054.6	2,172.7	2,172.7
MOGD500	899.6	937.8	1,027.9	1,027.9
FLND550	2,100.9	2,180.8	2,286.2	2,286.2
FLSD1500	6,825.5	7,165.4	7,312.6	7,312.6
Ranches				
MTB500	221.9	236.0	236.0	236.0
WYB335	314.1	349.5	349.5	349.5
COB250	202.0	214.1	214.1	214.1
MOB250	171.2	173.5	173.5	173.5
MOCB400	219.0	229.3	229.3	229.3
NMB240	157.1	168.6	168.6	168.6
FLB1155	619.8	651.4	651.4	651.4
NVB700	348.0	373.8	373.8	373.8
CAB500	438.3	482.8	482.8	482.8
SDB375	158.2	167.8	167.8	167.8
TXSB200	123.2	129.4	129.4	129.4
TXRB500	314.1	327.3	327.3	327.3

Table 9. Average Annual Net Cash Farm Income for AFPC Representative Feedgrain/Oilseed and Wheat Farms, 2010-2016.

	Baseline --$1,000--	C&T with No Ag Carbon Credits --$1,000--	C&T with Ag Carbon Credits --$1,000--	C&T with Ag Carbon Credits and Saturation --$1,000--
Feedgrain/Oilseed				
IAG1350	208.9	231.0	238.5	235.8
IAG3400	605.3	658.7	682.4	675.6
NEG1960	507.7	544.7	562.7	559.2
NEG4300	1,016.4	1,092.3	1,132.5	1,125.1
MOCG2050	488.3	516.0	535.3	531.3
MOCG4000	1,140.6	1,193.3	1,239.2	1,231.4
MONG1850	230.9	241.8	260.1	256.4
ING1000	112.3	124.1	131.4	129.4
ING2200	367.6	392.6	416.5	412.2
NDG2180	268.6	277.3	308.2	305.5
NDG7500	1,214.3	1,275.2	1,396.9	1,387.5
TXNP3000	174.5	124.4	108.2	102.9
TXNP8000	584.5	500.4	442.6	428.1
TXHG2000	69.0	80.4	88.6	85.9
TXPG2500	237.9	187.7	212.5	208.2
TXMG1800	105.7	107.8	90.6	88.1
TXPG3760	-474.0	-527.2	-578.8	-585.1
TXWG1600	57.3	60.8	83.2	82.1
TXUG1200	-15.0	-27.0	-28.8	-29.6
TNG900	-26.9	-20.4	-21.2	-23.1
TNG2750	416.2	453.4	471.7	466.2
LANG2500	531.7	525.8	537.9	534.0
LAG2640	257.4	258.9	224.3	219.0
SCG1500	25.7	20.2	16.4	14.1
SCG3500	417.0	449.9	485.7	478.8
Wheat				
WAW1725	314.0	314.7	314.7	314.7
WAW5500	645.8	629.7	629.7	629.7
WAAW3500	163.9	155.4	155.4	155.4
KSCW2000	190.1	191.8	204.9	202.2
KSCW4500	475.2	480.8	517.0	511.2
KSNW2800	128.8	127.5	134.6	133.2
KSNW5000	359.5	368.4	362.0	359.2
COW3000	190.0	195.2	198.2	196.4
COW5640	320.1	319.2	328.4	325.0
MTW4500	188.3	188.5	204.5	199.8
ORW3600	284.5	275.6	275.6	275.6

Table 9 (continued). Average Annual Net Cash Farm Income for AFPC Representative Cotton and Rice Farms, 2010-2016.

	Baseline --$1,000--	C&T with No Ag Carbon Credits --$1,000--	C&T with Ag Carbon Credits --$1,000--	C&T with Ag Carbon Credits and Saturation --$1,000--
Cotton				
CAC4000	1,505.4	1,409.9	1,409.9	1,409.9
TXSP2500	-77.9	-120.0	-146.0	-148.2
TXSP3745	-57.0	-113.0	-137.2	-140.3
TXRP2500	28.9	11.3	18.0	16.3
TXCB2250	119.1	120.4	99.4	96.4
TXCB8000	363.7	373.6	323.2	312.5
TXVC4500	350.6	328.6	350.6	347.8
TXEC5000	363.9	309.6	225.1	218.0
GAC2300	85.8	63.8	7.7	4.1
TNC1900	255.2	264.6	214.0	210.3
TNC4050	-1,166.0	-1,251.1	-1,609.5	-1,617.9
ARNC5000	474.5	462.5	186.7	176.6
ALC3000	199.7	203.4	155.4	149.3
NCC1500	101.2	99.1	69.6	66.5
Rice				
CAR550	27.2	-25.5	-25.5	-25.5
CAR2365	216.0	42.4	42.4	42.4
CABR1300	235.1	173.2	173.2	173.2
CACR715	105.5	54.0	54.0	54.0
TXR1350	9.4	-23.2	-23.2	-23.2
TXR3000	233.4	179.7	179.7	179.7
TXBR1800	-70.9	-144.3	-144.3	-144.3
TXER3200	-105.9	-189.8	-189.8	-189.8
LASR1200	155.0	120.9	120.9	120.9
ARMR7500	504.6	387.2	308.7	297.2
ARSR3240	344.2	288.7	288.7	288.7
ARWR1200	-441.1	-526.9	-526.9	-526.9
ARHR3000	8.4	-76.1	-76.1	-76.1
MOWR4000	654.7	603.3	603.3	603.3

Table 9 (continued). Average Annual Net Cash Farm Income for AFPC Representative Dairies and Ranches, 2010-2016.

	Baseline --$1,000--	C&T with No Ag Carbon Credits --$1,000--	C&T with Ag Carbon Credits --$1,000--	C&T with Ag Carbon Credits and Saturation --$1,000--
Dairies				
CAD1710	762.0	706.5	766.6	766.6
WAD250	220.4	221.7	221.7	221.7
WAD850	569.3	580.7	563.2	563.2
IDD1000	814.2	756.3	751.6	751.6
IDD3000	2,546.3	2,409.0	2,542.8	2,542.8
TXCD550	341.9	340.5	313.8	313.8
TXCD1300	424.5	347.7	370.1	370.1
TXED450	131.8	104.4	104.4	104.4
TXED1000	366.1	331.1	325.2	325.2
TXND3000	1,501.3	1,342.9	1,502.3	1,502.3
WID145	284.6	287.2	287.2	287.2
WID775	1,316.9	1,321.4	1,305.0	1,305.0
NYWD1200	854.3	802.3	806.5	806.5
NYWD600	17.4	-41.1	-99.9	-99.9
NYCD110	193.0	192.0	192.0	192.0
NYCD550	277.3	211.8	154.9	154.9
VTD140	68.6	62.9	62.9	62.9
VTD400	235.3	233.9	233.9	233.9
MOCD500	227.0	228.2	168.7	168.7
MOGD500	369.3	371.7	340.2	340.2
FLND550	461.6	462.8	425.9	425.9
FLSD1500	216.4	94.8	134.4	134.4
Ranches				
MTB500	108.7	85.0	85.0	85.0
WYB335	-15.7	-53.8	-53.8	-53.8
COB250	32.8	19.3	19.3	19.3
MOB250	141.3	137.9	137.9	137.9
MOCB400	78.3	60.2	60.2	60.2
NMB240	28.0	11.7	11.7	11.7
FLB1155	103.3	52.6	52.6	52.6
NVB700	61.2	22.9	22.9	22.9
CAB500	-109.6	-166.3	-166.3	-166.3
SDB375	99.1	81.8	81.8	81.8
TXSB200	44.6	34.5	34.5	34.5
TXRB500	151.6	125.4	125.4	125.4

Table 10. Average Ending Cash Reserves for AFPC Representative Feedgrain/Oilseed and Wheat Farms, 2016.

	Baseline --$1,000--	C&T with No Ag Carbon Credits --$1,000--	C&T with Ag Carbon Credits --$1,000--	C&T with Ag Carbon Credits and Saturation --$1,000--
Feedgrain/Oilseed				
IAG1350	785.7	890.8	945.8	927.0
IAG3400	1,813.1	2,043.0	2,203.0	2,155.7
NEG1960	2,250.7	2,427.5	2,544.1	2,519.6
NEG4300	4,455.6	4,819.3	5,080.4	5,028.1
MOCG2050	1,268.1	1,402.6	1,531.7	1,503.4
MOCG4000	4,669.6	4,935.5	5,231.1	5,175.9
MONG1850	-180.7	-136.1	-18.0	-43.4
ING1000	-227.8	-176.4	-127.0	-141.1
ING2200	800.2	925.7	1,084.8	1,054.3
NDG2180	1,223.0	1,267.1	1,469.3	1,450.1
NDG7500	6,315.1	6,636.4	7,398.6	7,331.6
TXNP3000	336.9	16.6	-86.7	-123.7
TXNP8000	1,988.3	1,485.3	1,144.0	1,042.0
TXHG2000	-139.7	-81.0	-23.7	-42.5
TXPG2500	88.6	-234.6	-66.4	-96.5
TXMG1800	-267.4	-272.2	-391.4	-408.5
TXPG3760	-5,096.1	-5,486.4	-5,891.8	-5,935.9
TXWG1600	-248.0	-237.3	-89.8	-97.4
TXUG1200	-822.8	-917.3	-931.6	-937.4
TNG900	-815.9	-781.9	-790.7	-803.8
TNG2750	852.8	1,031.4	1,156.1	1,117.6
LANG2500	1,430.8	1,394.3	1,479.7	1,451.9
LAG2640	816.0	809.5	602.9	565.9
SCG1500	-525.6	-576.8	-604.2	-620.4
SCG3500	1,587.9	1,755.0	1,995.7	1,946.9
Wheat				
WAW1725	1,502.1	1,505.6	1,505.6	1,505.6
WAW5500	2,557.0	2,486.6	2,486.6	2,486.6
WAAW3500	408.5	352.1	352.1	352.1
KSCW2000	606.6	606.2	696.0	677.5
KSCW4500	1,852.5	1,875.8	2,114.4	2,072.9
KSNW2800	130.4	112.2	159.2	149.3
KSNW5000	1,271.9	1,306.5	1,280.3	1,260.6
COW3000	709.5	730.9	755.8	743.3
COW5640	964.4	948.1	1,016.6	992.3
MTW4500	694.0	687.2	810.0	776.4
ORW3600	1,248.6	1,201.2	1,201.2	1,201.2

Table 10 (continued). Average Ending Cash Reserves for AFPC Representative Cotton and Rice Farms, 2016.

	Baseline --$1,000--	C&T with No Ag Carbon Credits --$1,000--	C&T with Ag Carbon Credits --$1,000--	C&T with Ag Carbon Credits and Saturation --$1,000--
Cotton				
CAC4000	8,276.0	7,803.7	7,803.7	7,803.7
TXSP2500	-1,145.9	-1,444.0	-1,642.3	-1,658.1
TXSP3745	-1,860.6	-2,265.6	-2,457.0	-2,479.1
TXRP2500	-288.6	-412.2	-365.6	-377.7
TXCB2250	50.0	43.7	-97.6	-118.7
TXCB8000	106.4	105.4	-201.8	-277.0
TXVC4500	907.2	776.6	917.6	897.7
TXEC5000	1,655.1	1,344.2	821.5	771.1
GAC2300	-1,310.5	-1,468.9	-1,837.9	-1,863.0
TNC1900	703.8	740.2	434.8	408.6
TNC4050	-12,719.1	-13,334.5	-16,078.1	-16,136.9
ARNC5000	-156.0	-265.5	-2,019.6	-2,090.7
ALC3000	-707.6	-720.3	-1,036.2	-1,079.5
NCC1500	-391.4	-422.8	-617.9	-639.5
Rice				
CAR550	-532.0	-892.6	-892.6	-892.6
CAR2365	-215.2	-1,320.1	-1,320.1	-1,320.1
CABR1300	352.4	-35.2	-35.2	-35.2
CACR715	163.6	-149.1	-149.1	-149.1
TXR1350	-773.6	-1,006.0	-1,006.0	-1,006.0
TXR3000	966.4	648.2	648.2	648.2
TXBR1800	-1,499.0	-2,009.8	-2,009.8	-2,009.8
TXER3200	-1,820.8	-2,399.8	-2,399.8	-2,399.8
LASR1200	525.7	327.1	327.1	327.1
ARMR7500	-932.9	-1,694.8	-2,195.9	-2,276.6
ARSR3240	314.6	-28.6	-28.6	-28.6
ARWR1200	-5,473.8	-6,083.5	-6,083.5	-6,083.5
ARHR3000	-2,704.3	-3,297.2	-3,297.2	-3,297.2
MOWR4000	1,530.5	1,235.9	1,235.9	1,235.9

Table 10 (continued). Average Ending Cash Reserves for AFPC Representative Dairies and Ranches, 2016.

	Baseline --$1,000--	C&T with No Ag Carbon Credits --$1,000--	C&T with Ag Carbon Credits --$1,000--	C&T with Ag Carbon Credits and Saturation --$1,000--
Dairies				
CAD1710	402.9	49.6	101.3	101.3
WAD250	145.1	137.6	137.6	137.6
WAD850	1,327.8	1,363.3	1,023.6	1,023.6
IDD1000	2,820.6	2,546.3	2,284.7	2,284.7
IDD3000	8,914.3	8,190.3	8,501.3	8,501.3
TXCD550	1,410.1	1,401.4	1,024.7	1,024.7
TXCD1300	854.9	362.6	227.4	227.4
TXED450	-16.1	-201.4	-201.4	-201.4
TXED1000	352.2	117.1	-166.4	-166.4
TXND3000	6,008.8	5,120.3	5,650.2	5,650.2
WID145	1,026.7	1,038.7	1,038.7	1,038.7
WID775	7,129.8	7,181.1	6,859.8	6,859.8
NYWD1200	3,476.4	3,202.3	2,948.9	2,948.9
NYWD600	-1,844.7	-2,261.2	-2,909.7	-2,909.7
NYCD110	602.1	587.1	587.1	587.1
NYCD550	-478.9	-898.8	-1,491.0	-1,491.0
VTD140	-111.0	-156.9	-156.9	-156.9
VTD400	221.8	197.8	197.8	197.8
MOCD500	-337.6	-354.6	-908.2	-908.2
MOGD500	1,653.9	1,661.3	1,253.1	1,253.1
FLND550	983.3	978.3	563.3	563.3
FLSD1500	-2,186.7	-2,960.1	-3,001.6	-3,001.6
Ranches				
MTB500	304.0	153.6	153.6	153.6
WYB335	-645.1	-918.6	-918.6	-918.6
COB250	-54.7	-148.6	-148.6	-148.6
MOB250	601.4	578.6	578.6	578.6
MOCB400	212.3	97.0	97.0	97.0
NMB240	-106.2	-226.3	-226.3	-226.3
FLB1155	-56.6	-400.8	-400.8	-400.8
NVB700	-123.5	-394.0	-394.0	-394.0
CAB500	-1,397.6	-1,802.6	-1,802.6	-1,802.6
SDB375	344.8	230.8	230.8	230.8
TXSB200	-148.0	-228.3	-228.3	-228.3
TXRB500	704.6	553.5	553.5	553.5

Figure 2. Representative Farms, Dairies, and Ranches Analyzed Under the C&T with Ag Carbon Credits Scenario Showing Higher and Lower Ending Cash in 2016.

Farms, dairies, and ranches are classified as "green" if their ending cash in 2016 is higher under the C&T with Ag Carbon Credits scenario compared to the Baseline. Similarly, those classified as "red" had lower ending cash in 2016 under the alternative versus the Baseline.

Legend

FG: Feedgrain	D: Dairy
W: Wheat	B: Beef Cattle
C: Cotton	R: Rice

Table 11. Representative Farms by Type That Have Higher or Lower Ending Cash Reserves For the C&T with Ag Carbon Credits Scenario Relative to the Baseline.

Farm Type	Higher	Lower	Total
Feedgrain/Oilseed	17	8	25
Wheat	8	3	11
Cotton	1	13	14
Rice	0	14	14
Dairy	1	21	22
Cattle Ranches	0	12	12
Total	27	71	98

Table 12 indicates the average level of carbon prices necessary for the farms to be as well off as under the Baseline. Obviously, for some farms such as rice and the cattle ranches, since they are assumed not to participate, no level of carbon prices would make them as well off as the Baseline. For other farms that are better off relative to the Baseline under the cap and trade scenarios, most notably the feedgrain/oilseed farms and plains wheat farms, they are marked as such. While a few farms would be as well off as the Baseline with only slightly higher carbon prices each year, there are also several farms that would need $80 per ton per year or more to make them as well off as the Baseline.

Average Ending Real Net Worth

Ending real net worth in 2016 differs by scenario based on the differences in ending cash as seen in the previous financial measure and the rate of land appreciation and the general rate of inflation. Land ownership arrangements are unique, so farms owning more land will experience greater changes in wealth through changing land values than those owning little or no land. For the livestock operations, the market value of the livestock on hand will differ as prices change relative to the baseline. In general, most all of the farms are projected to increase their real net worth relative to the Baseline (Table 13).

Summary and Conclusions

At the request of Senator Saxby Chambliss, the Agricultural and Food Policy Center conducted an analysis of the economic impacts of cap and trade provisions of "The American Clean Energy and Security Act of 2009" (H.R. 2454) on their database of U.S. representative farms. This report assesses the impacts of H.R. 2454 by including:

- The anticipated energy related both direct and indirect cost increases.
- The expected commodity price changes resulting from producers switching among agricultural commodities.
- The estimated benefits to agricultural producers from selling CO2e credits.

AFPC utilized the EPA estimated energy price changes, as well as, their estimates of carbon and agricultural commodity prices to evaluate the farm level impacts of H.R. 2454. The results of this analysis are dependent on the projected outcomes in the EPA analysis of H.R. 2454. AFPC assumed that a fee structure similar to that used by the Chicago Climate Exchange (CCE) would likely be imposed under H.R. 2454 for CO2e trading.

Table 12. Average Annual CO_2e Price Needed to Achieve Projected Baseline 2016 Ending Cash Reserves Prior to Implementation of Cap and Trade Legislation.

Feedgrain/Oilseed	--\$/ton CO_2e--
IAG1350	Better than Baseline
IAG3400	Better than Baseline
NEG1960	Better than Baseline
NEG4300	Better than Baseline
MOCG2050	Better than Baseline
MOCG4000	Better than Baseline
MONG1850	Better than Baseline
ING1000	Better than Baseline
ING2200	Better than Baseline
NDG2180	Better than Baseline
NDG7500	Better than Baseline
TXNP3000	45.0
TXNP8000	35.0
TXHG2000	Better than Baseline
TXPG2500	25.0
TXMG1800	30.0
TXPG3760	60.0
TXWG1600	Better than Baseline
TXUG1200	60.0
TNG900	Better than Baseline
TNG2750	Better than Baseline
LANG2500	Better than Baseline
LAG2640	30.0
SCG1500	25.0
SCG3500	Better than Baseline
Wheat	
WAW1725	Better than Baseline
WAW5500	No Opportunity
WAAW3500	No Opportunity
KSCW2000	Better than Baseline
KSCW4500	Better than Baseline
KSNW2800	Better than Baseline
KSNW5000	Better than Baseline
COW3000	Better than Baseline
COW5640	Better than Baseline
MTW4500	Better than Baseline
ORW3600	No Opportunity

Table 12 (continued). Average Annual CO_2e Price Needed to Achieve Projected Baseline 2016 Ending Cash Reserves Prior to Implementation of Cap and Trade Legislation.

Cotton	--$/ton CO_2e--
CAC4000	No Opportunity
TXSP2500	90.0
TXSP3745	80.0
TXRP2500	30.0
TXCB2250	30.0
TXCB8000	25.0
TXVC4500	Better than Baseline
TXEC5000	60.0
GAC2300	70.0
TNC1900	40.0
TNC4050	>$100.0
ARNC5000	90.0
ALC3000	30.0
NCC1500	40.0
Rice	
CAR550	No Opportunity
CAR2365	No Opportunity
CABR1300	No Opportunity
CACR715	No Opportunity
TXR1350	No Opportunity
TXR3000	No Opportunity
TXBR1800	No Opportunity
TXER3200	No Opportunity
LASR1200	No Opportunity
ARMR7500	60.0
ARSR3240	No Opportunity
ARWR1200	No Opportunity
ARHR3000	No Opportunity
MOWR4000	No Opportunity

Table 12 (continued). Average Annual CO_2e Price Needed to Achieve Projected Baseline 2016 Ending Cash Reserves Prior to Implementation of Cap and Trade Legislation.

Dairies	--\$/ton CO_2e--
CAD1710	20.0
WAD250	No Opportunity
WAD850	40.0
IDD1000	60.0
IDD3000	20.0
TXCD550	50.0
TXCD1300	35.0
TXED450	No Opportunity
TXED1000	35.0
TXND3000	20.0
WID145	Better than Baseline
WID775	50.0
NYWD1200	60.0
NYWD600	>\$100.0
NYCD110	No Opportunity
NYCD550	>\$100.0
VTD140	No Opportunity
VTD400	No Opportunity
MOCD500	90.0
MOGD500	80.0
FLND550	50.0
FLSD1500	35.0
Ranches	
MTB500	No Opportunity
WYB335	No Opportunity
COB250	No Opportunity
MOB250	No Opportunity
MOCB400	No Opportunity
NMB240	No Opportunity
FLB1155	No Opportunity
NVB700	No Opportunity
CAB500	No Opportunity
SDB375	No Opportunity
TXSB200	No Opportunity
TXRB500	No Opportunity

Table 13. Average Ending Real Net Worth for AFPC Representative Feedgrain/Oilseed and Wheat Farms, 2016.

	Baseline --$1,000--	C&T with No Ag Carbon Credits --$1,000--	C&T with Ag Carbon Credits --$1,000--	C&T with Ag Carbon Credits and Saturation --$1,000--
Feedgrain/Oilseed				
IAG1350	2,702.4	3,033.1	3,086.8	3,068.4
IAG3400	8,406.4	9,440.2	9,596.6	9,550.4
NEG1960	4,813.6	5,239.0	5,352.9	5,329.0
NEG4300	10,936.8	11,858.9	12,114.0	12,063.0
MOCG2050	8,602.0	9,661.2	9,787.5	9,759.8
MOCG4000	16,685.5	18,460.3	18,749.2	18,695.2
MONG1850	7,580.8	8,584.0	8,699.4	8,674.6
ING1000	2,816.7	3,234.6	3,282.8	3,269.1
ING2200	8,447.8	9,542.0	9,697.4	9,667.6
NDG2180	2,075.8	2,180.8	2,378.4	2,359.6
NDG7500	12,473.7	13,386.6	14,131.4	14,065.9
TXNP3000	2,011.2	1,855.1	1,754.2	1,718.0
TXNP8000	6,753.0	6,688.6	6,355.0	6,255.4
TXHG2000	1,357.9	1,582.2	1,638.3	1,619.8
TXPG2500	3,787.3	3,871.0	4,035.3	4,005.9
TXMG1800	874.5	932.7	816.2	799.4
TXPG3760	159.0	424.0	27.9	-15.2
TXWG1600	983.8	1,117.3	1,261.4	1,254.0
TXUG1200	-541.9	-633.3	-647.3	-653.0
TNG900	288.7	424.2	415.7	402.9
TNG2750	5,013.2	5,593.6	5,715.4	5,677.8
LANG2500	7,182.5	7,757.5	7,840.9	7,813.8
LAG2640	1,768.9	1,782.3	1,580.4	1,544.3
SCG1500	710.6	779.8	753.0	737.1
SCG3500	8,911.4	10,040.3	10,275.5	10,227.8
Wheat				
WAW1725	2,868.8	3,017.7	3,017.7	3,017.7
WAW5500	9,234.4	9,889.6	9,889.6	9,889.6
WAAW3500	2,036.9	2,183.2	2,183.2	2,183.2
KSCW2000	2,460.3	2,673.9	2,761.7	2,743.6
KSCW4500	4,549.6	4,821.1	5,054.2	5,013.7
KSNW2800	2,270.0	2,494.2	2,540.2	2,530.5
KSNW5000	4,936.3	5,385.5	5,359.9	5,340.7
COW3000	2,262.8	2,464.1	2,488.4	2,476.2
COW5640	3,639.9	3,892.3	3,959.2	3,935.5
MTW4500	3,790.0	4,191.4	4,311.3	4,278.5
ORW3600	2,512.0	2,601.3	2,601.3	2,601.3

Table 13 (continued). Average Ending Real Net Worth for AFPC Representative Cotton and Rice Farms, 2016.

	Baseline --$1,000--	C&T with No Ag Carbon Credits --$1,000--	C&T with Ag Carbon Credits --$1,000--	C&T with Ag Carbon Credits and Saturation --$1,000--
Cotton				
CAC4000	26,872.0	29,072.2	29,072.2	29,072.2
TXSP2500	-263.1	-485.9	-679.7	-695.1
TXSP3745	-22.1	-324.6	-511.6	-533.3
TXRP2500	342.6	279.0	324.5	312.8
TXCB2250	1,462.0	1,599.3	1,461.2	1,440.5
TXCB8000	2,110.3	2,194.1	1,893.9	1,820.5
TXVC4500	4,009.5	4,171.4	4,309.3	4,289.8
TXEC5000	3,251.9	3,030.2	2,519.4	2,470.2
GAC2300	3,899.2	4,377.9	4,017.3	3,992.8
TNC1900	3,676.3	4,027.3	3,728.9	3,703.2
TNC4050	-6,198.7	-6,110.5	-8,791.5	-8,849.0
ARNC5000	6,929.1	7,400.8	5,686.7	5,617.2
ALC3000	966.4	961.4	652.8	610.4
NCC1500	3,014.0	3,321.5	3,130.9	3,109.7
Rice				
CAR550	1,730.0	1,647.2	1,647.2	1,647.2
CAR2365	7,012.4	6,809.2	6,809.2	6,809.2
CABR1300	5,425.8	5,679.0	5,679.0	5,679.0
CACR715	2,848.6	2,915.6	2,915.6	2,915.6
TXR1350	813.5	754.6	754.6	754.6
TXR3000	1,653.1	1,343.4	1,343.4	1,343.4
TXBR1800	-877.1	-1,374.5	-1,374.5	-1,374.5
TXER3200	-438.1	-889.6	-889.6	-889.6
LASR1200	1,010.0	832.4	832.4	832.4
ARMR7500	6,980.3	6,691.5	6,201.9	6,123.0
ARSR3240	4,000.7	3,922.2	3,922.2	3,922.2
ARWR1200	-1,873.8	-2,156.6	-2,156.6	-2,156.6
ARHR3000	2,689.8	2,558.8	2,558.8	2,558.8
MOWR4000	14,032.0	15,118.5	15,118.5	15,118.5

Table 13 (continued). Average Ending Real Net Worth for AFPC Representative Dairies and Ranches, 2016.

	Baseline --$1,000--	C&T with No Ag Carbon Credits --$1,000--	C&T with Ag Carbon Credits --$1,000--	C&T with Ag Carbon Credits and Saturation --$1,000--
Dairies				
CAD1710	21,762.2	23,420.0	23,470.5	23,470.5
WAD250	4,374.9	4,757.5	4,757.5	4,757.5
WAD850	10,251.5	11,069.6	10,737.7	10,737.7
IDD1000	10,216.3	10,472.3	10,216.8	10,216.8
IDD3000	32,867.1	33,950.4	34,254.3	34,254.3
TXCD550	5,860.8	6,222.2	5,854.1	5,854.1
TXCD1300	8,093.7	7,932.3	7,800.2	7,800.2
TXED450	3,288.5	3,382.5	3,382.5	3,382.5
TXED1000	6,587.7	6,750.8	6,473.8	6,473.8
TXND3000	19,793.8	19,154.3	19,672.1	19,672.1
WID145	3,792.0	4,083.5	4,083.5	4,083.5
WID775	12,572.5	13,044.9	12,731.0	12,731.0
NYWD1200	14,080.0	14,610.9	14,363.4	14,363.4
NYWD600	3,654.7	3,671.4	3,037.7	3,037.7
NYCD110	1,822.2	1,904.7	1,904.7	1,904.7
NYCD550	5,315.3	5,289.6	4,711.0	4,711.0
VTD140	1,308.4	1,386.2	1,386.2	1,386.2
VTD400	4,760.9	5,154.0	5,154.0	5,154.0
MOCD500	4,079.7	4,380.4	3,839.4	3,839.4
MOGD500	4,012.0	4,180.6	3,781.7	3,781.7
FLND550	6,401.5	6,923.4	6,517.8	6,517.8
FLSD1500	11,086.6	11,651.8	11,611.2	11,611.2
Ranches				
MTB500	6,024.6	6,546.7	6,546.7	6,546.7
WYB335	3,816.8	4,038.0	4,038.0	4,038.0
COB250	22,239.8	25,236.7	25,236.7	25,236.7
MOB250	3,656.8	3,979.8	3,979.8	3,979.8
MOCB400	5,262.4	5,798.1	5,798.1	5,798.1
NMB240	6,918.9	7,724.1	7,724.1	7,724.1
FLB1155	51,559.0	58,329.5	58,329.5	58,329.5
NVB700	5,831.9	6,218.3	6,218.3	6,218.3
CAB500	4,251.8	3,822.8	3,822.8	3,822.8
SDB375	6,894.3	7,574.9	7,574.9	7,574.9
TXSB200	3,548.0	3,899.0	3,899.0	3,899.0
TXRB500	9,140.9	10,026.2	10,026.2	10,026.2

AFPC has developed and maintains data to simulate 98 representative crop farms, dairies, and livestock operations chosen from major production areas across the United States. The location of these farms is primarily the result of discussions with staffers for the U.S. House and Senate Agriculture Committees. Information necessary to simulate the economic activity on these representative farms is developed from panels of producers using a consensus-building interview process.

The economic impacts of H.R. 2454 on the representative farms over the 2010-2016 period were analyzed for the following scenarios.

- Baseline – Food and Agricultural Policy Research Institute (FAPRI) January 2009 Baseline.
- C&T without Ag Carbon Credits – EPA estimated costs and prices.
- C&T with Ag Carbon Credits – EPA estimated costs and prices.
- C&T with Ag Carbon Credits and Saturation after 2014 – EPA estimated costs and prices.

Five alternative measures of economic performance were used for the farms. These are:

- Average Annual Total Cash Receipts
- Average Annual Total Cash Costs
- Average Annual Net Cash Farm Income
- Average Ending Cash Reserves in 2016
- Average Ending Real Net Worth in 2016

Results show that all of the crop farms and dairies are expected to realize slightly higher average annual cash receipts under the C&T scenarios due to slightly higher crop and milk prices resulting from instituting cap and trade. The lone exception is the 12 cattle ranches that realize slightly lower receipts due to lower calf prices. As one would expect, the C&T with Ag Carbon Credits scenario results in slightly higher cash receipts than the Baseline and C&T without Ag Carbon Credits scenario. The amount of the carbon credits is relatively small with many farms averaging less than $10,000 per year higher receipts. Losing the revenue from selling carbon credits in 2015 and 2016 due to saturation for carbon sequestration has a relatively small effect on the annual average cash receipts for the farms who were selling carbon credits.

Costs under the C&T without Ag Carbon Credits scenario differ from the Baseline due to different rates of change for input prices resulting from cap and trade legislation. Costs differ from the base under C&T with Ag Carbon Credits due to imposition of those same higher costs and expenses incurred for conversion to no-till on farms eligible for carbon credits and construction of methane digesters on eligible dairy farms.

In general, the feedgrain/oilseed farms located in or near the Corn Belt and wheat farms located in the Great Plains, have higher average annual net cash farm income under the three cap and trade alternatives. Most cotton and dairy farms and all of the rice farms and ranches will likely experience lower net cash farm incomes under the cap and trade alternatives. The rice farms and cattle ranches, are assumed to not participate in carbon sequestration activities so they experience higher costs, without carbon revenue and their commodity prices do not increase enough to offset higher costs.

Most of the feedgrain and plains wheat farms have higher average ending cash reserves under either of the C&T without Ag Carbon Credits or C&T with Ag Carbon Credits scenarios. In addition, all but a few of the feedgrain/oilseed farms end the analysis period with higher cash reserves even under the saturation scenario. Eight wheat farms are better off under the C&T with Ag Carbon Credits scenario, while one cotton and no rice farms or cattle ranches are better off. One dairy (WID145) is better off because it produces and sells surplus corn and soybeans which are projected to see higher prices as a result of cap and trade.

The average level of carbon prices necessary for the farms to be as well off as under the Baseline were estimated for farms who would be worse off under the C&T with Ag Carbon Credits scenario. Given the assumptions in this study, for some farms such as rice and the cattle ranches, no level of carbon prices would make them as well off as the Baseline. While a few farms would be as well off as the Baseline with only slightly higher carbon prices each year, there are also several farms that would need carbon prices of $80 per ton per year or more to make them as well off as the Baseline.

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Appendix A: Description of Representative Farms

2008 CHARACTERISTICS OF PANEL FARMS PRODUCING FEEDGRAINS AND OILSEEDS

IAG1350 IAG1350 is a 1,350-acre northwestern Iowa (Webster County) grain farm. The farm is moderate-sized for the region and plants 810 acres of corn and 540 acres of soybeans annually. Sixty-nine percent of this farm's 2008 receipts come from corn production.

IAG3400 This 3,400-acre large-sized grain farm is located in northwestern Iowa (Webster County). It plants 2,040 acres of corn and 1,360 acres of soybeans each year, realizing 70 percent of receipts from corn production.

NEG1960 South central Nebraska (Dawson County) is home to this 1,960-acre grain farm. This farm plants seventy-five percent of cultivated acres to corn and fifteen percent to soybeans. Alfalfa is grown on the remaining land. The farm produces both yellow and white food-grade corn on 56 percent of the corn acres. Eighty-two percent of gross receipts are derived from corn sales.

NEG4300 This is a 4,300-acre grain farm located in south central Nebraska (Dawson County). This operation plants 2,666 acres of corn and 1,118 acres of soybeans each year. Remaining acres are planted to alfalfa. A portion (40 percent) of the corn acreage is food-grade corn. In 2008, 72 percent of total receipts were generated from corn production.

MOCG2050 MOCG2050 is a 2,050-acre grain farm located in central Missouri (Carroll County) and plants 1,025 acres of corn and 1,025 acres of soybeans annually. This farm is located in the Missouri River bottom, an area with a large concentration of livestock production. This proximity allows grain producers in this area to supply feed to livestock producers at a premium to other areas of Missouri. This farm generated 61 percent of its total revenue from corn and 39 percent from soybeans during 2008.

MOCG4000 A 4,000-acre central Missouri (Carroll County) grain farm with 1,975 acres of corn, 1,975 acres of soybeans, and 50 acres of wheat. This farm is located in the Missouri River bottom, an area with a large concentration of livestock production. This proximity allows area grain producers to supply feed to livestock producers at a premium to other areas of Missouri. Corn sales accounted for 59 percent of farm receipts and soybeans accounted for 40 percent in 2008.

MONG1850 MONG1850 is a 1,850-acre diversified northwest Missouri grain farm centered in Nodaway County. MONG1850 plants 900 acres of corn, 900 acres of soybeans, and 200 acres of hay annually. The farm also has a 200-head cow-calf herd. Proximity to the Missouri River increases marketing options for area grain farmers due to easily accessible river grain terminals. In 2008, 48 percent of the farm's total receipts were from corn, 38 percent from soybeans, and 13 percent from cattle sales.

ING1000 Shelby County, Indiana, is home to this 1,000-acre moderate-sized feedgrain farm. This farm annually plants corn and soybeans in a 50/50 rotation. Due to this farm's proximity to Indianapolis, land development pressures will likely constrain further expansion of this farm's operations. Fifty-six percent of 2008 receipts came from corn sales.

ING2200 ING2200 is a large-sized grain farm located in east central Indiana (Shelby County). This farm plants 1,100 acres to corn and 1,100 acres to soybeans each year. In 2008, 58 percent of gross receipts were generated by corn sales.

NDG2180 NDG2180 is a 2,180-acre, moderate-sized, south central North Dakota (Barnes County) grain farm that plants 480 acres of wheat, 300 acres of corn, and 1,300 acres of soybeans. The remaining acres are enrolled in the Conservation Reserve Program. The farm generated 57 percent of 2008 receipts from soybean sales.

NDG7500 This is a 7,500-acre, large-sized grain farm in south central North Dakota (Barnes County) that grows 3,750 acres of soybeans, 2,000 acres of corn, 1,200 acres of wheat, and 300 acres of dry peas annually. The remaining acreage is enrolled in the Conservation Reserve Program. Soybean and corn sales accounted for 80 percent of 2008 receipts.

TXNP3000	This is a 3,000-acre feedgrain farm located on the northern High Plains of Texas (Moore County). This farm plants 630 acres of cotton, 960 acres of irrigated corn, 240 acres of irrigated sorghum for seed production, and 870 acres of irrigated wheat annually.
TXNP8000	TXNP8000 is a large-sized feedgrain farm located in the northern Texas Panhandle (Moore County). This farm annually plants 1,872 acres of irrigated cotton, 3,120 acres of irrigated corn, 867 acres of sorghum (587 acres of dryland and 280 acres of irrigated production for seed), and 1,555 acres of winter wheat (968 acres irrigated and 587 acres dryland).
TXHG2000	This 2,000-acre grain farm is located on the Blackland Prairie of Texas (Hill County). On this farm, 1,000 acres of corn, 500 acres of sorghum, 250 acres of cotton, and 250 acres of wheat are planted annually. Feedgrain sales accounted for 67 percent of 2008 receipts with cotton accounting for 19 percent of sales. Forty beef cows live on 300 acres of improved pasture and contribute approximately four percent of total receipts.
TXPG2500	The Texas Panhandle is home to this 2,500-acre farm (Deaf Smith County). Annually, cotton is planted on 200 irrigated acres, 1,242 acres are planted to wheat (875 irrigated and 367 dryland), and 875 irrigated acres are planted to corn. Sixty-three percent of 2008 cash receipts were generated by corn sales.
TXMG1800	This 1,800-acre farm is located on the Coastal Plain of southeast Texas (Wharton County). TXMG1800 farms 600 acres of cotton, 620 acres of sorghum, 480 acres of corn, and 100 acres of soybeans. In 2008, feedgrain and oilseed sales comprised 48 percent of total cash receipts on this operation.
TXPG3760	TXPG3760 is a predominately irrigated farm located in the Texas Panhandle (Castro County). Annually, 1,878 acres are planted to corn and 564 acres are planted to cotton. In 2008, 59 percent of cash receipts were generated from corn sales.
TXWG1600	This 1,600-acre farm is located on the Blackland Prairie of Texas (Williamson County). TXWG1600 plants 1,000 acres of corn, 300 acres of sorghum, 200 acres of cotton, and 100 acres of winter wheat annually. Additionally, this farm has a 50-head beef cow herd that is pastured on rented ground that cannot be farmed. Feedgrain sales accounted for 68 percent of 2008 receipts with cotton accounting for 23 percent of sales.
TXUG1200	TXUG1200 is a grain farm located in Uvalde County, Texas. This farm plants 550 acres of corn, 300 acres of grain sorghum, 200 acres of cotton, and 150 acres of wheat each year. All crops except wheat are grown under irrigation. In 2008, feedgrain sales accounted for 58 percent of farm receipts.
TNG900	This is a 900-acre, moderate-sized grain farm in West Tennessee (Henry County). Annually, this farm plants 500 acres of corn, 400 acres of soybeans, and 100 acres of wheat (planted before soybeans) in a region of Tennessee recognized for the high level of implementation of conservation practices by farmers. Sixty percent of 2008 farm receipts were from sales of corn.
TNG2750	West Tennessee (Henry County) is home to this 2,750-acre, large-sized grain farm. Farmers in this part of Tennessee are known for their early and continued adoption of conservation practices. TNG2750 plants 1,100 acres of corn, 550 acres of wheat, and 1,650 acres of soybeans (550 of which are double-cropped after wheat). The farm generated 40 percent of its 2008 gross receipts from sales of corn and 43 percent from soybeans.
LANG2500	This is a 2,500-acre, large-sized northeast Louisiana (Madison Parish) diversified farm. This farm harvests 500 acres of rice, 800 acres of soybeans, 250 acres of cotton, and 950 acres of corn. For 2008, 55 percent of farm receipts came from corn and soybean sales.

LAG2640	This is a 2,640-acre diversified farm located in northern Louisiana (Morehouse Parish). LAG2640 plants 924 acres of cotton, 1,056 acres of corn, and 660 acres of soybeans each year. During 2008, 52 percent of farm receipts were generated from corn and soybean sales.
SCG1500	SCG1500 is a moderate-sized, 1,500-acre diversified farm in South Carolina (Barnwell County) consisting of 525 acres of corn, 525 acres of cotton, 75 acres of soybeans, and 75 acres of wheat.
SCG3500	A 3,500-acre, large-sized South Carolina (Clarendon County) grain farm with 2,100 acres of corn, 700 acres of wheat, and 1,400 acres of soybeans (700 double-cropped after wheat). The farm generated 54 percent of 2008 receipts from corn sales and 26 percent from soybean sales, with an additional 15 percent coming from wheat sales. Timing precludes further expansion of relatively lucrative double-cropped acres.

2008 CHARACTERISTICS OF PANEL FARMS PRODUCING WHEAT

WAW1725 This is a 1,725-acre moderate-sized wheat farm in the Palouse of southeastern Washington (Whitman County). It plants 1,147 acres of wheat, 120 acres of barley, and 458 acres of dry peas. Disease concerns dictate rotating a minimum acreage of barley and peas to maintain wheat yields. This farm generated 75 percent of 2008 receipts from wheat.

WAW5500 A 5,500-acre, large-sized wheat farm in the Palouse of southeastern Washington (Whitman County). Annually, this farm allocates 3,055 acres to wheat, 611 acres to barley, and 1,204 acres to dry peas. Diseases that inhibit wheat yield dictate the rotation of a minimum acreage of barley and peas. Wheat sales accounted for 72 percent of 2008 receipts.

WAAW3500 South central Washington (Adams County) is home to this 3,500-acre, large-sized wheat farm. Annually, this farm plants 1,500 acres of wheat in a wheat-fallow rotation. Additionally, 500 acres are enrolled in a CRP contract. In 2008, wheat sales accounted for 95 percent of the farm's gross receipts.

KSCW2000 South central Kansas (Sumner County) is home to this 2,000-acre, moderate-sized wheat farm. KSCW2000 plants 1,200 acres of winter wheat, 200 acres of sorghum, and 400 acres of soybeans each year. For 2008, 63 percent of gross receipts came from wheat.

KSCW4500 A 4,500-acre, large-sized wheat farm in south central Kansas (Sumner County) that plants 2,700 acres of winter wheat, 450 acres of sorghum, 675 acres of corn, and 675 acres of soybeans. Sixty-three percent of this farm's 2008 total receipts were generated from sales of winter wheat.

KSNW2800 This is a 2,800-acre, moderate-sized northwest Kansas (Thomas County) wheat farm. This farm plants 1,400 acres of winter wheat (wheat-fallow rotation), 467 acres of corn, and 233 acres of sorghum. KSNW2800 also owns 80 head of beef cows. This farm generated 58 percent of 2008 receipts from wheat and 32 percent of its receipts from feedgrains.

KSNW5000 KSNW5000 is a 5,000-acre, large-sized northwest Kansas (Thomas County) wheat farm that annually plants 2,325 acres of winter wheat, 1,013 acres of corn, 382 acres of sorghum, and 130 acres of soybeans. This farm also runs 100 head of beef cows. The farm generated 46 percent of receipts from wheat and six percent from cattle during 2008.

COW3000 A 3,000-acre northeast Colorado (Washington County), moderate-sized wheat farm that plants 970 acres of winter wheat, 805 acres of millet, and 600 acres of corn each year. This farm generated 39 percent of its receipts from wheat, 33 percent from millet, and 26 percent from corn.

COW5640 A 5,640-acre, large-sized northeast Colorado (Washington County) wheat farm. It plants 2,256 acres of wheat, 490 acres of millet, and 490 acres of corn. During 2008, 77 percent of gross receipts came from wheat sales and 12 percent came from corn sales.

MTW4500 North-central Montana (Chouteau County) is home to this 4,500 acre farm on which 2,330 acres of wheat (1,711 acres of winter wheat, 619 acres of spring wheat) are planted each year. In 2008, 99 percent of cash income came from wheat.

ORW3600 A 3,600-acre large-sized wheat farm located in northeastern Oregon (Morrow County). This farm plants 1,600 acres annually in a wheat-fallow rotation, with 400 additional acres enrolled in a CRP contract. Ninety-five percent of this farm's 2008 total receipts came from wheat sales.

2008 CHARACTERISTICS OF PANEL FARMS PRODUCING COTTON

CAC4000 A 4,000-acre cotton farm located in Kings County, California, CAC4000 plants 1,333 acres to cotton, 267 acres to hay, 2666 acres of silage, and harvests 400 acres of almonds. Twenty-nine percent of 2008 receipts came from cotton sales.

TXSP2500 A 2,500-acre Texas South Plains (Dawson County) cotton farm that is moderate-sized for the area. TXSP2500 plants 1,958 acres of cotton (1,658 dryland, 300 irrigated), 190 acres of sorghum (160 dryland, 30 irrigated), 95 acres of wheat, and 50 acres of peanuts. For 2008, 81 percent of receipts came from cotton.

TXSP3745 The Texas South Plains (Dawson County) is home to this 3,745-acre, large-sized cotton farm that grows 2,916 acres of cotton (2,406 dryland, 510 irrigated), 120 acres of wheat, 120 acres of peanuts, and has 288 acres in CRP. Cotton sales comprised 81 percent of 2008 receipts.

TXRP2500 TXRP2500 is a 2,500-acre cotton farm located in the Rolling Plains of Texas (Jones County). This farm plants 1,117 acres of cotton and 825 acres of winter wheat each year. The area is limited by rainfall, and the farm uses a conservative level of inputs. Seventy-six percent of 2008 farm receipts came from cotton sales. Seventeen head of beef cows generated two percent of farm receipts.

TXCB2250 A 2,250-acre cotton farm located on the Texas Coastal Bend (San Patricio County) that farms 1,000 acres of cotton, 1,125 acres of sorghum, and 125 acres of corn annually. Sixty-three percent of 2008 cash receipts were generated by cotton.

TXCB8000 Nueces County, Texas is home to this 8,000-acre farm. Annually, 2,800 acres are planted to cotton and 5,200 acres to sorghum. Cotton sales accounted for 49 percent of 2008 receipts.

TXVC4500 This 4,500-acre farm is located in the lower Rio Grande Valley of Texas (Willacy County) and plants 2,388 acres to cotton (500 irrigated and 1,888 acres dryland), 1,887 acres to sorghum, and 225 acres of sugarcane. In 2008, 52 percent of TXVC4500's cash receipts were generated by cotton sales.

TXEC5000 This 5,000-acre farm is located on the Eastern Caprock of the Texas South Plains (Crosby County). Annually, 3,650 acres are planted to cotton (2,650 irrigated and 1,000 dryland), 300 acres to dryland wheat, and 550 acres of grain sorghum (300 irrigated and 250 acres dryland). In 2008, cotton sales accounted for 94 percent of gross receipts.

GAC2300 Southwest Georgia (Decatur County) is home to a 2,300-acre cotton farm that plants 1,495 acres to cotton, 575 acres to peanuts, and 230 acres to corn. This farm was added during 2001 to represent resurgent cotton production in the Deep South. In 2008, farm receipts were comprised largely of cotton sales (62 percent) and peanut sales (32 percent).

TNC1900 A 1,900-acre, moderate-sized West Tennessee (Fayette County) cotton farm. TNC1900 consists of 990 acres of cotton, 440 acres each of soybeans and corn, and 30 acres enrolled in CRP. Cotton accounted for 69 percent of 2008 gross receipts, with corn and soybeans contributing 18 percent and 13 percent, respectively.

TNC4050 TNC4050 is a 4,050-acre, large-sized West Tennessee (Haywood County) cotton farm. This farm plants 2,670 acres of cotton, 820 acres of soybeans, 560 acres of corn, and 328 acres of wheat each year. During 2008, cotton sales generated 74 percent of gross receipts.

ARNC5000 Far northeast Arkansas (Mississippi County) is home to this 5,000-acre cotton farm. ARNC5000 plants all its acres to cotton annually, generating 100 percent of its receipts from cotton.

ALC3000 A 3,000-acre cotton farm located in northern Alabama (Lawrence County) that plants 1,500 acres to cotton, 1,350 acres to corn, and 150 acres to soybeans annually. Cotton sales accounted for 62 percent of total farm receipts during 2008.

NCC1500 This is a 1,500-acre cotton farm located on the upper coastal plain of North Carolina (Wayne County). NCC1500 plants 575 acres of cotton, 325 acres of wheat, and 650 acres of soybeans annually. Cotton accounted for 47 percent of this farm's 2008 receipts with 21 percent coming from soybean sales.

2008 CHARACTERISTICS OF PANEL FARMS PRODUCING RICE

CAR550 CAR550 is a 550-acre moderate-sized rice farm in the Sacramento Valley of California (Sutter and Yuba Counties) that plants 500 acres of rice annually. This farm generated 100 percent of 2008 gross receipts from rice sales.

CAR2365 This is a 2,365-acre rice farm located in the Sacramento Valley of California (Sutter and Yuba Counties) that is large-sized for the region. CAR2365 plants 2,240 acres of rice annually. Ninety-nine percent of 2008's total receipts were generated from rice sales.

CABR1300 The Sacramento Valley (Butte County) is home to CABR1300, a 1,300-acre rice farm. CABR1300 harvests 1,200 acres of rice annually, generating 100 percent of 2008 farm receipts from rice sales.

CACR715 CACR715 is a 715-acre rice farm located in the Sacramento Valley of California (Colusa County). This farm harvests 650 acres of rice each year. During 2008, 100 percent of farm receipts were realized from rice sales.

TXR1350 This 1,350-acre rice farm located west of Houston, Texas (Colorado County) is moderate-sized for the region. TXR1350 harvests 450 acres of first-crop rice and 360 acres of ratoon rice. The farm generated 98 percent of its receipts from rice during 2008.

TXR3000 TXR3000 is a 3,000-acre, large-sized rice farm located west of Houston, Texas (Colorado County). This farm harvests 1,200 acres of first-crop rice and 1,080 acres of ratoon rice annually. TXR3000 realized 100 percent of 2008 gross receipts from rice sales.

TXBR1800 The Texas Gulf Coast (Matagorda County) is home to this 1,800-acre rice farm. TXBR1800 harvests 1,200 acres of rice annually (600 acres of first-crop rice and 600 acres of ratoon rice) and realized 100 percent of 2008 farm receipts from rice sales.

TXER3200 This 3,200-acre rice farm is large for the Texas Gulf Coast (Wharton County). TXER3200 harvests 1,067 acres of first-crop rice and 960 acres of ratoon rice each year. The farm also grows 427 acres of soybeans and 640 acres of grain sorghum annually. Eighty-five percent of 2008 receipts came from rice sales.

LASR1200 A 1,200-acre southwest Louisiana (Acadia, Jeff Davis, and Vermilion parishes) rice farm, LASR1200 is moderate-sized for the area. This farm harvests 660 acres of rice and 250 acres of soybeans. During 2008, 88 percent of gross receipts were generated from rice sales.

ARMR7500 ARMR7500 is a 7,500-acre diversified rice farm in southeast Arkansas (Desha County) that plants 1,500 acres of cotton, 1,875 acres of rice, 2,375 acres of soybeans, and 1,500 acres of corn. For 2008, 27 percent of gross receipts came from cotton sales, 37 percent from rice sales, 15 percent from corn sales, and 15 percent from soybean sales.

ARSR3240 ARSR3240 is a 3,240-acre, large-sized Arkansas (Arkansas County) rice farm that harvests 1,620 acres of rice, 1,620 acres of soybeans, and 324 acres of wheat each year. Seventy-three percent of this farm's 2008 receipts came from rice sales.

ARWR1200 East central Arkansas (Cross County) is home to this 1,200-acre rice farm. Moderate-sized for the region, ARWR1200 annually plants 600 acres to rice, 600 acres to soybeans, and 60 acres of double-cropped wheat. During 2008, rice sales generated 73 percent of gross receipts.

ARHR3000 ARHR3000 is a 3,000-acre large-sized northeast Arkansas (Lawrence County) rice farm that annually harvests 1,450 acres of rice, 1,250 acres of soybeans, and 300 acres of corn. Rice sales accounted for 72 percent of 2008 farm receipts.

MOWR4000 A 4,000-acre rice farm located in southeast Missouri (Butler County), MOWR4000 is large-sized for the region. Seventy-three percent of receipts for this farm came from rice sales in 2008.

2008 CHARACTERISTICS OF PANEL DAIRIES PRODUCING MILK

CAD1710 A 1,710-cow, large-sized central California (Tulare County) dairy. The farm plants 1,200 acres of hay/silage for which it employs custom harvesting. Milk sales generated 94 percent of 2008 total receipts.

WAD250 A 250-cow, moderate-sized northern Washington (Whatcom County) dairy. This farm plants 200 acres of silage and generated 92 percent of its 2008 gross receipts from milk sales.

WAD850 An 850-cow, large-sized northern Washington (Whatcom County) dairy. This farm plants 605 acres for silage annually. During 2008, 95 percent of this farm's gross receipts came from milk.

IDD1000 A 1,000-cow, moderate-sized Idaho (Twin Falls County) dairy. This farm plants no crops. Milk sales accounted for 92 percent of IDD1000's gross receipts for 2008.

IDD3000 A 3,000-cow, large-sized Idaho (Twin Falls County) dairy. This farm plants 2,000 acres for silage annually. Milk sales represent 94 percent of this farm's gross receipts.

TXCD550 A 550-cow, moderate-sized central Texas (Erath County) dairy. TXCD550 plants 1,100 acres of hay each year. Milk sales represented 94 percent of this farm's 2008 gross receipts.

TXCD1300 A 1,300-cow, large-sized central Texas (Erath County) dairy. TXCD1300 plants 680 acres of silage and 440 acres of hay annually. During 2008, milk sales accounted for 94 percent of receipts.

TXED450 A 450-cow, moderate-sized northeast Texas (Hopkins County) dairy. This farm has 850 acres of improved pasture and 50 acres of hay. During 2008, milk sales represented 91 percent of annual receipts.

TXED1000 A 1,000-cow, large-sized northeast Texas (Hopkins County) dairy. This farm plants 1,025 acres of hay/silage. This farm generated 95 percent of 2008 receipts from milk sales.

TXND3000 A 3,000-cow, large-sized dairy located in the South Plains of Texas (Bailey County). This farm plants 180 acres of sorghum for silage annually. Milk sales account for 94 percent of 2008 gross receipts.

WID145 A 145-cow, moderate-sized eastern Wisconsin (Winnebago County) dairy. The farm plants 180 acres of silage, 90 acres for hay, 150 acres of corn, and 130 acres of soybeans. Milk constituted 86 percent of this farm's 2008 receipts.

WID775 A 775-cow, large-sized eastern Wisconsin (Winnebago County) dairy. The farm plants 696 acres of hay and 454 acres of silage each year. Milk sales comprised 95 percent of the farm's 2008 receipts.

NYWD1200 A 1,200-cow, large-sized western New York (Wyoming County) dairy. This farm plants 1,900 acres of silage and 200 acres of corn annually. Milk sales accounted for 95 percent of the gross receipts for this farm in 2008.

NYWD600 An 600-cow, moderate-sized western New York (Wyoming County) dairy. This farm plants 600 acres of silage, 450 acres of haylage, 100 acres of corn, and 50 acres of hay annually. Milk sales accounted for 94 percent of the gross receipts for this farm in 2008.

NYCD110 A 110-cow, moderate-sized central New York (Cayuga County) dairy. The farm plants 30 acres for hay, 90 acres for corn, and 185 acres for silage annually. Milk accounted for 91 percent of the gross receipts for 2008 on this dairy.

NYCD550 A 550-cow, large-sized central New York (Cayuga County) dairy. This farm plants 625 acres of hay and haylage and 475 acres of silage. Milk sales make up 93 percent of the 2008 total receipts for this dairy.

VTD140 A 140-cow, moderate-sized Vermont (Washington County) dairy. VTD140 plants 30 acres of hay, and 190 acres of silage annually. Milk accounted for 92 percent of the 2008 receipts for this farm.

VTD400	A 400-cow, large-sized Vermont (Washington County) dairy. This farm plants 100 acres of hay and 900 acres of silage annually. Milk sales represent 93 percent of VTD400's gross receipts in 2008.
MOCD500	A 500-cow, large-sized southwest Missouri (Dade County) dairy. The farm plants 210 acres of hay, 320 acres of silage, and 70 acres of improved pasture annually. Milk accounted for 94 percent of gross farm receipts for 2008.
MOGD500	A 500-cow, grazing dairy in southwest Missouri (Dade County). The farm plants 40 acres of silage annually, and grazes cows on 345 acres of improved pasture. Milk accounted for 93 percent of gross farm receipts for 2008.
FLND550	A 550-cow, moderate-sized north Florida (Lafayette County) dairy. The dairy grows 130 acres of hay each year. All other feed requirements are purchased in a pre-mixed ration. Milk sales accounted for 94 percent of the farm receipts.
FLSD1500	A 1,500-cow, large-sized south central Florida (Okeechobee County) dairy. FLSD1500 plants 100 acres of hay and 400 acres of silage annually. Milk sales represent 94 percent of 2008 total receipts.

2008 CHARACTERISTICS OF PANEL RANCHES PRODUCING BEEF CATTLE

MTB500 A 500-cow ranch located on the eastern plains of Montana (Custer County). MTB500 runs cows on a combination of owned land and land leased from federal, state, and private sources. Federal land satisfies one quarter of total grazing needs. The ranch owns 14,000 acres of pasture. 640 acres of hay are produced annually on the owned land. Also, all deeded acres are leased for hunting. Cattle sales represented 98 percent of this ranch's 2008 receipts.

WYB335 This 335-cow ranch is located in north central Wyoming (Washakie County). The ranch leases 2000 AUMs from the U.S. Forest Service and owns 1,000 acres of range. In response to drought, the ranch has begun leasing 700 acres of private pasture. Annually, the ranch harvests 305 acres of alfalfa and grass hay on owned ground. The ranch backgrounds two-thirds of its calves for ninety days. In 2008, cattle sales accounted for 74 percent of gross receipts, while hay sales accounted for 25 percent.

COB250 This 250-cow ranch is located in northwestern Colorado (Routt County). Federal land provides seven percent of the ranch's grazing needs. The ranch owns 2,300 acres of rangeland, and the cattle graze federal land during the summer. COB250 harvests 450 acres of hay each year at a projected yield of 2.5 tons per acre. Cattle sales accounted for 65 percent of the ranch's 2008 total receipts.

MOB250 A 250-cow beef cattle operation is the focal point of this diversified livestock and crop farm located in southwest Missouri (Dade County). MOB250 plants 120 acres of corn, 120 acres of wheat, 160 acres of soybeans, and 560 acres of hay. Improved pasture makes up another 570 acres of this ranch. During 2008, cattle sales comprised 48 percent of gross receipts.

MOCB400 MOCB400 is a 400-cow beef cattle farm located in central Missouri (Dent County). This farm consists of 1,060 acres of owned ground and 500 acres of leased ground. Annually, 410 acres of hay are harvested on owned land. 2008 cattle sales represented 93 percent of MOCB400's cash receipts.

NMB240 NMB240 is a 240-cow ranch located in northeastern New Mexico (Union County). In 2002, this ranch liquidated 20 percent of its mature cowherd in response to oppressive drought, culling 60 of its 300. With improving range conditions, ranchers have opted to fill the gap with summer stockers. Accordingly, 200 summer stocker steers were added to this ranch. During 2008, 83 percent of gross receipts were derived from cattle sales with the balance of receipts generated from fee hunting.

FLB1155 This is a 1,155-cow ranch located in central Florida (Osceola County). FLB1155 runs cows on 5,400 acres of owned improved pasture, from which 3,560 acres of hay are harvested annually. Sales of sod are a burgeoning source of agricultural income for area ranches. During 2008, cattle sales represented 85 percent of total receipts.

NVB700 NVB700 is a 700-cow ranch located in northeastern Nevada (Elko County). The operation consists of 1,300 acres of owned hay meadow and 8,725 acres of owned range, supplemented by 4,450 AUMs leased from the U.S. Forest Service. Each year, the ranch harvests 975 acres of hay. Annually, cattle sales represent all of the ranch's receipts.

CAB500 Located in the northern Sacramento Valley (Tehama County, California), this 500-cow operation covers 10,000 acres of deeded and privately owned leased range. Additionally, 2,000 AUMs are leased from the federal government. All 2008 receipts were generated by the cow-calf operation.

SDB375 SDB375 is a 375-cow West River (Meade County, South Dakota) beef cattle ranch. This operation produces hay on 1,150 acres of owned cropland, and runs its cows on 6,700 acres of owned native range. In 2008, calf and culled cow/bull sales accounted for 100 percent of gross receipts.

TXSB200 A 200-head cow-calf operation is the central focus of this full-time agricultural operation in south central Texas (Gonzales County). Faced with continued drought, the ranch liquidated 30% of its mature cowherd in 2006. Contract broiler production is an important source of agricultural revenue for this ranch; even so, cattle sales accounted for 69 percent of 2008 gross receipts.

TXRB500 The western Rolling Plains of Texas (King County) is home to this 500-head cow-calf operation. This ranch operates on 20,000 acres (half owned, half leased) of native range. After weaning, calves are placed on wheat pasture and then either sold as feeder cattle or retained as replacement females. Eighty percent of 2008 receipts came from cattle sales, while 20 percent came from fee hunting.

Appendix B. Average Annual Revenue Generated from Selling CO2e for AFPC Representative Farms, 2010-2016.

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Feedgrain/Oilseed	
IAG1350	7,884.8
IAG3400	19,857.9
NEG1960	10,337.8
NEG4300	22,096.8
MOCG2050	11,973.2
MOCG4000	23,362.3
MONG1850	10,513.0
ING1000	5,840.6
ING2200	12,849.3
NDG2180	8,098.9
NDG7500	28,229.4
TXNP3000	15,185.5
TXNP8000	42,052.1
TXHG2000	7,787.4
TXPG2500	12,459.9
TXMG1800	7,008.7
TXPG3760	17,732.9
TXWG1600	3,115.0
TXUG1200	2,336.2
TNG900	5,256.5
TNG2750	16,061.6
LANG2500	11,681.1
LAG2640	15,419.1
SCG1500	6,570.6
SCG3500	20,442.0
Wheat	
WAW1725	0.0
WAW5500	0.0
WAAW3500	0.0
KSCW2000	7,787.4
KSCW4500	17,521.7
KSNW2800	4,088.4
KSNW5000	8,244.9
COW3000	5,256.5
COW5640	10,143.1
MTW4500	13,955.1
ORW3600	0.0

Appendix B (continued). Average Annual Revenue Generated from Selling CO2e for AFPC Representative Farms, 2010-2016.

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Cotton	
CAC4000	0.0
TXSP2500	6,391.5
TXSP3745	8,952.6
TXRP2500	4,867.1
TXCB2250	8,760.9
TXCB8000	31,149.7
TXVC4500	8,322.8
TXEC5000	21,026.1
GAC2300	10,075.0
TNC1900	10,921.9
TNC4050	23,654.3
ARNC5000	29,202.9
ALC3000	17,521.7
NCC1500	8,760.9
Rice	
CAR550	0.0
CAR2365	0.0
CABR1300	0.0
CACR715	0.0
TXR1350	0.0
TXR3000	0.0
TXBR1800	0.0
TXER3200	0.0
LASR1200	0.0
ARMR7500	32,853.2
ARSR3240	0.0
ARWR1200	0.0
ARHR3000	0.0
MOWR4000	0.0

Appendix B (continued). Average Annual Revenue Generated from Selling CO2e for AFPC Representative Farms, 2010-2016.

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Dairies	
CAD1710	40,914.2
WAD250	0.0
WAD850	14,006.7
IDD1000	16,478.2
IDD3000	49,435.6
TXCD550	13,159.8
TXCD1300	31,104.0
TXED450	0.0
TXED1000	23,926.9
TXND3000	71,779.6
WID145	0.0
WID775	9,153.1
NYWD1200	14,173.1
NYWD600	7,086.6
NYCD110	0.0
NYCD550	6,495.7
VTD140	0.0
VTD400	0.0
MOCD500	8,239.1
MOGD500	8,239.1
FLND550	13,159.8
FLSD1500	35,889.3
Ranches	
MTB500	0.0
WYB335	0.0
COB250	0.0
MOB250	0.0
MOCB400	0.0
NMB240	0.0
FLB1155	0.0
NVB700	0.0
CAB500	0.0
SDB375	0.0
TXSB200	0.0
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