DRAFT

Minutes
LEGISLATIVE COMMISSION ON GLOBAL CLIMATE CHANGE

Tuesday 25 April 2006
10:00 a.m.
643 Legislative Office Building

The Legislative Commission on Global Climate Change convened its fourth meeting on Tuesday 25 April 2006 at 10:00 a.m. in Room 643 of the Legislative Office Building with Mr. John Garrou, Co-Chair, presiding. Other members present were: Representative Joe Hackney, Co-Chair, Senator Charlie Albertson, Senator Pittenger, Representative Wilma Sherrill; Representative Alice Underhill, Representative Winkie Wilkins, Ms. Caroline Choi, Dr. Douglas Crawford-Brown, Mr. Walter Clark, Dr. Dolores Eggers, Dr. Edward W. Erickson, Dr. George Everett, Mr. Preston Howard, Dr. Daniel Phaneuf, Mr. Tim Profeta, Dr. Sethu Raman, Dr. Stanley Riggs, Mr. Michael Shore, Mr. Robert Slocum, Dr. Stephen Smith, Mr. James Stephenson, Mr. Tim Toben, Mr. Ivan Urlaub, Dr. Godfrey Uzochukwu. Absent were: Senator Janet Cowell, Representative Becky Carney, Representative Pricey Harrison, Mr. Thomas Cecich, Mr. Barry Eveland, Mr. Robert Glaser, Mr. Michael Nelson, Mr. Mitchell Peele, and Ms. Susan Tompkins.

A copy of the meeting notice for this meeting, a copy of the agenda and the visitor's registration are attached to these minutes as Exhibits A, B, and C.

Mr. Garrou called the meeting to order and welcomed everyone to the fourth meeting of the Commission of Global Climate Change. The co-chair had no introductory remarks so he asked Mr. Givens to come forward.

Mr. Givens thanked Mr. Garrou and hoped that everyone works together to get through two exciting panels of presenters. At the last meeting minutes were distributed for the 3 Feb. meeting and those minutes are available for approval if the co-chairs so desire. They are referred until a later date. The minutes of the second meeting (5 April) will be distributed electronically later today and your help is needed with a few things. If you search the word inaudible and know what goes in that blank, we would appreciate it. In addition to other materials distributed to you, attached to your reminder notice is a transcript from the second meeting that was intended to resolve what was said that was sent to you by the request of the co-chairs. Also, an item from the Wall Street Journal of 11 June of 2001 is submitted by Senator Pittenger (Exhibit D) and a publication titled North Carolina Climate is submitted by Sethu Raman, our State Climatologist (Exhibit E).

We have a morning panel and an afternoon panel. The first panel is on technology, the second panel on economics. Our next meeting will be scheduled after Sessions ends.

Mr. Garrou called on the first speaker, Dr. David Green, Corporate Fellow from the Oak Ridge National Laboratory in Knoxville, TN to talk about the transportation sector.

Dr. Green: Good morning. It certainly is a pleasure to be here. There are a few key points I would like to make in my presentation this morning about transportation. The first one is that very often it's said that little can be done with the transportation sector. I and a colleague at Massachusetts Institute for Technology did a study for the Pew Center on Global Climate Change which I think they are providing a copy (Exhibit F) to you which shows that using a mixture of policy economic measures but also regulatory as other measures that you should be able to reduce greenhouse gas emission from transportation in the United States by 20-25 percent by 2015 and by as much as half by 2030 (Exhibit G), compared to a case in which we don't make active efforts to reduce greenhouse gases. Now I'll be drawing to a large extent from that study about the United States and there are significant differences between what can be accomplished at the national level and what can be accomplished by a single state acting on its own. I'll mention some of those but I hope we will have time for questions to get into others.

The second point I would like to make is there is no one simple policy that accomplishes every thing that can be done in the transportation sector. The transportation sector differs in many respects from the other sectors of the economy. First of all, governments have a very large role in providing and regulating transportation infrastructure, the states especially do. This is not the case, for example, in the industrial sector for the most part. And there are, as I will spend quite a bit of time trying to explain significant market failures in markets for automotive fuel economy. And I'm not talking about the extra-nalities as we say of climate change in greenhouse emissions. I'm talking about an inefficient market for fuel economy and I'll try to explain that. And of course, we all know, and we're feeling right now the fact that there are not sufficient competitive alternatives to petroleum to power our transportation system. We know that well, in spite of having worked on alternative fuels for the past two/three decades. It's important, also that we advance technology. Technology such as hydrogen fuels sells vehicles are not yet ready for the market place. And if we want to get the benefits of those, we have a lot of work to do to improve the technology.

And then there is a strong inter-dependence between the way we build our communities and the amount of transportation we have to do. And that land use decisions are under state and local control for the most part. There are other areas as well in which state and local policy will and should differ. Little bit of background we have not surprisingly the largest transportation system in the world, 5.4 trillion passenger miles of travel. That is to give you a rough measure enough to send everybody in the United States around the world once every year. Three point eight trillion ton miles of freight, the transportation is second to industry in greenhouse gas emissions but the largest emitter of carbon dioxide. And the carbon dioxide emitted from our transportation sector is more than the carbon dioxide emitted by any other country in the world in total except for China. Most of this carbon dioxide comes from highway vehicles, 72% and over half of the carbon dioxide comes from passenger cars and light trucks. This shows that graphically you can see transportation shooting past the industrial sector in carbon dioxide emission just before

the turn of the millennium. As far as what kinds of greenhouse gas emissions comes from transportation, its all about carbon dioxide. There is a little bit of methane that is produced a little bit of nitrous oxide from our catalytic converters mainly that keep the air clean, we need those and some haligenous flora carbons from our air-conditioners but almost all of it, 96 percent is carbon dioxide. So when we talk about transportation, we're talking about CO_2 emissions. The graph illustrates the dominance of light duty vehicles, passenger cars and light trucks and those emissions, heavy vehicles airs in just seconds of the highway mode followed by water, rail and others.

One proposal for reducing carbon emissions that is a useful proposal but not a solution to the big problem is to move people to transit. Of all forms of public transit in the US as this pie chart illustrates, deliver about one percent of passenger miles of travel in the United States. So to have a significant dent on the transportation sectors carbon dioxide emission by increasing public transit, you would have to have an enormous investment in public transit to make a significant dent. That's not to say it's not a useful thing to do, that it can't in the long run have benefits, but it has to be one small piece of a larger strategy. Not only that the differences in energy intensity and carbon emissions across modes of transport are not as great as one might think as the graph shows. Shifting modes of traffic turns out to be on one hand difficult and on the other hand not as productive as you would hope. The single biggest strategy we have had for reducing our oil dependence over the past 30 years and the single biggest strategy we have in the future for reducing carbon emissions from transportation is to increase fuel economy.

First of all, we know that meaningful increases are achievable at low to moderate cost. I've been on two national cabinet panels looking at cooperate average fuel economy standards and the technological potential for increasing fuel economy. Both panels concluded that significant improvements in fuel economy could be made at cost that would be paid for by the fuel savings over the life of the vehicle and it would not call for reductions in the size or the performance of vehicles. This is a big opportunity. Of course, no infrastructure changes are required to do this and there are barriers however. And the key barrier I want to talk about today is the consumer evaluation of fuel economy and their car buying decisions.

There are many ways to implement policies to increase fuel economy. Corporate average fuel economy standards are just one, there are economic instruments that could be used, the National Highway Transportation Administration has just proposed a major reform of the fuel economy standards which I think is well worth looking at and solves many of the objections with respect to fairness of the standards, with respect to possible safety impacts, my own view is that is essentially a red herring. But there are many ways to skim this cat, let's put it that way and one can pick one.

Since 1978 when cooperate average fuel economy standards first took effect, they were passed in 1975, the fuel economy improvements we've made in this country are saving us an enormous amount of gasoline. We would be consuming 50 billion gallons more gasoline every year had we not improved the fuel economy of passenger cars and light trucks, a strategy that we know works. And we know that essentially it was the fuel

economy standards that we largely responsible for bringing about that improvement in light duty vehicle fuel economy. Here you see the standards plotted against the history of new passenger car and light truck fuel economy and they track almost exactly. We also see here that we really haven't improved passenger car or light truck fuel economy in about 20 years and that therefore the shift that we all know about from passenger cars to light trucks has actually resulted in a reduction in fuel economy. This improvement has been estimated by scientific panels and these panels have found that technologies exist if applied to passenger cars and light trucks will significantly reduce fuel consumption within 15 years and obviously greenhouse gas emissions as well. A little bit less potential for smaller passenger cars and larger potential for SUVs and larger light trucks, but these are all cases where the value of the fuel savings over the life of the vehicle exceeds the cost of the fuel economy technology required to improve miles per gallon, with no change in the size, weight or performance of the vehicles. Of course, vehicles have been getting larger and more powerful all the time so we might have to forego some future increases in weight and performance in order to achieve this. These numbers that the National Academy finally came up with do not include the potential impacts of hybrids or clean diesel vehicles which are coming along. Each of which could offer a further 30 to 40 percent improvement in fuel economy.

But technology alone doesn't do the job; we need some policy for a variety of reasons. The Environmental Protection Agency estimates that had the new 2005 light duty vehicles fleet had the same distribution of performance and the same distribution of weight as the 1987 it could have achieved about 24 percent higher fuel economy. That's almost entirely due to the performance increase the weight is just a little bit higher. This graph shows a number of advanced technologies that are on their way that can expand the potential to improve fuel economy at a lower cost than is possible today. There's a constant increasing supply of technology to this vehicle manufacturing sector that allows them to potentially continue to improve fuel economy over time.

Part of the problem here is us the consumers. Economist assumes generally, that consumers will evaluate the full fuel savings of fuel economy improvement over the life of the vehicle which today is about 15 years. Discount that fact to present value and compare that with the cost of improving fuel economy or with a trade off that might have to make against performance or weight. But a recent study by the University of California at Davis in depth interviews of 60 households, their full lifetime history of buying cars and selling cars found no evidence that this rational economic model of behavior exists. Out of the 60 households, only nine stated that they had ever considered fuel economy in buying a vehicle. Only four knew how much they spent each year on fuel and none had made any kind of quantitative comparison of the value of fuel savings over one year verses another. We know from other surveys that 40 percent of US car buyers don't consult any source of fuel economy information, not the window sticker, not the fuel economy guide, not any of the many other sources including our website fueleconomy.gov when they buy a car.

But consumers are not completely irrational, there's a reason why they don't consider fuel economy. This shows data from the National Academy of Sciences study, the red

curve is the cost of increasing fuel economy from a typical passenger car which is about 28 mpg and it shows the value of fuel savings in the solid black line as a discounted present value of fuel savings over the life of the vehicle. Consumers are interested in neither the total cost nor the total savings but what they're interested in is the difference between the two. What do they get out of it, what is the net value and that's plotted in this gray line. The point I would like to make about that is that over a range of about 10 mpg from 31 to 41 mpg there is not more than one or $200 difference in this net value. Never mind the uncertainty that consumers feel about what those EPA fuel economy numbers really mean. The real value is on a par with wheel covers, floor mats and those types of things. Consumers have a lot more important things to think about when they're buying a new car, especially negotiating the price for example. This is not, even for a perfectly rational consumer, going to be very high on the list of things to worry about. However, we know that consumers don't fit that model and manufacturers use a rule of thumb as they've told us in research over the years. Consumers will pay for about three years worth of fuel savings, they believe. If you use that rule, then this gray line shows the net value of fuel economy improvements to consumers. Again, there is a wide range of fuel economy over which there is almost no difference in net value and furthermore there is almost no incentive to improve fuel economy here if you believe this. Manufacturers tell us they believe it, Honda says 50,000 miles of fuel savings, Toyota says four years, some other manufacturers say two years, but on average about three years is what the manufacturers believe. If you believe this, there is no reason to use technology to improve the fuel economy of cars; rather you should put it into performance and other factors.

As we note today, after consumers buy their cars they do realize sometimes that they care about the fuel economy every time they go to the pump. We run the fueleconomy.gov website for the Environmental Protection Agency and the Department of Energy. We know there is tremendous interest on the part of consumers in ways to improve their in use fuel economy. This is an area in which states can have an influence, by speeding and aggressive driving is probably the single most important factor that degrades the fuel economy of vehicles. A driver who likes to pass every one on the road, who likes to weave in and out of lanes, stomp on the accelerator, and consequently using the brake as well, can cost himself 30 to 40 percent in fuel economy. There are other factors that have lesser impact, tire inflation, tune-up and removing excess weight from your car, a variety of tricks that can give you a significant improvement in real world fuel economy. We know consumers are interested in this because they come to our website and try to learn about it.

Another strategy for reducing the carbon emissions from transportation and that is lower carbon fuels. We have a lot of experience in the United States with alternative fuels, vehicles that can run on compressed natural gas or methanol or LPG but not gasoline. Those frankly have not been successful in achieving large market shares. What have worked, is what we call replacement fuels, fuels that can be blended with conventional gasoline or diesel fuel and which have lower carbon content. No change in infrastructure, no change in the vehicles. You have heard the President say we have five million flex fuel vehicles running around on the road today that are capable of using 85 percent

ethanol, 15 percent gasoline. Every gasoline using vehicle on the road is capable of using up to ten percent ethanol. Ethanol from corn reduces carbon emissions on an energy equipment basis by anywhere from 20 to 30 percent. There are still some studies and people going around saying that's not true but recent articles and science demonstrated that those studies are incorrect and there is a small but none trivial reduction in carbon from ethanol made from corn but far better than ethanol made from corn is ethanol made from cellulose which the President also highlight in his State of the Union address and that can reduce carbon emissions on an energy equipment bases by about 90 percent. I don't know the situation in North Carolina well enough to know what the potential here is for using agricultural waste products and dedicated agricultural products to produce cellulosic ethanol, but that would certainly be something that could have a significant impact on greenhouse gas emission if it could be done. This graph shows the relative greenhouse gas emissions from ethanol based on a number of different studies and you can see there some ethanol produced from cellulose has only about 10 percent of the greenhouse emissions of gasoline. Without going into the slide in much detail, the Departments of Energy and Agriculture have estimated that there is really a very substantial potential to increase bio-fuel production in the US.

To make a significant impact on the transportation sector it is not enough to have a single policy, carbon tax, carbon cap and trade system, it simply will not have a huge impact. A $50 a ton carbon tax translates into about $.25 per gallon of gasoline. Things like that would send a tremendous signal to save the utilities sector to switch from coal to something with lower carbon will have only a minimal impact on transportation. You have to have a mixture of policies at the national level and at the state level. I'm sure you have seen other lists as well. It's important to combine everything from consumer information with regulatory strategies, with pricing strategies, with land use and transportation planning strategies all the way down the line.

I just want to reiterate what I said in my first slide that when you put all of these strategies together a few substantial potential to reduce transportation greenhouse gas emissions. We found practical strategies that either pay for themselves in fuel savings or are useful in doing these like reducing traffic congestion or air pollution that could reduce greenhouse gas emissions by up to 50 percent by 2030 and even more is possible with policies that are more expensive. This show a kind of rainbow slide how those policies stack up and you can see that aside from light duty vehicle efficiency improvement there are no strategies that just dominate. It is a number of things that need to be done.

I would like to close in effect by making a few remarks about how state policies differ from the national policy context and I'm sure the people here are well aware of that. Greenhouse gas emission standards such as the California standards simply at the state level for a single state like North Carolina would not have the leverage on manufacturers to persuade them to implement technology that would a national greenhouse gas emissions standard. On the other hand, California alone represents ten percent of the North American vehicle market when you add to that the northeast states and build other states on that. You have about a third or so of the North American vehicle market and no manufacturer can ignore a market that size. It depends not only then on what you do but

what everybody else is doing at the same time. My own belief is that a manufacturer faced with a number of significant states adopting such standards should they stand up in court, as you all know they are being challenged in court, would probably ask for one simple standard that they make for the whole country. States I think also have a key role to play in educating motorist, that's really important both in terms of how they drive, how they maintain their vehicles, but also how they use fuel economy information to select vehicles. States can play and do, such as the state of Minnesota, play an important role in promoting biomass fuels. And states and local governments have the greatest influence when it comes to the transportation system and the transportation infrastructure, land use planning and those factors that accumulatively all put together can have a major effect on transportation demand. I've said many times, a comprehensive approach is essential for the transportation sector. Thank you for your attention if there's time I'll be happy to take any questions.

Mr. Garrou thanked Dr. Greene and called for questions.

Rep. Wilkins asked if we could have Dr. Greene back up about three frames to that multi-colored frame so that we might have a moment to look at it.

Dr. Greene – This comes from the Pew Center study that I mentioned and is explained in detail there.

Dr. Smith had a couple questions about state local policies. Is there any experience with differentiating the local registration to give a sentence for higher fuel economy vehicle sales or lower and pricing for securing your state or local registration, do you have any knowledge of anything like that?

Dr. Greene – There have not been significant policies actually implemented along those lines to my knowledge. There have been a number of studies of policies called peabics in which one picks what I would call a pivot point, that any empty g-value for gallons per mile, above which you pay a penalty. So if you consume more fuel than that per mile you pay a penalty when you buy the vehicle and if you are below that you receive a rebate. Such a system can be designed such that the revenues taken in equal the revenues paid out. This can have a very significant impact on the vehicle fleet fuel economy, however, 90 percent or so of that impact comes from manufacturers implementing technological design changes in the vehicles and only about 10 percent from these studies. We don't have a real world example of the peabic system except the gas guzzler tax. Those can have a very significant impact on fuel economy but most of it comes from changing the design of the vehicle, the actions of manufacturers not the mix-shifting from consumers buying smaller, less powerful, more fuel efficient cars. Studies have been done by Canada for what would happen if the Canadian government implemented a peabic system but the United States did not and you get only about 10 to 15 percent of the potential impact split about half between vehicle changes and consumer mix-shift. One state going alone on this has a difficult problem because the manufacturers may not pay attention. They may not decide to redesign vehicles just for your North Carolina peabic

system. But if a nation as a whole did it, it could have a very significant impact similar to the true economy standards.

We do have a gas guzzler tax many people don't realize that because it applies to so few vehicles, Ferraris etc. That gas guzzler tax essentially persuaded all the manufacturers that those are very high performance high priced vehicles to make sure that those vehicles don't pay any of that tax. We do have some experience with that and the tax was effective and unfortunately applies to only passenger cars and not light trucks. So you're squeezing the passenger cars and essentially and not gas guzzler tax for light trucks.

Dr. Smith: Follow-up question, a little different direction. As far as the ag. fuels you spoke about, what about now that the heavy duty diesel rule is coming in, the opportunity for more higher efficiency diesel vehicles, the diesel is generally a better fuel because of the BTU value and the diesel hybrids getting market penetration in the United States. What are your thoughts about that and then how does the buy diesel play into an opportunity for both increasing fuel economy and also getting a lower carbon fuel into the marketplace?

Dr. Greene: Right there have been tremendous advances in diesel technology made in over the past two decades and mostly in Europe. Modern diesel engines are quieter they are almost as quiet as a gasoline engine and they don't smell like diesels, they don't put out black smoke anymore. They have good acceleration performance because they're all turbo charged and improvements have been made. They are excellent for towing things and those kinds of applications where you need a lot of torque. The problems the diesels have had is meeting the new emissions standards and with the new tier two emissions standards they will need to get into bin five or better. All of the ones sold today are in bin one that's not good enough. They will have to do better. They have two problems, particulate emissions and knox emissions. The particulate emissions problem is solved both from a technical point of view and an economic point of view. Their particulate traps works, they're durable and not too expensive. Now the problem is knox. The solution that the Europeans are going with and that heavy trucks in the US appear to be going with is the selective catalytic reductions system. That requires that you have Eurea underneath the vehicle to act as a reductant. How will that play out? So far the catalytic system and those things don't require any maintenance or any replenishment of fluids on the part of the owner. So far those don't work well enough to meet the tier two standards. They may some day, they're getting better and better, but right now what works is this Eurea basic selective catalytic reductant system and it remains to be seen how consumers will react to that. It's not like you have to do it every time you fill up, maybe every 3,000-4,000 miles, you would need to make sure this tank is filled up. But from the EPA purposes they would want to make sure that it never ever was depleted and you would never run your car without that. Given that I think diesels can be reasonably priced and meet the tier two standards. Under those circumstances my own view is that they can achieve a substantial market share in the US especially for light trucks and larger passenger cars.

Unfortunately, I have a negative view of bio-diesel. It s a fine fuel for a niche market but I don't see it as being a major fuel partly because of cost and partly because of the yield from agricultural land it comes the oils of the plants and you will always have a much smaller yield from that than from say ethanol either made from sugar cane or ethanol made from cellulose where you can use most of the energy from the sunlight that's been stored in the plant. That is my personal view.

Mr. Garrou: Senator Pittenger.

Senator Pittenger: Thank you Mr. Greene. Thank you very much for your presentation. I have two questions one is related to the efficiency of the cars and the correlation between efficiency and the make of the car. What studies have you seen that reflected the impact relative to serious accidents and deaths as a result of the lighter weight vehicles?

Dr. Greene: Right. There is a fairly substantial literature on this. Up until the National Academy report in 2002 almost all of this literature said that decreasing the weight of the vehicles would lead to increased traffic fatality and injuries. I was on the National Academy panel at that time and I looked very carefully at this evidence. In my own mind I came to the conclusion that it was seriously flawed for the application for this problem. It's a very complicated question but basically if I could try and summarize it, it comes down to this. The key argument has to do with fundamental laws of physics and collisions of objects. If an object with greater mass collides with an object of lesser mass, the change in velocity experienced by the object of lesser mass will be injuriously proportional to its weight. In other words, if a small car hits a big truck, the big truck will keep going and the small car will reverse direction. It is well known that the probability of fatality goes up greatly with the change in velocity experienced by the car to the fourth power, a huge factor. So in a collision between two objects there is no doubt that the object with bigger mass will be safer for its occupants than the object with smaller mass. It's no question about that. However, the fuel economy standards apply to both vehicles so the question is now what happens when the weight the mass associates with is reduced. Here the laws of physics say nothing, because it's the relative mass of those vehicles that matters, not the absolute mass. So now this question changes from fundamental laws of physics to how did you design the vehicles, what are the vehicles made of, how do those materials perform under crash conditions and it gets extremely complicated and it's all about the engineering and design and not about fundamental laws of physics anymore.

Looking at the National Highway Traffic Safety Administration study the best study that was available at that time and applying that reasoning, what I discovered was that their model also predicted no change in fatalities and vehicle to vehicle collisions if you took ten percent of the weight out of one vehicle and ten percent of the weight out of the other. Since that time there have been a number of studies that have challenged the view that was prevailing at the time and a number of peer reviewed articles that essentially say that there is no impact of fuel economy on traffic fatalities. One of them is my own study published in the Transportation Research Record in 2004. I think that at the present time

the best understanding of this issue is that from societal prospective taking mass out of vehicles without changing the size of the vehicle would either be neutral with respect to safety or beneficial with respect to safety. There is a major study done by DRI funded by Honda that shows that taking some weight out of vehicles but maintaining their size, material substitution mainly, would be beneficial to safety. Finally, weight reduction is one strategy out of many for increasing fuel economy and reducing greenhouse gas emissions. Although the weights of vehicles were decreased in the late 1970's in response to higher gas prices and fuel economy standards that cars and light trucks sold today combine light duty vehicles weigh more than the cars and light trucks sold in 1975 on average and get significantly better fuel economy about 75 percent better fuel economy.

Senator Pittenger: This may not be the question to ask Dr. Greene but maybe others might know. I read in the paper a couple of months ago that we waived the requirement for emission testing on older cars, 1995 or older, is that correct did any of you all read the same thing? If so why did we do that?

Dr. Greene: Emissions testing from older cars is generally a state requirement rather than a national requirement.

Senator Pittenger: Right, I'm saying that North Carolina waived that.

Dr. Greene: I don't know the answer to that.

Mr. Givens: We made the decision as a state a few years ago to shift technology from tail pipe technology to what's called on board diagnostic. OBD first became available in 1996 model vehicles as time goes on the number of vehicles that are in the fleet for any given year go down so there was a determination made essentially that because at the same time we were expanding from the nine original counties and we're now up to 48 counties where we have vehicle emissions testing. The cost of the analyzers for tail pipes is an order of magnitude higher than the cost of the OBD technology in other words $3,000 maybe for an OBD analyzer verses $30,000 for a tail pipe analyzer. So there's no thought about requiring tail pipe test in the expansion counties because the vehicles that would be available the pre 1996 vehicles were a declining fleet of vehicles. What we really did is say that within the original nine counties we would allow the tail pipe tests to continue for a period of time in order to advertise the investment that inspection stations had made in those expensive analyzers but not require the purchase of new analyzers. That's how we got to where we are.

Mr. Shore: Thank you. So hybrid cars seem to be coming more and more popular in North Carolina and I am curious are they reflected on this graph that's showing up there and can you just talk a little bit about the potential of getting more hybrids on the road as a tool to reduce global warming pollution.

Dr. Greene: Right. No, hybrid vehicle technology is not reflected in here. We use the National Academy of Sciences study for our technology potential for light duty vehicles

that did not include hybrid or diesel. I think hybrid sets a very substantial potential the cost of hybrids keeps coming down. I had the opportunity two years ago to meet with Toyota, Honda, and some others who are making hybrids and hybrid components in Japan and talk with their engineers about their cost targets and where they are going. The conclusion is that hybrid vehicle cost will come down, I think to about half of what they started out. They started out being about $4,000 more expensive for a mid size car then it came down to about $2,000. Now that is well within the range of what a consumer might pay to get a more efficient vehicle. I think the problems that people initially thought might occur with hybrids have been over come. People worried about the battery life, the battery life is certified to 100,000 miles and the manufacturers believe they will last considerable longer than that. I think hybrids do have tremendous potential and the sales of hybrids will grow as more makes and models of hybrids are offered. Of course the tax credit that is now available will help as well.

Mr. Toben: Thank you Mr. Chairman. Dr. Greene the first slide you presented reads using a mix of practical political measures US transportation should be able to cut greenhouse gas emissions by 20 to 25 percent by 2015 and 45 to 50 percent by 2030. At the end of the presentation you spoke to the economic impact, could you just speak to the economic cost where a return associated with these reductions at those levels?

Dr. Greene: Right. This is an extremely important point because many economic studies from the top will come to the conclusion that almost nothing happens in the transportation sector and the reason is because you need to attack the transportation sector from many different angles and different ways. When you do that it can be done very cost effectively. For example the biggest bar you see here is light duty vehicle efficiency. Those improvements over the life of the vehicle are paid for by the fuel savings at, in the case of our study, $1.50 per gallon. The air efficiency improvements are also cost effective the heavy truck efficiency improvements are also cost effective. The low carbon fuel in 2030 is mostly cellulosic ethanol and that requires some technical advance. So if we don't get the advance in technology that we hoped for that may not be economical. The hydrogen requires very significant technological improvements. We are working on it hard but there is no guarantee that's going to work. The carbon cap is simply a $50 a ton of carbon equivalent tax and so that cost whatever that cost. Pricing strategies are shifting the incidence of cost not changing the total cost of travel. For example, the most significant pricing strategy there is taking about 25 percent of the cost of automobile insurance and shifting it to a tax on gasoline. That gives everybody who drives a car a minimal amount of insurance, it makes some of the cost of insurance proportional to how much driving you do but requires everybody to sign up with some insurance company for the rest of that cost and if they belong to a high risk pool or something like that. This doesn't change the cost of travel at all but it does move the incidence around in a way that's beneficial to reducing carbon emissions.

The systems changes and the land use changes are very difficult to say what those cost are because its extremely difficult to quantify what is the cost of making sure that walking and cycling are options in a newly constructed community verses not building any sidewalks or not having any bike paths or anything like that and not constructing the

community in a way that people can walk from one place to another. Those kinds of things the costs are very difficult to quantify and we did make an attempt to do so.

Mr. Clark: Thank you Mr. Chairman. Mr. Greene state governments often have very large motor pools and have a large inventory of vehicles, are you aware of any states around the country that provide good examples of state governments setting a good example by using hybrids or alternative fuel vehicles?

Dr. Greene: I guess off the top of my head I can't say, I'll be happy to get back to you on that. I'm sure there are I'm just not connecting at this point.

Mr. Garrou: Thank you very much Dr. Greene for your presentation. Our next speaker is Dr. Edward Rubin from the Center for Energy and Environmental Studies, the Department of Engineering and Public Policy at Carnegie-Mellon University. Dr. Rubin. Thank you for coming sir.

Dr. Rubin: Thank you Mr. Chairman, it's a real pleasure and honor to be here. Before I get started Mr. Chairman I would like the record to note that I meet the official definition of an expert that being someone who comes here from more 500 miles away. I say that because on this topic and several of the others you certainly as I am sure you know, have many valuable local resource persons who are certainly as knowledgeable as many of us are including two of my best former students who are faculty members at two of your great North Carolina campuses. So with that caveat let me take on the assignment that I was asked to do here which is talk about greenhouse gas reductions from the electric power sector. I want to basically try to touch on three questions, first why focus on the electrical power sector secondly and mostly talk about what options are available to reduce power sector emissions of greenhouse gases and finally what some of the key policy considerations and options might be.

First the why question. The answer is perhaps intuitive but I wanted to start here with two points. I know in past presentations you have had extensive deliberations about climate change and greenhouse gases. You know that carbon dioxide is not the only greenhouse gas but it certainly is the dominant greenhouse gas of concern for climate issues. For the electric power sector it is perhaps unquestionably the major focus, so for simplicity I want to try to focus on this major greenhouse gas of CO_2. The picture before you (Exhibit G) is a sketch showing where CO_2 comes from nationally in the United States allocated across the four major activities that give rise to greenhouse gas emissions. This picture does not include power plants at least not directly, it includes the things that we do. The industrial sector that makes all the things that we like to have is roughly another third and the other two bars residential and commercial are essentially energy used in buildings in which we live and work. The carbons are the sources of the CO_2 emissions. So for transportation it's basically an oil related problem, the blue. For the industrial, residential and commercial sectors the largest share of greenhouse gas emissions comes from that top yellow bar which is the electricity. Electricity is one of those things that are an intermediate energy from the raw resources we use. Here is

where the electric power sector comes in. The electric power sector is responsible for about 42 percent of the greenhouse gas emissions.

One important take home message which applies roughly in North Carolina as well as the US is power plants and transportation together accounts for about three quarters of the problem. So electric power plants are the larger source of carbon dioxide in the US as well as internationally and that is the major focus of it, most of that depends on how electricity is generated. Here is a figure from the most recent projections by the US Energy Information Administration which shows the historical trend of US power generation and their so called reference case scenario out to 2030 the dotted line separates the two. In this country a little more than half of the electricity we use comes from coal. The projections of the reference case scenario which assumes no change in policy over the next 25 years assumes substantially higher increases in that amount. I'm curious how many of you here from the legislature believe there will be no change in policies over the next 30 years. So we could throw this scenario out, unfortunately a lot of people take this as the gospel, this is only if nothing else happens along the way. So you know we can be wrong we don't yet know what the right answer is going to be but if we stick with this reference case scenario essentially its business as usual.

The carbon dioxide implications of this are that we will continue to increase substantially CO_2 emissions nationally. I should also note on the handouts (Appendix G) there was a typo it should be millions shown here not thousands as shown on your hard copy. Here is the picture in North Carolina thanks to some data that Judy Greenwald showed you earlier this year. The plants in North Carolina are even more economically core based, a little over 60 percent as opposed to 50 percent nationally. So again coal fired power plants are a major local consideration as well as the key national consideration. Here is a picture of CO_2 emissions from those power plants in North Carolina according to data that PIA puts out and you can see where it is still currently on an upward trend.

The climate change driver has been with us for close to two decades now. A lot of it goes back to the 1992 so called earth summit where the United Nations spring convention on climate change was agreed to 150 countries around the world including the US. The US agreed to the long term goal of stabilizing in the atmosphere the concentration of greenhouse gases so as to prevent dangerous anthropogenic interference from the climate system. A lot of ambiguity as to what that means but the key message is that any policies aimed at stabilizing in the atmosphere of the concentration of greenhouse gases implies over the long term a drastic reduction in CO_2 emissions. Almost independent of what that target is and the time table for achieving it we understand the physics well enough to know that. Over the long term CO_2 emissions have to come down by 70, 80, and 90 percent of what it might be 50 to 100 years from now. It's a long term drastic change in energy pictures that we're looking at to achieve that stabilization goal. And that has motivated a lot of the concerns that motivated the Kyoto protocol and is motivating a lot of the activities around the world today.

So let me focus on CO_2 problem for the power sector and briefly touch on some of the options that are currently available and or will be available in the near term. There are a

couple of general approaches that apply to many other sectors as well. First, any technologies that reduce the demands for electricity will almost proportionally reduce the emissions from electric power generation. Secondly, improved efficiency in the technologies that are used for power generation as well as for transmission and distribution will reduce the amount of fuels that are needed to provide the electricity we like to have and that will reduce emissions. Thirdly, power generation technologies that use energy sources with either lower carbon levels than currently or zero carbon levels will also by definition lower greenhouse gas emissions. And finally, technologies that might be able to both capture and then store or sequester CO_2 produced at power plants could be a fourth option. Now there is a lot of information and large literature on each of these topics, let me try to say a brief word on each of them and perhaps entertain some questions if there is time.

Options to reduce demand is part of the first thing to look at, Mary will follow and elaborate substantially on this so I will say no more than there is an enormous potential here again to go thru and improve efficiency of the technologies that use electricity and potentially ensure the modest initial changes in consumer demand the way the kinds of things we like to have. All of these things can reduce the demand for electricity and reduce emissions from the electric power sector. The programs that are called demand site management which have had often other objectives and these could be part of the solution depending on the details in the specific systems that these potentially could be less beneficial in terms of reducing greenhouse gas emissions although they could be beneficial in managing electricity. The records on DSM programs in general this was in the 80's and 90's, they clearly had relatively small impact in reducing demand but there are substantial variations from one location to another so these are things that demand a location of a specific analysis.

Options to increase the efficiency of generating electricity - this sketch is simply to remind us that with the technology that we currently use in the US today to produce electricity has an efficiency of roughly 35 percent. That is for every 100 units of energy in the fuels that we burn for use to produce electricity we get about 35 units worth of electricity. Now that electricity has different characteristics it is a lot more valuable in some ways thermodynamically than the energy and the fuels but the efficiency is on the order of 35 percent. So we throw about 65 percent of the energy away at the power plant typically in the form of waste heat that goes into the air or water. The transmission and distribution lines that take the electricity from the large power plants and bring it here typically lose about another 10 percent of that electricity in heating and other loses. So we wind up with a system deficiency well in the low 30's percentages. How can we do a better job? Each of the individual blocks potentially could be improved particularly the electrical power plant which is kind of a part of this. There are technologies in use around the world today that are significantly more efficient than the technologies we have in place in this country and in North Carolina. Today these are technologies that use natural gas in what are called combined cycle plants. There are more efficient technologies for burning coal and there are technologies not for burning coal but for turning it into a coal gasification and then using that clean gas to generate electricity in

much the same way that natural gas would do it in a combined cycle plant some call IGCC plants.

Part of the set of options available to improve the efficiency of electricity use that might involve doing away with the transmission and distribution and putting the power plant closer to where the energy is actually needed is called distributed generation. These are typically smaller facilities that might be in shopping centers or neighborhoods. Many of the technologies that are available to do that are smaller and actually less efficient, some substantially less efficient than the power plants we currently use but others like certain kinds of fuel cells that we have now are on the horizon could be substantially more efficient. Again the opportunities there are sites specific, one of the advantages potentially is that this offers in the right environments the ways to use some of that waste heat for heating and air conditioning and other uses that would otherwise require additional fuels to be burned. So there are potentially substantial improvements in the overall efficiency of using energy and along with potentially significant reductions in greenhouse gas emissions.

Finally, there is also technology available that is starting to come into use to do a better job of managing electric transmission and technologies that can improve efficiency at that end as well. Some of the big players have to do with options for using alternative energy sources that are either zero carbon or low carbon emitters. The two I've highlighted here are natural gas and nuclear power. These are the two options that realistically today probably have at least from a technical point of view the largest capability of serving the large amounts of electricity demand we have. Available today but with more illuminative deployment wind is technology whose cost have been coming down significantly biomass is another option particularly here in North Carolina although again it has its limitations. Geothermal resources are located in various parts of the country again potentially conserve but with more limited details. Things like solar and low head hydro also might serve mixed applications. The cost of solar technologies today is still roughly ten times where it needs to be to be competitive with some of the options shown here. All of these options have various kinds of issues both technical, economic, social, and political and limitations that have to be considered. I believe in your handout you have a copy produced last year by three of my colleagues at Carnegie Mellon that goes into substantial detail on all of these things. A report from the PEW Center and I would recommend strongly a look at that for a lot more detail in these areas.

What I've tried to show here is to put all this together to give you some of the trade offs between producing emissions and what it would cost. What I'm showing here on this graph along the horizontal axis is the rate of CO_2 emissions, tons of CO_2 per megawatt hour of electricity generated. If we continue to build for example the kinds of PC pulverized coal plants that we have already we emit roughly a ton of CO_2 for every megawatt hour of electricity we generate and the total cost of building those plants would be about four or five cents per kilowatt hour or $40 to $50 per megawatt hour including the cost of the whole plant. But if we move to more efficient plants that we have today already we can essentially get a ten to fifteen percent reduction in CO_2 emissions with essentially no increase in cost. IGCC, integrated gasification combined cycle is a

technology with comparable efficiencies but today would have ten to fifteen to potentially twenty year 25 percent higher cost for a number of reasons. The red bar shows natural gas combined cycle plants, here we get two benefits. One because natural gas as a fuel has less carbon in it and secondly, because the combined cycle plants are about 50 percent efficient as opposed to 38 or 40 percent deficient for the coal plants. So overall the natural gas combined cycle plants we can get roughly a 50 percent reduction in CO_2 emissions per megawatt hour relative to the coal plants that we currently have. As I am sure most of you know there has been large increases in the price of natural gas over the last couple of years, so that red bar is being stretched vertically basically reflecting the bottom is basically the price a couple of years ago about $2 a million BTU. At the top I think I stopped at about $6 currently it's about $7 or $8, so if you're betting on the futures of natural gas prices as to what the cost will be. It's in that same range roughly, the zero option from those shown here, nuclear and wind so they are basically non emitters of CO_2 and their costs are somewhat speculative. The best wind systems today are in fact getting quite competitive already competitive with coal plants and less desirable locations wind costs are still high. The cost of nuclear is still hard to note because we haven't built one in 20/25 years and so there is still a bit of uncertainty and that's reflected in this range.

I didn't put biomass on this slide, I perhaps could have and it would have been in that same ball park as wind. This is roughly what we see as we go down in CO_2 emissions we can come down significantly with fossil fuels, coal and natural gas once we go to non emitting fuels - in general the costs are going to go up. Again just a reality check as to where we're starting from. We're starting from a base where over half of the electricity we currently use comes from coal and so there has been an especially important interest in and we have a lot of domestic coal resources that don't require imported fuels. So there has been a lot of interest in can we have our coal without CO_2. That's the segment into the last of those four options that I indicated earlier that the technology called CO_2 capture and storage for sequestration. In the community here the word storage is being used to indicate this technology is close to sequestration that you will hear about a little later which is typically associated with forestry and terrestrial ways of taking CO_2 from the atmosphere. Since the "s" has become the acronym for that.

This is a recognition that fossil fuels would be used extensively for many decades we're heavily reliant on it already. The alternative that I've shown you earlier while very important are not likely to achieve the kind of long term large reductions in CO_2 that would be required to stabilize atmospheric concentrations in which are significant interest to the policy community. So the technology of CO_2 caption storage offers a way to in fact continue to use fossil fuels especially coal in a way that doesn't totally eliminate but substantially reduces by 85/90 percent the CO_2 emissions. So if you think of this as a bridging strategy that might last over several decades to essentially toward the ideal substantial future this has some interest. Particularly interesting is a lot of the large energy models that are used to look at climate change policies in areas indicate that if capture and storage is part of the mix of technology options, part of the portfolio, the overall cost of achieving substantial reduction in CO_2 are substantially lower by 30/40/50 percent sometimes than if you don't have CCS in the mix. So it has gotten a lot of

interest in the last half dozen years. I want to spend a little more time on this since this may be a technology that is less familiar to many of you than some of the others I've shown here. I am going to draw on a recently completed report that I was involved in the International Intergovernmental Panel on Climate Change IPCC completed late last year - a comprehensive report on this technology. This picture shows schematically how you would take various carbonations fuels, fossil fuels but biomass as well bring it to the power generation rather large industrial facilities where CO_2 is generated. Capture that technology and then transport it typically by a pipeline to a storage option and the one I'll focus on here is the geologic storage option we're talking about putting CO_2 into a pipeline and then putting it a mile or two into the ground. The leading candidates because these are the leading sources of CO_2 as well are large fossil fuel power plants we have three types of the large industrial sources. And again let me focus on geologic storage and show you in the next few slides some of the potential applications of this technology. Here is a cartoon that shows how you would do this at a conventional pulverized coal plant today. At the end of that train would be another vessel of CO_2 scrubber after the SO_2 scrubber. This is technology that exist today it's not fiction it's not something that needs development you can go out kick the tires, here are a couple of pictures of this. What doesn't exist today is that technology implemented on large power plants. On the left is a picture of the technology at a smaller power plant in Oklahoma where using the CO_2 is an industrial commodity here they are using it to send next door to a food plant where it goes into some beverages, so when you open your next Coke the fizz that's the CO_2 released. But it's an industrial commodity that has substantial value. The picture on the right is a much larger unit at an industrial facility in Malaysia but it is also treating the flu gas from a plant that burns natural gas. So you see this stuff looks more like petroleum refineries it doesn't look like burners it actually is technology that is widely used and quite familiar to the chemical and petroleum industries.

Here is a cartoon with that other technology I mentioned integrated gasification with combined cycle. When carbon capture comes into the picture this technology has a special interest because the cost of taking the CO_2 out in this option is substantially low and the efficiency is substantially higher than doing it from a conventional coal burning plant. Here is one of the four IGCC plants of the world this one is in Florida, we have another one in Indiana, in this country and the other two are in Europe. This plant doesn't have carbon capture on it but if it did it would look like one of these, again on the left is a coal gasification plant in North Carolina which separates the routinely captured CO_2. Up until a couple of years ago the CO_2 just went into the air. I'll show you in a minute where it's going now. The other picture is a chemical plant which also separates CO_2 to produce hydrogen that it uses to make ammonia and other chemicals. So again, it's technology that's well known and exist at fairly large scales. What do you do with the CO_2 after you get it? The notion is to transport it typically by a pipeline, you compress it to where it becomes kind of a liquid so it's not gas any more and you put it into a pipeline to the storage reservoir. We have thousands of miles of CO_2 pipelines mostly in the western part of this country which have been in operation for many decades taking natural CO_2 out of natural sources in the ground and pumping it substantial distances. Often the CO_2 can lubricate and help get more oil out of the ground. There are many places also in the world now that either have started or about to start on CO_2

geologic storage sites, these circles are three of the larger ones. One of them is nearby here that coal gasification plant in North Dakota that I mentioned a couple of years ago put a CO_2 pipeline at the end of the CO_2 captured. Instead of venting it into the atmosphere they put it in a pipeline and sent it 200 miles north to southern Saskatchewan to an oil field called Rayburn in southern Canada that is depleted and is being used today for enhanced oil recovery and is being closely monitored because that CO_2 is intended to stay in the ground as a geologic sequestration demonstration. So it makes money in the short term in terms of producing oil and long term as a way of storing the CO_2. There are two projects that use similar technologies, the one on the top is the oldest, it looks like an off shore oil rig. It's actually a natural gas processing plant in the North Sea. It's a Norwegian project called Slighter - they extract natural gas from well below the sea bed. That's a little insert on the top there and natural gas has a lot of CO_2 when you produce it. So you simply separate it out and routinely send to the atmosphere. Another way to put a tax on CO_2 emissions ten years ago which was big enough to get stat oil interest and instead of releasing it to the atmosphere they rejected it below the sea bed into a large reservoir and that's a project that's being replaced now for close to ten years about a million ton of CO_2. That's a big project and very closely monitored and you can actually see the CO_2 that are being sequestered and stored and so far things are going along quite well. The lower project is the newest of the three big ones. This is a BP form of the British petroleum, another gas processing plant, this one is in Algeria. If BP is doing this just to get some experience, they think they can make money with this technology and they are one of the leaders in this. They extract the CO_2 and there is a pipeline that takes it several miles away where it's again injected into a very deep reservoir. So this isn't science fiction it's something that is in fact being implemented in many parts of the world today. Over the long term on a large scale as a climate of (inaudible) measure we're talking about fairly large amounts of this stuff but just for calibration we already inject in various parts of the country many wastes and liquids into the ground today. This is a graph put together by one of our former students that simply makes the point that if you took all of the CO_2 emissions from all the power plants in the US, the mass of that CO_2 would be roughly comparable than all the stuff we're currently injecting already. So while it's certainly something on a large scale that would be nontrivial it is comparable to other things that we're doing.

If I put those options back on the graph I showed earlier, they fall in that range so here we can get it in 85 to 90 percent reductions in CO_2 but at higher cost. The costs are wide because it depends on where the plant is and what type of technology and a whole bunch of other factors. One of the key messages in terms of coal burning technologies is that with capture and storage the orange bar the IGCC plants systematically would lower in cost than burning coal. That is one of the reasons that IGCC has been getting a lot of attention in this country even without the CO_2 it has environmental benefits relative to many of the combustion plants that are in operation. So we see a lot of interest in terms of getting this technology into the electric power sectors - the next generation technologies using coal. There are a lot of cultural issues to be overcome in that because the utility industry is used to burning that gasifying expertise in a different industry but there are major projects underway by American Electric Power Southern Company and others to start looking at that technology.

This is a slide that was put together by my colleagues as part of the study that was done by the PEW Center that simply took a quick look and ask is this possible if we use a variety of low carbon or zero carbon sources, is it possible to make a significant dent in CO_2 emissions. They looked at a scenario that looked at a more aggressive building schedule that is looking over the next 50 years at replacing power plants as they retire and then also dealing with new plants we take to supply the increased demand for electricity and concluded that doubling the current construction rate which will be aggressive but not outrageous would allow potentially over a 50 year period all of the CO_2 emissions to be taken out. That will obviously overcome a lot of the other issues associated with the use of these energy sources.

It's getting late and I included so that you will have it to take home and read rather than talk about it here, a number of policy options and considerations your DNR has already done a wonderful job in getting starting laying out some of these options and these are things that I'm sure you are all quite familiar with. You've probably already been briefed on a number of the programs around the world interestingly enough the two largest states in this country are both with Republican governors have programs that are intended to reduce CO_2 emissions. I was involved in some of the California issues last year and there are a number of other states that also as you are looking seriously at this issue. I've left with you also just basically for comment perhaps after today's meeting my blue sky list of various kinds of policy options and handles for introducing reductions to the utility sector. Some of the ones I've talked with perhaps familiar are carbon taxes, cap and trade, there are other ways of working that problem as well.

I was involved in a Pew Center study a couple of years ago looking at the issue of technology and innovation and its role in climate. We rarely do a lot of things that generally go under the (inaudible) policy these are things like R&D expenditure, tax credits, portfolio standards, educational programs. These are basically all carrots no sticks and they have in varying degrees of success being very effective in stimulating innovations that ultimately reduce the cost of technology. So getting started on that path toward lowering future costs through innovation is a key message and something that's strongly encouraged. Think about it, I know this can be done again through incentives. Many of the options that are used at the federal level are also available at the state level and I would urge you to look at it more fully. There is another Pew report that talks about this in detail if you are interested in it.

We've also done work at Carnegie Hall, I'm looking particularly at a class of technologies and environmental technologies, these are things you would not normally do unless there was an environmental reason to do it. What we find is that regulations like the sulfur dioxide regulations we had over a decade ago and nitrogen dioxides more recently, those regulations enclosed by state and federal governments in facts in stimulating innovations that reduce costs and make money for some people. Those are important take home messages because reductions in cost over a couple of decades of 40 to 50 percent are often overlooked in analyses of what some of these options may cost.

My next to closing slide is first with the climate changes and environmental problem that cannot be addressed by voluntary technology policies alone. Regulatory policies that limit greenhouse gas emissions also are needed. Energy policies this is more a national but potentially state can further help and impede progress on reducing greenhouse gas emissions and my own preference is for a combination of these traditional technology policies together with regulatory policies that put caps and time tables on CO_2 emissions productions. It's that combination that we're looking for as a way forward. I took a quick look with the help of one of my colleagues over the weekend at the situation here in North Carolina. It's true nationally but even more true in North Carolina that your fleet of existing power plants is aging. Most of the power plants are generating electricity here from fossil fuels coal in the 35 to 50 year old range. There is a couple down in the 60 well it's not quite a one point analogy. Power plants are not unlike people when you get out toward the tail end of that thing, things don't look as well as they used to when you were younger. Things start breaking down and you have to start worrying about replacement. So I think you have a situation here in North Carolina where quite soon you will have to be worrying about what will replace these plants and those decisions will have very important consequences for greenhouse gas emissions and I would say that you have a lot of time but not a lot of time and you will be in the forefront of states that will be dealing with this issue. Thanks very much for your time.

Mr. Garrou thanked Dr. Rubin and stated he did not want to limit questions but we do need to move quickly so if you would ask your questions fast and if Dr. Rubin would respond briefly that would be good.

Dr. Riggs – You showed a lot of examples of CO_2 sequestration in subsurface. You said they were all successful, is this just a matter of out of site out of mind? You didn't present any data whatsoever that suggest just how successful these things are. Do we really know that this stuff stays there and how much is coming back out?

Dr. Rubin – It's a great question and a key one. This is a question also that we've dealt with extensively in this IPCC report that I recommend to you. The longest experience we have right now is the Red Sea operation at Slighter which has been in operation for ten years, the other one has only been in operation for two years and the BP plant even less. Those have been quite successful there have been no issues of leakage or seepage. Models have been used to predict where things will be going and by and large pay for the crude as we go along but things have been working very well. One of the barriers that still remains to using this technology more widely though is a more uniform and appropriate regulatory regime for these kinds of operations. Right now any injection programs into the ground typically regulated by the state there are some federal classifications. There are programs including one led by World Resources Institute that is looking at trying to develop the larger issues associated with what this EPA is involved in it. So what the geological community reports is that in a world characterized in a well selected site, one with a cap lock that this is likely to be secured. One of the interesting things here unlike other kinds of waste the longer the CO_2 in the ground the longer it's going to stay in the ground. It gets injected as a liquid but it's relatively buoyant but it gets injected into typically a mud, think about it, there's not just this big hole that you can

puncture it. Over time the CO_2 begins to react with the local water so it dissolves which makes it less amenable to escaping over time periods of hundreds of years. And over time period of hundreds to thousands of years it starts to react chemically and eventually turns into limestone and rock. The longer it's in the ground the longer its going to stay in the ground but the key is putting it in a well characterized and well monitored site. That's where a lot of the focus of this work currently is.

Dr. Uzochukwu: Thank you Mr. Speaker. On page 12 of the handout of your presentation second slide Innovation Policies to Mitigate Climate Change you indicated that global climate change is an environmental problem that cannot be addressed by voluntary technology policies alone, why not?

Dr. Rubin: Look at history it just doesn't work. That's the short answer. We've had voluntary CO_2 reductions in place in this country since at least the early 1990's.

Dr. Uzochukwu: But also how aggressively are the power plants upgrading their facilities? Are they doing it just because or is there a sense of urgency to get this done in order to reduce the CO_2?

Dr. Rubin: I don't think CO_2 yet has the sense of urgency that other environmental issues have. It's plain to see that it's faced with all sorts of problems. This is one of many issues on their plate they've been worried a lot about deregulation/re-regulation all sorts of business related issues. They've been worried about sulfur dioxide in the 80's, nitrogen oxides, mercury, there are a lot of near term issues that have the quality of maturing in the regulatory process. As one of my colleagues and I frequently do, if you ask utility CEO's the kind of question I ask you to raise your hand if you think there is not going to be some reduction of requirements on CO_2 emissions over the next ten years, you see very few hands go up. So everybody is expecting it but it doesn't have quite the urgency yet in some cases. Some utilities in some cases it does.

Dr. Smith: Mindful of the time here I was intrigued by the last couple of slides. The mission of this Commission is to consider looking at setting a goal and I gleamed from your slides that potentially setting or what we're doing is debating whether we should set a goal and if we set a goal I gleamed from your slides that you, correct me if I'm wrong, that there are benefits to states or any form of government that sets the bar and lets innovation follow and works with RD to get those technologies. Can you talk a little about how you would envision or what your thoughts are about a state setting a goal and then setting the rules correctly and how that could lead to innovation and also lead to potential economic development for the state.

Dr. Rubin: I think that's the kind of market signal if you will that a lot of people I talked to in not only in the utility industry but in other industries are waiting for. The lack of clarity as to time tables and requirements I think is putting an awful lot of decisions now that soon need to be made. I think once those requirements are in place there's inevitably going to be some moaning from some sectors but again there are a lot of people that are trying to position themselves as BP for example in this situation to take advantage and

move into these markets. One case in point, I think you've already heard California. California last year enclosed the standards such that California doesn't have coal fired power plants in its borders but it allows electricity generated from coal outside of its borders. As of now any load serving entity that wants to sell its electricity to California from coal must meet a CO_2 standard that is equivalent to what a natural gas combined cycle plant would be about half of what current coal plants would be. BP announced recently a project in California that would use its technology to turn petroleum coal into hydrogen to provide electricity to California's market under those situations.

Mr. Urlaub: Thank you and thank you for this very thorough presentation. I had a question, clarification on prices. You have a slide titled Approximate Cost of the Options and I was comparing it also to the Pew Center report that was handed out. Looking at both the time frame in the Pew Center report, for example, it says IGCC with carbon capture available in volume in 15 years, biomass and wind in 10 years, nuclear now. One does that mean advanced nuclear and two, I've looked at DOE cost assumptions and the annual energy outlook above 2005 and they placed advanced nuclear to about just over $2000 per kilowatt overnight capital cost and wind around $1100, biomass like $1400. Could you talk about where is the difference here because your cost chart does not match up with that?

Dr. Rubin: Sure, those numbers are just cited with the capital cost, the cost of constructing those plants dollars per kilowatt. The cost I've shown here are dollars per kilowatt hour or megawatt hour so these are cost basically its called a levelized cost but its basically the cost over full operating life of the plant. So it includes both the capital cost as well as the operating cost over typically 30 years. And part of the variation in those numbers comes about by things like interest rates. What's it going to cost to borrow the money that it will take to build those plants? What will the cost of fuels be? So the levelized cost is not something like an average it's equivalent to a mortgage payment kind of term. So it's the cost of the electricity as opposed to cost of building a plant. I think on that basis those numbers are probably comparable to what you would find in other reports recently. And those are reflective of cost, those numbers were really generated a couple of years ago, so it's probably on the order of 2002 dollars that you're looking at here.

Mr. Urlaub: May I ask a quick follow-up? Uranium, traditionally the understanding has been that Uranium is cheap as a fuel. We've seen it go from less than $10 per pound to close to $40 over $30 at least, is that a trend that you expect to continue and is that reflected in this.

Dr. Rubin: That's hard to know. Those things all obviously depend on how many plants are being built and how much demand there is for these fuels. You don't want to take these numbers to the bank they're simply indications of ranges that are reflective of estimates you can find today for cost. Projecting these costs out into the future is as you know quite flawed with uncertainty and so I would say there are probably a lot of studies you could find that might make those speculations.

Mr. Toben: Thank you Mr. Chairman, just a quick question. On the same chart related to cost the range that you have wind energy I am sure that you are aware that the wind energy cost is a function of the wind resource, the technology, and the location of the plant of the wind farm. In North Carolina we're finding because we have such great wind resource in the mountains and on the coast that the cost per megawatt hour is about $40 up in the mountains and about $70 at the coast. So our range is a little bit narrower and probably a lower bit lower based. On the nuclear side here I understand that you're carrying the entire operating cost out here in terms of that range, are you including the commission cost of the nuclear storage costs long term?

Dr. Rubin: I think those are embedded in a lot of the estimates that I've put there. There was a study done at MIT a couple of years ago that looked at nuclear issues and they came out with a cost somewhere a little shy of around seven cents per kilowatt hour including some of those costs. But to the extent those costs change in the future, one doesn't know. Your point about wind is certainly well taken. The wind still is the intermittency issue and the storage issue and as you start to try to bring more significant amounts of wind into the system you've got to deal with that sometimes because of the intermittency. That means you have to build a natural gas combined cycle plant to handle the times when the wind isn't blowing and worry about transmission and distribution lines if they don't exist. There is a lot of site specific kind of considerations that need to go into the wind. Let me also say a word about biomass, it's an essentially important resource. While it certainly is true that you can use biomass exclusively to generate electricity and combustion gasification, one of the major limitations is being on the size usually very small facilities and while the cost of the facility gets cheaper as you build a larger one, the cost of getting more and more biomass in the facility tends to go in the other direction. The numbers that you find today for a purely biomass based power plant either gasification or combustion would be higher than the fossil fuel ones. But probably the most effective use of biomass certainly in the near term is a supplemental fuel for either combustion or gasification. That is you can feed 10 perhaps 15 percent of the energy with biomass as a supplement to fossil fuels and that can make good economic sense. If you go all the way to carbon capture and storage plants that have some biomass (inaudible) with carbon captured storage you're actually getting a negative emission. The biomass is taking carbon out of the air and then you're putting it back in the ground and that's also something that over the long term could improve the economics of some of these things. Probably not as a stand alone facility at least not from your term but in conjunction with other fuels could make a lot of sense if you've got a lot of biomass issues here.

Senator Pittenger: Thank you Chairman Garrou. Thank you Dr. Rubin. Dr. Rubin you mentioned natural gas and nuclear as alternate sources of energy. We have significant reserves we're told off our continental lateral shelf of natural gas. You mentioned how the sequestration in Norway and other places have been effective with the CO_2. We have companies who are advocating or desiring to see expansion in nuclear energy. Would you be an advocate of regulatory change in a form that would relax the codes and guidelines that restrict nuclear expansion and natural gas expiration?

Dr. Rubin: You're not asking a leading question are you?

Senator Pittenger: No I'm seeing if the opportunity is there for areas that have minimum or no CO_2, you didn't see any oil rigs down during Katrina. I mean there are some opportunities there that could seem to be a logical part of this solution.

Dr. Rubin: I think Senator in all of these cases there are balances that need to be achieved. I don't think I'm in a position to say categorically that we can't have our cake and eat it too in that demand that is. It is not clear to me that you need relaxations in certain areas but again that's perhaps a separate discussion.

Senator Pittenger: But as you advocated CO_2 the restrictions and regulatory there I just wanted to know on the other side you advocated expansion in these other two areas the regulatory change.

Dr. Rubin: I think if they could be expanded in ways that preserve the other things we value, environment and others, we should certainly do it and there is a lot of work going on in those areas. The nuclear issue is particularly prominent these days and has its problems but the nuclear issue is perhaps the most serious. My personal feeling is that until the issues of waste disposal the back end of the system are clearly resolved and issues of proliferation are addressed adequately nuclear is going to continue to be problematic in this country and many others despite advances in the technology and the safety of the nuclear plants. I think there are still a lot of issues that need to be worked through that we are not quite there yet.

Senator Pittenger: France is 78 percent nuclear with regard to electricity is that right?

Dr. Rubin: They show that can be done.

Dr. Everett: Thank you Mr. Chairman. This is a great discussion by the way. In looking at this cost of options on page 9 one of the things that interest me at Duke Energy, we spent, I'm going to say, close to eight billion dollars on gas plants combined cycle we built around the country. Unfortunately none of those are running these days. There is a loop effect here once we convert our electricity to gas generation we burn a lot of that fuel that is useful to other people and so we see this price spike that doesn't show up in these kinds of graphs. I wonder if there is a way to account for those feedbacks once we convert to this other fuel type.

Dr. Rubin: It's clearly a critical issue and it does show up in that graph because before I came here the graph which is stretch this way was kind of down here. So I stretched it to reflect in fact the higher prices that we've seen over the last few years.

Dr. Everett: If we were to convert some of our coal plants to gas we would stretch that curve a lot higher.

Dr. Rubin: There are different voices in terms of what the future of natural gas supplies look like as certainly you know. LNG, we can have more LNG or not it's one of the key ones. I've seen curves from equally prominent experts as I've defined them that show things going both ways so it has that potential and certainly that's one of the key issues with natural gas as whether that would go in the other direction. The other issue is just from a purely balance of trade point of view we are now net importers of natural gas as we are of oil. If you will look at the data that directories for natural gas look very much like the directories for oil did thirty years ago. So we are going down a slope where we will be sending dollars out of the country to buy fuels from other parts of the world, again one of the major reasons for looking back at coal potentially with capture and storage to avoid those kinds of issues.

Ms. Choi: Thank you Mr. Chairman. I am at Progress Energy and we are involved in a study with a couple of other utilities including Duke looking at carbons geological sequestration in the Carolinas and the initial indications look pretty bleak. I am interested in hearing from you what you've seen as far as particularly the North Dakota project, the cost of transporting the CO_2 and the sequestration.

Dr. Rubin: I've tried to get some information on North Carolina resources. At the end of last week things got busy and I thought the DOE folks would have everything I needed because I had heard something to that effect as well. I was not able to get the information as the DOE did not have it as quickly at hand. I did not understand that there were some projects now with Duke University and others to do a characterization and I think until that work is done the answers will not really be known. The cost of transporting CO_2 while not insignificant or not unreasonable, the major cost is at the capture plant. We do modeling of these types of things and have looked at that so you can reasonable afford to transport CO_2 a couple hundred miles at cost typically a couple of dollars a ton of CO_2 is kind of the ball part we're looking at as opposed to ten of dollars per ton for the capture. Costs are typically in the 20 to maybe 40 or $50 a ton. The crude operation the actual cost numbers are not actually public. They are probably in the higher 10 or more. They report the combined cost of transport and storage and so it's hard to know what those are but that's a 200 mile pipe line that was certainly economical enough to do the project.

Mr. Garrou: Thank you very much Dr. Rubin we've had a request that you provide your contact information to the Commission. Would you be willing to do that?

Dr. Rubin: I would be happy to do that. My e-mail if you need it is just Rubin@cmu.edu, that's the easiest way to get to me.

Mr. Garrou: Our next speaker is Dr. Marilyn Brown who is the interim director of the Engineering Science and Technology Division of Oak Ridge National Laboratory in Oak Ridge, Tennessee. Dr. Brown, thank you and welcome.

Dr. Brown: Thank you very much for inviting me to participate in these hearings. You do indeed have a lot of energy research and analyses assets at your fingertips in the great state of North Carolina. And Oak Ridge Laboratory has had the privilege of working

with many of them, Larry Shirley who heads your North Carolina State Energy Office, Bob Koger who heads Advanced Energy we've worked with the NC State University Solar Center here in Raleigh and with Duke University. And in addition on the western side of the state we've had the privilege of working with Max Lennon who heads the Education and Research Center of the Western Carolinas in a project that's been supported by Congressman Charles Taylor to try to transfer some of the technologies from the National Laboratory System into use in the western Carolinas to build jobs and new small businesses around some of the technology advances. It's a pleasure to be here.

I am going to talk about opportunities to reduce greenhouse gas emissions from the built environment. I did want to note that at Oak Ridge National Laboratory we have identified a number of global challenges that we are addressing and you will notice at the top of that chart (Exhibit G) its climate change. That's the first time in all the 24 years I've been at the lab that our lab's strategic planning effort has placed that challenge so prominently. Of course there is also a challenge of meeting the increasing demand for energy and also all of the energy security and global security issues that surround our energy infrastructure. We are attempting to help address those with investments and energy R&D and science and technology education. You've heard all of the various important sectors that need to be addressed and looking at opportunities for reducing greenhouse gas emissions and I'm here to tell you that buildings are the place to look at first. You can slice and dice this pie in many different ways. All together buildings when you total residential, commercial and industrial buildings they count for 43 percent of US carbon dioxide emissions. Now that's not to mean that there are not other ways that you can indirectly reduce the energy requirements of buildings, for instance if we were producing electricity without any CO_2 emissions then that would have an important reducing impact on the role that buildings are playing. Because buildings are the principal consumer of the electricity in this nation, so you can either make buildings more efficient or you can de-carbonize the electric sector. Now obviously that is not a choice you really want to make, we need to do it all because the magnitude of the challenge is so great.

The building sector does use energy in many different ways and it's traditional to look at how homes use energy and how larger offices and industrial buildings use energy. Homes are much more climate responsive and so they consume energy principally for heating and cooling although water heating and other uses are important and there is a massive increase in the plug loads in homes and in offices. When you look at commercial buildings lighting is the most important energy use and because of the heat that is emitted from lighting systems cooling is also extremely important and space heating and all of the office plug loads as well. One of the problems in addressing the opportunities for greater efficiencies in buildings is that decisions in this sector made by so many different stake holders. This diagram shows some of decision makers that influence how buildings are built and occupied. You just take a look at home building in the United States. There are half a million home builders and the top five of them dominate only seven percent of the market. It's not like Detroit where you can get them in one room and talk to them one on one, it's just not that easy.

Now there have been some successes in improving the efficiency with which we use energy in buildings and I've developed this chart for the Pew Center report that I think you all have copies of. If you look at how much energy is used per person over the last two/three decades, it has reduced significantly. If you look at how much energy is used per household or per capita the similar trend is true of energy consumption per square foot of office building, we're doing a much better job. One of the problems is our homes are bigger and expanding our built infrastructure at such a rapid pace. As an example of one of the improvements that has occurred over the past several decades, take a look at how much energy has gone into refrigerator. The standard refrigerator in your home use 75 percent less energy for our household refrigerator today than we did in 1970 approximately the same size 22 or so cubic feet. One of the ways that we've done that is through R&D we've improved compressors, insulation and motors and actually that work was done at Oak Ridge National Laboratory. It's been coupled with appliance standard beginning with the state of California and then moving to federal standards which have racked down the requirements for new appliances manufactured in the US. So we have seen an incredible drop in the energy required to maintain your household refrigerator. I like this chart this is one that was developed by a colleague of mine, Art Rosenfeld, from the California Energy Commission, last year he pulled this together. It shows that had we not improved our household refrigerators it would be like having to build twice as many hydropower dams as are currently in the US. It would be about equivalent to having to have as many power nuclear plants built to meet that demand. It's saved billions of dollars and that's only one appliance. It was the focus of a major R&D and appliance standards program and similar programs could tackle other end uses.

Future energy challenges are going to require that we address these other opportunities. In say 30 years most of the current stock of buildings that exist today will still be standing so we need to retrofit them. The built-in environment is going to grow by 70 percent over the next quarter century or so. So we need to figure out how to build them for long term prosperity and also how to situate them so that we can also consider the implied transportation demands that occur either with choices we make between more sprawls or more urban in filling. We need to figure out how to meet new energy services because we're demanding more and more from our buildings every year. It used to be 25 years ago that only about 20 percent of the homes had air conditioning. Well today it's considered a necessity, almost all new homes do and similar examples are pertinent to other services as well. So the forecast is that if current trends continue, greenhouse gas emissions from buildings are going to increase at about 1.5 percent per year.

There are opportunities to shave that growth rate I think it's quite feasible to imagine a future in which our annual growth for energy for buildings is cut in half to 0.75 percent per year. If you look at buildings today the full compliment of efficiency approaches are not used, you've got less than a quarter of the glass sold for windows today having low (inaudible) that is reflecting heat. We have almost none of them yet with electric chrome principles per properties, these are where you reflect the heat in the summer and you absorb it in the winter. They're a little pricey but just wait a few years and we will see more of those. You have insufficient use of insulation in attics and walls and we don't have reflective roof coatings as we should, that's a cost effective measure for homes and

for offices. We've got sprawling urban landscapes and rarely are considerations of life cycle issues built into our considerations. So how much did it cost to make the materials that are being installed? What are the greenhouse gas implications of the materials that we are using to build our infrastructure?
This is a list of some of the emerging energy technologies that could make a difference. I mention the electric chromic windows, various unconventional water heaters - one of my favorites is being developed in that partnership in the western Carolinas. That's an integrated water heater dehumidifier all in one should hopefully cost no more than the two appliances together and it's a heat pump water heater. Which means it's twice as efficient as a standard resistance electric water heater with thermo electric materials where you take a small temperature differential and convert it into electricity, lots of emerging technologies. And looking out further, scientific discoveries are going to transform how we use energy and the technologies available to us. Today we are developing materials atom by atom, we're manipulating them at the atomic scale. That's the scale at which properties are determined such as melting point, even color. We are also involved in molecular biology and looking at the DNA of living organisms for instance to develop bio-energy plants that can more easily be converted into ethanol or plants that have more oil so that bio-diesel could make a bigger difference.

And finally, we now have paraflow capabilities in our performance computing nationwide. That means billions of calculations per seconds and this means that we can simulate so much of our science. Instead of having to do experiments and relying on theory we can preliminary simulate into solutions. One of the sort of break through technologies that I think we will be seeing more of are net zero energy homes. These are homes that produce as much energy as they require to fuel and power their appliances. I know Steve Smith's been out to Lenoir City where we have a subdivision of Habitant for Humanity homes with five of these with net zero energy homes that TVA has helped to construct with sort of opaque panels. Making up almost the entire difference between what these homes need to consume and what they can produce. The average utility bill for these homes is now 40 cents per day. So it does cost a little more today than you might want to pay, the life cycle payback is still not there but I'm optimistic that within the next 10 to 20 years these could be affordable. We are working also with Clayton Homes. I know that the manufactured housing is a large portion of the market in North Carolina and they are going to try to develop one of these net zero energy manufactured homes to show in their upcoming summer home display.

Another technology which is emerging and very promising is combined heat and power or distributed energy. I think Ed talked a little bit about how power plants could be made so much more efficient if the heat from power production could be put to productive use. Well here we have the possibility of a paragon shift from massive central generation to much smaller and distributed power generators such as fuel cells or micro-turbans, reciprocating engines. Now the advantage is by putting that small power producer right next to your office building it will operate say at say 35 percent efficiency, I'll give some amount of electricity, and we've got one of these at the National Transportation Research Center in Knoxville. Almost all of the waste heat that the micro-turban is producing is going into preheating a hot water system. So that whole system is working at 80 percent

efficiency. The improvements and the reduction in greenhouse gas is significant and that's a new paradigm and we're going to see more of and it's nearly cost competitive today. So if you total all of these technology opportunities and a series of policies that we investigated that are itemized in the Pew report, we believe that you can bring greenhouse gas emissions in the building sector down by the year 2025 to today's levels. Significant reductions are possible and that amounts to a 10 percent overall reduction in the nation's greenhouse gas emissions in 2025 relative to what would be emitted without taking accelerated action.

I did want to spend a minute saying that the Energy Policy Act has been in place simply because of the policies that will be needed to stimulate these investments. In fact Judy Greenwald from the Pew Center on Global Climate Change asked me to say something about the act and then she saw how much I have here she said but that's implying that the job is done. So first I want to say that while there is a lot in this Energy Policy Act and we need to take advantage of it in terms of taxing centers for clean energy options. It's not sufficient to meet the challenges that the nation faces and in particular it doesn't have much in the way of mandatory regulations. So you all know it was the first major energy legislation passed since 1992 and just a few of the provisions that impact building are highlighted in the next few year graphs so there are 12 new residential and five new commercial product standards that are legislated within the Energy Policy Act. Lots of new tax credits and one reason for bringing this to your attention is that you want to be sure that North Carolina gets more than its fair share of these tax incentives. So be sure that your home owners know that they have tax credits up to $500 for qualified energy efficiency improvements like $50 off for an advanced air circulating fan and be sure the builders know that they get $2000 incentive for homes that are 50 percent more efficient and there is a $1000 tax credit for manufacturers of mobile homes that require 30 percent less heating and cooling than the IECC standards and current practice.

Noted here some of the features of homes that might be typical of those built in a hot humid climate like North Carolina that would qualify for these tax credits. And there are tax credits for commercial buildings that are built to higher energy efficiency standards. There are energy efficiency provisions to legislate greater efficiency in the federal sector as well. I wanted to be sure that you knew that there is also activity that requires states to facilitate development of these combined heat and power and distribute generation technologies. And particular states are encouraged to improve the inter-connections standards to enable these distributed power systems to interconnect to the grid.

I have five maps coming up that show how the states are doing in terms of implementing some of the more advanced policies and you will see that in terms of the first two state residential energy codes North Carolina does real well and for commercial energy codes likewise he's adopted EPCA compliance of efficient standard codes. But when you look at supplemental appliance efficiency standards you don't have any. Many states do and here are about ten of them that have implemented their own standards for a ray of different appliances that are not currently regulated by the federal government, you should consider that. These are standards which pay back to the consumer. It's just sort of forcing the market to behave more efficiently. And then there are also standards for

state buildings that I recommend you consider for instance, the possible adoption of lead certification for state buildings that is a leadership and energy and environmental design. Many states are requiring that of their state buildings.

And finally one of my very favorite policy tools is the energy efficiency resource standard. This is a standard that was first pilot tested in Texas about five years ago where the Texas legislature required that its investor on utilities reduce the growth of electric demand in their territories by a certain percentage and they could do it any way they wanted through some system of rebates or incentives and it would have to be monitored and measured. And they have done this and they have reduced their growth by ten percent through incentives that they put in place that have been managed by the utilities. In ways that best meet the economic of those service territories and you can trade too it's a cap and trade kind of set up so it adds even more to the efficiency of this type of policy approach.

This is my last slide in conclusion there are many near term opportunities to bring building practices up to best practices. And the longer term 2025 I see zero energy buildings and some of these integrated energy systems that combine heat and power systems is playing a big role. And of course looking further out we are going to need to consider smart growth concepts and take a much broader integrated approach to the development of our energy infrastructure including the built-in environment. Thank you very much.

Mr. Garrou: Thank you Dr. Brown. Questions for Dr. Brown?

Mr. Shore: This is just a question about low hanging fruit. Our utility commission is considering energy efficiency issues maybe the General Assembly will be thinking about these issues when the session comes in. Do you have a sense of what are the lowest hanging fruits, what are the things that are just a no grainer for North Carolina to be doing to promote energy efficiency in the building sector?

Dr. Brown: I think some of those policies that I just mentioned should be considered. The supplemental state appliance standards, take a look at a recent report by the American Council for an Energy Efficient Economy. I think they looked at something like a dozen different appliances and you would want to consider how big a role they would play in North Carolina like pool heaters. Is it important or not here? I do think that energy efficiency is the fastest, cheapest, cleanest way to go in terms of meeting climate and energy challenges. There is an array of technology so if you want to go down the technology path its all traditional insulation and windows and reflective roofs and there's a lot to be done.

Senator Pittenger: Thank you Chairman Garrou. Thank you very much for your presentation. You mentioned in your presentation advances have been made in technologies for example the refrigerator and other things have really improved. Was that done through government mandates or through the research and development in the private sector and market driven?

Dr. Brown: That is a combination, the requirements for federal standards is that they have to be proven to be acceptable economically to a consumer. That is you can't force an un-economic option upon consumers. So the technologies have to be available and shown to pay back over the lifetime of their existence but what you saw was this combination of research triggering advances and then standards catching up with them and then more research and then stricter standards. It was a really nice companion you ask was it a private R&D or public R&D was that also part of your question?

Senator Pittenger: Actually my question was it driven by the private sector market driven or was it government mandates to require the transition? What are the mandates regarding the efficiencies of refrigerators?

Dr. Brown: Yes a little bit of both. The first mandates were the California appliance standards for refrigerators because they saw that it was an economic proposition for their state consumers and they could prove it in the state court. Then the federal court launched about a 5 million dollar R&D program done with industry and partnership with cost shared efforts with industry and drove up the performance of compressors and insulation and motors. And then the standards in California racked down and then the federal government caught up. California was always a few years ahead of the feds.

Senator Pittenger: I think to clarify if it's ok Mr. Chairman. The standards were related to receiving the R&D they set is that correct?

Dr. Brown: Well not exactly. The research shows that the manufacturers could produce a more efficient refrigerator. The research next improvement and in fact in one case it was a major Georgia compressor manufacturer at the time it was called Columbus Compressor Products, a big company in Georgia. And they started to roll off the assembly line a refrigerator that could perform well and wasn't very much more expensive. So with that on the market the federal government could conclude that every manufacturer could do that. The research has been done and so the mandate then was across all manufacturers for that appliance. I hope that that helps. I can give you more literature.

Dr. Everett: Thank you Mr. Chairman. I'm interested in some information exchange that maybe would be helpful to everybody across the state who is very interested bridging the gap, deciding what do I do next that's out there in the market place that I can select from that is cost effective. So if I wanted to build a zero energy efficient home who do I go to, what's the cost to me as a consumer added on to my anticipated cost in the first place or what kind of appliance do I need to buy, where can I get it. So that for all those people who are eager to step forward and do something we need some tools that I think are just missing.

Dr. Brown: There are some great websites to go to: the Energy Star website that EPA and DOE manage and then there are two associations I direct you to the American Council for an Energy Efficient Economy www.aceee.org has incredible literature and

material on the website and then there is the Alliance to Save Energy in the Pew Center has a lot of reports posted as well.

Dr. Everett: Yes I guess we need some how to make them more user friendly to refer people to a web page probably is not the solution I suspect but I think there are tools out there that just aren't readily available and used and if we had them in a user friendly form we might do better.

Dr. Brown: I think probably the biggest success in terms of communicating recommended projects is the Energy Star Label has great acknowledgement across consumers nationwide. So when you go into Home Depot or Lowes you can find that label or not and that really helps. That's only part that I recognize that doesn't get you all the way to the really premium products that I think we need to move to.

Dr. Urlaub: I had a question for you about who should be carrying out implementation. For example some programs it's most appropriate for electric utilities to carry them out for some its government programs and what not. A lot of your input you pointed out especially with buildings, where do you think with the appropriate institutions that we should be presenting those kinds of programs?

Dr. Brown: Well it used to be in the 90s that the electric utility industry was a great conveyor of demand size management options but then with the restructuring of the industry the incentives were no longer there. So their return on investments a function of sales and there are no longer options for rate based energy efficiency to be implemented by utilities. Now that is a state decision how you manage your utilities. So these energy efficiency resource standards that I mentioned is something that you can put in place in the today restructure environment. I think utilities should play a role. They are in the energy business but the state energy office is also a great place to reach out to state consumers. And so working with them is very useful.

Mr. Toben: Thank you Mr. Chairman. You mentioned California has typically been a few years ahead of some of the other states. And it looks from your chart like they have adopted the residential energy codes, the commercial codes and the appliance energy standards. What is the per capita energy consumption in California verses North Carolina? Do you have that number?

Dr. Brown: Well the BTUs not the dollars but the amount of energy consumed in California per capita is probably less than in North Carolina. It is a lot less than in Tennessee and Tennessee and North Carolina have very similar climates. Were you suggesting that you thought maybe they paid more and consumed more so it was more of an issue?

Mr. Toben: I am more interested in the impact of the standards on consumption rates.

Dr. Brown: California has been able to institute policy such that their electricity consumption has not grown state wide over the past decade or something like that. It has

had a big impact and yet their economy has boomed. So they have really made a big difference and following the rolling blackouts in the summer of 2000 and 2001 that period when they appear to be the crest of this they put in place a big program that's called the 20/20 program. If you could reduce your electricity consumption by 20 percent they would give you an additional 20 percent off your electricity rate. And they showed an impact of something like 10 percent reduction in electricity consumption that next summer which made a very big difference in terms of grid stability and keeping the lights on. So they really have done a lot and made a powerful impact.

Mr. Profeta: Thank you Mr. Chairman. First I would like to second to what George has said about the Commission thinking about the education assimilation because I'll just use myself in having some construction projects. It's not that easy to determine what is capable and clearly if we are going to deal with our missions we are going to have to deal down shore demand. I want to go back to a line of questioning on the economic feasibility test on standard center. If a jurisdiction was to bring in a program that created a market based system that values carbons lowering energy use what affect would that have and what range do these technologies become more economically viable?

Dr. Brown: Well it would certainly lead to the improved attractiveness of these options across the board. Depending on the magnitude of either the cap or the carbon tax, maybe you're asking would this solve the problem, would a price or cap and trade system do it all, probably not.

Mr. Profeta: Would it stimulate more of these technologies and be able to penetrate the market?

Dr. Brown: It would I think David Greene did a nice job explaining how consumers don't really pay that much attention to energy prices so I would hate to be on the record as saying that the price signal would do it alone. Price and necessity of demand for energy show its not very elastic maybe a ten percent reduction for 100 percent increase.

Mr. Profeta: One last follow-up. If the standard or being able to create the standard is it to be shown to pay back economically, would more technology be able to have a stand set for them because they would be now economic?

Dr. Brown: Yes they would indeed.

Dr. Smith: Thank you very much Mr. Chairman. In response to Tim's question my understanding is that on a residential perk applicative consumption of electricity in North Carolina slightly below 1100 kilowatts per hour. I think the national average is about 850 and California is about 580 so I think that gives you a sense that California is probably consuming approximately half on kilowatt hour basis rather than take in BTUs. The other question I have is I think North Carolina is projected to grow electricity demand slightly less than two percent per year going out. In your professional opinion do you believe that that could easily be met with energy efficiency programs to offset growing demands by some of the things you outlined?

Dr. Brown: I've come to sort of rest on feeling comfortable with cutting the gross rate in half. Its professional judgment but I do think certainly that is feasible and California has shown that you can go further.

Mr. Garrou: Thank you very much Dr. Brown for your presentation. Our last speaker before lunch is Dr. Dennis W. Hazel who is not an expert because he is from Raleigh. He is a Professor in the Forestry and Environmental Outreach Program at North Carolina State. Thank you for being here Dr. Hazel.

Dr. Hazel: Thank you and in the spirit of Dr. Brown's presentation and since in fifteen seconds we are supposed to be breaking for lunch I shall attempt to speak efficiently. So it will not be in fifteen seconds. What I would like to do is to cover the range of opportunities represented by the forestry and agricultural sectors and I hope the take home message will be a fairly simple one. If these are large sectors the opportunities are large and that's the good news. There are a couple of words of caution that I would like to leave you with. What I would like to do in the next few minutes is describe why agriculture and forestry are significant sectors to look to and I'm going to give you what I'm going to call a partial laundry list (Exhibit G) of those things that we might do as solutions to global change from both of these sectors. The list largely comes from sort of the sister group that's meeting concurrently, the Climate Action Plan Advisory Group. I'm part of that and I serve on the agricultural and forestry technical work groups. Of course our job is to tease apart the specific options, look at them, weigh them, prioritize them, look at the cost of implementing them and then get back to you. The group that is facilitating our discussions has given us a list of what they call action items that is being done in other states. Those of us on that group are also of course coming to the table with some of our own ideas and I'm going to give you a partial list of those. We have just begun our deliberations. And then there are several things I think are particular opportunities. They're implementable and they are implementable on a large scale in the relatively near future and I'm going to try to focus a little bit of extra attention on that.

Why are these such good sectors to look to? They are large. Forestry is our second largest industry in the state, have over 18 million acres of forest land in North Carolina. Most of it owned by 650 to 700,000 private individuals, a 29 billion dollar a year economy additive of business for North Carolina. Those of you who know Bob Slocum or hear him on the radio, he is our ambassador for forestry in North Carolina and his group is the one group that truly represents all aspects and parts of our forestry community. We think of agriculture as being somewhat in the decline and it is but we still have nine million acres in North Carolina in farms representing 52,000 farms and without some of the net multipliers just last year's net cash payments to farmers was 1.9 billion.

There are four general ways that forestry and agriculture can contribute solutions to the global change issue. The first is reducing emissions from our own sector and the things that we are most concerned about are carbon dioxide which has been talked about a great deal today and I'm sure at previous meetings and also methane and nitrous oxidize. In

the case of nitrous oxidize, that's a product of our fertilizer applications with nitrogen based fertilizers. Second, sort of a general category of solutions is promoting carbon sequestration which you heard about several times this morning. An example would be increasing the land area that we have with plant, crops and forest. Maybe a more viable solution is improving the productivity of the land that we have in agriculture and forestry because the growth rates on every acre that are in agriculture and forestry are directly proportional to the carbon sequestration that takes place. So if we can improve productivity on the lands that we still have in forestry and agriculture then we have some solutions. Another sort of general way of heading for solution action items is substituting farm and forest biomaterials for others. Dr. Brown talked about some efficiencies and things being done in buildings. A 24 hundred square ft. frame house has enough wood in it that has sequestered about 23 ½ tons of carbon dioxide. So when we're using wood products to build for construction instead of some of the other products then we're on a long term basis using a product that has come from carbon sequestration. And then preserving land in farm and forest use, this is a very important one. I said there were a couple of cautions I wanted to add. The first one is that forestry has lost one million acres permanently to non forestry use between 1990 and the last statewide inventory that was done in 2002 represents about five percent of our forest land base. Farm acreage in North Carolina has dropped two percent between 2000 and 2004 and I would like to raise the question and maybe answer it or suggest some answers that address the question can global change solutions from these sectors help retain land in farm and forest and I think maybe the answer is yes.

I'll go through what I call the laundry list of the possible action items and I'll start with agriculture, the first one, protecting farm land from permanent conversions. Ways of getting at that or incentive programs, the use of conservation easements which are becoming more and more popular, continued employment of our use value taxation program in North Carolina. There is some rumblings of things going on that in my opinion will threaten the long term viability of that program. If you don't know what it is, we have a program where if your land is in agriculture or horticulture or forestry and you're actively managing for those commodities and you meet certain criteria in terms of acreage sizes, you can apply for and receive in your county what's called current use or use value property tax or property valuations and receive reduced property taxes. If you're living especially in an urban area it could mean a reduction in your annual property taxes of 90 percent. So it's a significant incentive for land owners to hold on to those current uses.

Another broad category is expanding our soil of carbon storage and this again we're talking about agriculture. There's a range of things that can be done and we'll be looking at them in our group basically designed to keep carbon or promote more carbon deeper into the soil. And loosely put its keeping the fields in production more of the year by having less fields fallow in the summer, using winter wheat as a cover crop. Of course conservation tillage is especially a good one because it maintains a cover on the land that degrades and introduces soil into the soil profile. And then there are crop rotation strategies that also reduce carbon lost.

Animals are emitters of greenhouse gases and there are some things that can be done we think in terms of improving feed efficiency. And then the emissions directly from the land itself and basically we're talking about nutrition strategies that reduce our nitrogen use on the landscape by using what we call precision agriculture where the rates are very much controlled by a map system if you will that controls the rates that are dispensed by the equipment. And it's a very high tech but it's a very cost effective way of approaching nutrient management on farms. Using deep rooted species on field borders happens to be another good strategy because it helps manage the nitrogen and the soil.

Another set of options that we will be looking at in our group are expanding the use of renewable energy directly on farms and expanding the use of farm products for off farm energy production. And there are a lot of things that are out there that are already developed or being developed, newer gas digesters, farm gasifiers, Mike Boyette in our department of Bio.& Ag. Engineering right now is working on a farm based gasifier that uses wood chips and would produce the energy on the farm and provide rate structure was favorable and net metering could produce some electricity for the grid in certain scales. In using bio-diesel in farm equipment, our farmers are agri-businessmen they're smart people, we are not producing bio-diesel in North Carolina but our farmers, especially our soybean farmers know that if they're using bio-diesel in their farm equipment they are setting the example, they're increasing the demand that promotes better prices for soybeans. And we have probably 300 to 350 farmers in North Carolina that are using bio-diesel in their own equipment and you can buy it if you have a diesel vehicle in about 24 or 25 of our counties at commercial service stations. And then a very large opportunity is using our agricultural commodities for feed stocks for off farm energy. Soybeans for bio-diesel, last year in North Carolina I think we had over 1.5 million acres of soybeans, so it's a very large crop. Feed stocks for ethanol production such as sweet potatoes and corn we had just a little under eight hundred thousand acres of corn in North Carolina last year.

And feed stocks for direct combustion and that can include things that you pick up and glean after harvesting so probably one of the bigger needs that's out there and that's our waste products. We are right at the top of the list nationally for the amount of livestock waste that we produce from our poultry and our swine industries. We produce an awful lot of waste, we're getting buildup of phosphorus in our soil across North Carolina and it's a real barrier to increase productivity at some of these sectors in our farm community and yet these particular wastes serve as potential feed stocks for both ethanol production and direct combustion. I'll give you some examples of that in a minute. Some other key action items are developing more efficient routing to get our commodities directly to market and encouraging windmill use on our farms as has already been noted. Those windmill technologies are getting more and more effective. Another really important one is taking our less productive farmlands our more erodible soils and planting them into trees. We get a terrifically increased rate of sequestration when we take farmland and we put into forestry and I've given you some numbers. A managed loblolly pine plantation in North Carolina can sequester over three tons of carbon dioxide a year as compared to typical farm crops which tend to be in the range of several hundred pounds per year.

Another action item that has a lot of interest, I don't know what the potential will be, is some new dedicated crops on our farmland for feed stocks for ethanol specially switch grass, several species of hard woods that grow and can be harvested in just a very few years. One of my concerns there is these tend to be terrifically expensive to establish. For forestry again the key action item is looking at things that reduce our conversion of our forestlands to permanent non-forestry use and better markets through healthy forest industry. Bob Slocomb if you're heard him you've heard this message from him that if we're going to have healthy forest and forest products derived from this almost three quarter of a million private land owners in the state, you've got to have healthy forestry industries and he's absolutely correct. There are some other mechanisms that are basically sort of legal mechanisms including land trust that have purchased land or purchased land rights for use of conservation easements are all incentives that can encourage the land owner to keep land and forest land.

And then some other directive incentive programs and again I'll mention the continued employment of use values. Increased use of residential and urban trees and promoting better health of those trees can be a very important item. We are losing our forest to everything from Wal-Marts to subdivisions but at least within those kinds of context we're encourage the use of shade trees and good management of shade trees. We're still keeping a good carbon sink out there working. We're storing non-forest lands to forest like wetlands, pastures and crop land is another potential action item. And developing improved trees for special uses through genetic and biotechnology in my own department at NC State our biotechnologist right now are engineering an improved variety or several varieties of loblolly pines that will be more efficient when converted to ethanol, so it's another action item, longer term.

Some other key action items are employing better utilization during harvesting. These can be pretty important, we're doing some studies in the group that I'm with now and we've estimated that by not changing what we're doing in our harvesting in terms of going after more acres but simply doing a better job of utilization in terms of getting what we're leaving out on the landscape now, which does degrade and does become carbon dioxide when it's left on the landscape. By going out and getting that through the use of chippers and using it, we've estimated that we can probably pretty easily in North Carolina produce 500/600 megawatts worth of electricity on a sustainable basis by doing nothing but better utilization. Then there are some opportunities in forest management and I described this as removing and easing trees to promote forest health especially thinning. Our number one from a dollar wise point of view problem we have with our forest in North Carolina in terms of pest and disease are the southern pine beetles in roughly half of our stands that are pines. And they especially go after slow going stands that are over stocked – that is too many trees growth rate slows down, sequestration rate slows down and the beetles go after them. And a biomass market for example could open up opportunities to manage for forest health and healthier higher sequestering forest. Just to let you know in the last ten years we've estimated we've lost 60 million dollars of pine timber – southern pine beetles.

Then improved silviculture – many are over stocked stands in North Carolina of about 18 million acres. About nine million of those acres over 50 percent of those are considered to be over stocked. Not only are they less healthy but when the growth rates slow down because that's what happens when you've got too many trees, your sequestration rate slows down. But we don't have markets for a lot of the materials that we need to remove to improve our growth rates. And also renovating the graded stands – the degradation of a lot of our forest especially our hard wood forest has been documented for years and they go all the way back to the administration of Governor Luther Hodges and that's occurred largely because of poor markets below value species. So timber buyers come in and the lower value species get less on the landscape because there's no market for them. The better trees get removed and when two or three cycles of that happens a lot of our landscape ends up in what we call a high graded condition with minimum very low stocking. It may look green, it may look pretty from the road but the growth rates are very, very minimum and that's related directly to carbon sequestration. And going in and renovating those stands or increasing stocking depending on how severely degraded they are can terrifically improve sequestration rates as well as providing potential good cash crop for our forest land owners which is yet one more incentive to encourage them to hang on to forest land. We have the distinction now in North Carolina to officially being the fastest organizing of the 50 states. And we have all over North Carolina subdivisions and individual homes being built in an around the forest which presents a very serious condition from a wildfire risk point of view. The program that has been developed nationally to address that is called Fire Wise, but the same problem exist there as with a lot of other problems that we have in forestry. Its low value material that needs to be removed from the landscape to reduce fire risk and it's that same low value material that we don't have markets for now.

So we've heard the term biomass several times this morning and a biomass market would make the economic opportunity to remove these dangerous fuels better. Salvage opportunities are a big factor in North Carolina. Annually about 426 million cubic feet that's about 16 million tons of wood that's often just left on the landscape, it degrades becomes carbon dioxide, with micro-degradation. Another possible key action item is improving carbon sequestration through nutritional amendments especially including agricultural waste. We have a group of our scientist that are in our air quality group in our department who have done a very good inventory of especially our agricultural waste in North Carolina and they're proposing scenarios where we use them wisely as nutritional supplements on our better soils where we have forests to improve growth rates which again are directly related to harvest sequestration. So that's a good option both for the forestry and agricultural sectors.

The one item that might be the biggest bang for the buck for ag and forestry and this is my opinion, and first of all using biomass for direct production of energy. Steam for heating and chilling – the chilling technology is very good now so you air condition with steam as well as heat electric power generation. I mention that there's also a second term which I'm calling the biomass bio-refinery and I'm asking why these are important. Well we'll go back to Thomas Edison and this is a quote. I would put my money on the sun and soil energy – what a source of power. I hope we don't have to wait until water and

coal run out before we tackle that, amazing thing considering when that was said – so what are the least expensive solar collectors currently available out there, our crops and our forest. They are out there doing the job converting carbon dioxide directly in the sequestered products and making energy. So biomass is important since its all about the carbon cycle and you don't need this re-explained to you today but through photosynthesis we've captured carbon dioxide, we turned it into products that you can create energy, carbon dioxide is released and then recaptured. So it's a recycling process and the estimates are that for forest it tends to be about 90 percent efficient. So that if you take a ton of carbon in the form of wood, make energy with it and then you keep that land in forest about 9/10 of a ton of wood would grow back to replace it. Actually if you think about what I said in terms of improving, using an energy market to improve the growth rates of our degraded forest instead of talking about a carbon neutral recycling procedure we may be talking about a carbon negative and that doesn't include things like geological sequestration, some of those others options you've heard about. It's a significant opportunity - you can make fuels chemical products, electric power or what is biomass. In the interest of time I will not read the definition but it's a lot of different things for agriculture from the crops grown to dedicated crops to agricultural waste. In the forestry when you look at the definition it's basically the things that we are now not using for our traditional forest products. That's what biomass is when it comes from the woods. Things that you can do with it, electric power generations, Craven wood energy in New Bern and Craven County 45 megawatt facility. About 40 percent of their furnace the last time I checked was chips that came directly off of better utilization from the forest. They used municipal waste from the Triangle that's shipped down there for making energy and they also use poultry litter. So the last trip I made down there they were actually producing 52 megawatts that day using poultry litter that's supposed to be a problem.

Heating and chilling for schools is another strong action item that I think we ought to think about in North Carolina. We have three states that are very aggressively going after institutional distributed generation for things like schools. Vermont has got one of the strongest programs. The General Assembly in Vermont has said that they will pay the freight on converting a school to a wood system or they will pay the extra cost because the wood system is a little more expensive for a new system school being built. And they are running entirely on wood chips with new systems that don't produce some of the particulars that some of the older boilers do and they are as automated as an oil or gas fired burner – you push the button and it goes. There are some higher tech options that some cities are trying when in the city themselves they locate a facility that can produce heating and chilling for downtown as well as electricity production.

I did want to especially highlight animal waste. The idea of using hog waste and poultry waste is not a novel idea it's a real opportunity. I've given you some facilities from around the world. I just saw an announcement yesterday that one of the largest energy facilities from biomass in Europe is being planned in Lockerbe and its going to use a lot of poultry litter in that. I did want to point out that there is a lot of existing use of biomass as a carbon nutrient fuel and its being done by forest industry. Our saw mills, our pulp mills and our dry fumes are being fired by wood waste right now and they're

already doing it. One problem is that a lot of them have boiler technology from the 50s and 60s and did produce particulars.

Last couple of things I would like to say is that we do have a lot of options. There are technologies that are emerging for using a wide variety of feed stocks from agriculture and forestry. There a variety of conversions processes for a huge variety of uses. One of the greatest potentials we have in North Carolina and anywhere is what our new department head in my college, Wood and Paper Science, who came from the National Renewal Energy Laboratory last year. He thinks one of the greatest opportunities we have any where are our pulp mills. They already have the infrastructure for procuring and handling wood – they have got technology and lots of other stuff that's in place. With some modifications and a couple of technological miracles that we ought to have achieved within the next five years they can become not only manufacturers of pulp and paper but bio-refineries producing a wide variety of products and especially ethanol. We think that ethanol conversion technologies are getting ready to be pretty good. We are learning how to do that. Many co-benefits of implementing such solutions in these sectors, first of all we are using renewable fuels, carbon neutral fuels, more incentives to keep land and forest and ag, keeping dollars spent for energy here in North Carolina, new jobs in rural areas. I will not read this but Ivan Urlaub with the Sustainable Energy Association, I borrowed a power point slide from him, one of the concerns is using things like biomass is what will it do to our utility rates. Will it go up? I will not attempt to answer that but there is a very real offset in terms of creation of jobs, social and environmental benefits. Some last co-benefits forest health is improved, things that reduce emissions tend to be soil friendly, reducing dependence on foreign energy sources, proved balance of trade and markets for ag and forest waste products.

I'll close with this point – its up to you to decide in this group whether we're going to do something in North Carolina and of course North Carolina is just part of the growth, but there is a cost to our forest communities for not doing something. I heard one of the arguments about not worrying too much about global changes but we've been there before. We've had ice ages we've had tropical climates in this part of the country ok so what, we'll do it again. The thing I would like to point out is that our communities adapted to those changes because those changes took many thousands of years. The kinds of things that we're talking about now are not thousands of years if you believe some of the things that are being published. I'll give you a for instance – the Barrier Forest that we have in North Carolina that we enjoy hiking in, seeing places like Mt. Mitchell, Rome Mountain, Grandfather Mt., Mt. Rogers those Barrier Forest are there because they adapted with the retreat of the glaciers during the ice age. Well a couple of the papers that I think are pretty good that are out are suggesting about a three degree rise by the year 2100 here in North Carolina. Other studies are shown because of things that control bug sect, germination and flowering that in three to four degrees rising temperatures will completely eliminate those communities. So there's one plant community that we could see disappear completely in less than 100 years. That is the price of not doing anything. With that I will entertain questions.

Mr. Garrou: Thank you very much Dr. Hazel.

Dr. Eggers: Thank you Dr. Hazel. There are two things that I didn't see on your laundry list that I am kind of excited about and since you are an expert in the area I wanted your opinion about these. One of those things is some of the research coming out of the Pacific northwest and other places which are going to impregnating chips after logging with mycelium and increased carbon sequestration. Because of that and decreased runoff and sedimentation and improved forest health because of the better fungal community in the soil. So a faster bigger crop coming out of it too. The other thing I didn't see was bio-char and could you comment on how excited you are about either of those?

Dr. Hazel: Both of those questions, I'm not an expert I apologize for correcting you. Both of those are exciting opportunities. I know less about the impregnation. Of course we do things like that already in our seedling production in North Carolina and I've read a little bit about it and it looks very exciting. It is probably something that ought to be added to our action list. The bio-char looks like it has huge potential. They are doing that at the University of Georgia which is the closest place. There are several ways of doing that but one of them that they think is commercially viable down at the University of Georgia is using what's called fisher stroke technology. They're producing a bio-diesel from wood chips and poultry litter and the product is a bio-char that can become a soil amendment and the productivity of the soils is just about unbelievable. But you've immediately got the sequestration potential improved through the bio-char and then you've got long term improved growth rates and the numbers that they're showing in terms of productivity increases are literally staggering. In fact we just had their principal person come up and make a presentation at NC State about a month ago. But yes very good thank you.

Senator Pittenger: Thank you Mr. Chairman. Thank you for your presentation. What has been the percentage change, amount of acreage change in the acreage in forest in our state in the last 40 or 50 years?

Dr. Hazel: We actually probably have more forest and I refer to Bob on this too but we probably have more forest now than certainly we did at the turn of the last century. So it depends on where you draw the line in time but since the soil back era when we had a huge amount of area that was added for forestry it's been a consistent decline. So you're probably talking about 20 percent that we've lost.

Mr. Shore: I'm just struck taking in all four of these presentations together with these diverse sectors of the economy. Opportunity after opportunity I'm just taking that in and I think it bodes well for us on this Commission as we figure out what is North Carolina's role in dealing with this challenge of global warming.

Mr. Garrou: Any other questions. If not thank you very much Dr. Hazel, I've altered my view you are an expert. We will now adjourn for lunch and how much time can we minimally have? We will start back at 1:35.

1:50 After Lunch

Mr. Garrou: Our first presentation this afternoon will be from Brock Nicholson and you've heard from him before and he is going to bring us up to date on what the Climate Action Plan Advisory Group is doing. Brock.

Mr. Nicholson: Thank you Mr. Chairman. I appreciate the opportunity again and I'll be pretty brief on this and I'll turn it over to Dr. Karl Hausker to explain a little bit more about what we're doing in the Climate Action Plan Advisory Group process. I want to report that we have had our first round of TWGC (Technical Work Group Calls) and again they were in the week of April 10 and we are divided up as we said before into these five categories, agricultural and forestry, and after the presentation just before lunch you probably have a little better appreciation of why that's a logical grouping. Energy supply, energy use by residential, commercial and industrial sector where we get into efficiencies that is a big point there; transportation and land use and then cross-cutting. I do want to say that we felt like we had very good cause. We had considerable enthusiasm especially in the energy supply and the ag and forestry. In fact a couple of extra suggestions that were made by participants in the ag and forestry that we particularly look at on farm production of bio-diesel as an option and understand what it might take there. In fact the bio-char topsoil incorporation was another suggestion that was brought up here before lunch but that brought up in our work group that we should include that. And crops that better take up carbon is another suggestion that we had as a starting point. Even though the first call was more of kind of a get together, get used to the process get used to the members and we'll plan to get on with it a little more earnest manner subsequently.

The general schedule that we're following is that we will have two work group calls between our advisory group meetings and we had the first meeting in February. We have our second meeting scheduled on May 23rd but what is listed is the first round of TWGC. Conference calls are actually two calls and each one of the rounds constitutes at least from the current planning that we will have two calls of each work group in between. I think the most important thing to note here is that we plan to finish up this project under the current schedule in the spring to summer period of 2007. And then of course be reporting again to this group along as we move along and I think as time goes on we will report a lot more substantive results of these discussions and work. With the report coming out in the June/July time frame. One of the questions that came up is an interface between the advisory group process where we're looking at mitigation options for actions in this Commission and we do have a considerable number from the Commission here. They are actually on the CAPAG process and we certainly wan to encourage that and in fact we would encourage greater volunteering if you want to be on the CAPAG process for members of this Commission or staff or other recommended individuals that you recommend to participate in this process of really digging into the cost benefits and so forth.

We handed out the catalog of mitigation options last time that we talked about which is a copulation of actions that are being developed, considered and in many cases implemented in other states. And these recommendations come from our September

Clean Smoke Stacks report which was referenced earlier in one of the presentations. That was our report to the legislature in the fall of potential mitigation options. The state energy plan recommendations and a lot of these three sources have considerable overlap. I do have a few for those that might want an extra written copy or otherwise they are available on our website which you can see at the bottom of the page there.

At this point I would like to transition to Dr. Karl Hausker who will share with you a little bit more of the specifics of the process of really considering each of the potential options.

Dr. Hausker: Thank you Brock and good afternoon to everyone. Brock has given a good lead up to my presentation. I am going to try to keep it very brief and help us get back on track timing wise. As I think many of your know the Center for Climate Strategies is a nonprofit group that provides analytic support and facilitation services to states, localities, regions in the area of climate change mitigation. We have a team of experts who have worked at the international levels, national levels and sub-national levels and we're very happy to be providing the service to DNER and to the CAPAG process. The slide you have up (Exhibit H) is just an example of the kind of information that we are going to be providing to the CAPAG. As Brock described for every state we work in we put together a catalog of options that other states are either considering or in some cases have implemented. I think this morning it was called a laundry list. I prefer to call it a catalog. I think the catalog metaphor captures it the best. There are some things in here that may make no sense for North Carolina but I think there are many things in this catalog that may indeed hold interest for North Carolina. In fact some of them are already under way being implemented or have been recommended as part of the state energy plan through some other process. A lot of this stuff will look familiar - some of it may give CAPAG and this Commission some new ideas on what could be implemented to reduce greenhouse gas emissions.

For every option that we put before the CAPAG we put before them some initial information on the potential GHG emission reductions that may come from this option in a high/medium/low kind of category. We put before them a cost per ton for reducing emissions, again its sort of a high/medium/low categorization and then a list of what we call (inaudible) impacts for additional impacts outside of the climate arena that this option might have in terms of air quality, water quality, energy security, economic development, things like that. This initial bundle of information can help the CAPAG screen which options it wants to focus on. We don't do a full blown analysis on an entire catalog of 200 options but in these early months go through a screening process to say what do you want to focus your attention on, what do you think might be best for North Carolina to focus on? Then we will take a subset and often in other states we've found that narrows down to perhaps 40-60 options that then require a very detailed examination and we do this in work groups, supplemented by other experts across the areas of agriculture and forestry, energy supply, energy demand, transportation and land use and then a series of cross-cutting options that don't easily fit in a single category. Then I think it has been described to you before those work groups developed recommendations, developed analytical support for the options and those are fed up into the full meeting of

the CAPAG for their consideration and ultimate recommendation in their final report. That is how we do our work.

The last speaker before lunch gave an excellent presentation on the very options that are available in the agriculture and forestry sectors. Then the speakers before although not in the same format they also were identifying the kind of options that could be undertaken. Dr. Greene was talking about the transport sector, technology, fuels, land use decisions that affect vehicle miles traveled. And the other presenters diagnosing all the different options within building construction and then of course the energy supply sector and how we generate our electricity. No one should ever say that there is only one or two options for dealing with climate change. There are entire portfolios of options you can take in each sector and they can be woven together into a state plan. The kind of plan that we've seen adopted in places like Connecticut, California, Maine and now underway in places like Arizona, New Mexico, and soon in Montana. We are advising a number of these states and we're very happy to be a part of this process too. In the interest of trying to get us back on schedule I'll stop there – our last slide is just to give you Brock and my contact information for questions or spam or very good clips from the daily show. Thank you.

Mr. Garrou: Thank you very much and to remind everybody you are encouraged to participate in this process with DNER and to participate in these task forces as you saw from Brock's slide. Many of you are already doing that. You have before you this afternoon's power point presentation behind a blue folder (Appendix H) and our first speaker this afternoon.

Mr. Shore: Mr. Chair may I ask a question or request on the CAPAG process? Brock one of the major responsibilities that this Commission has is to explore the possibility of global warming pollution reduction targets for North Carolina and I wondered if the CAPAG plans on providing some of the base line analytical information that could enable this group to have an informed debate about goals for global warming pollution? This is a request – this is something that the CAPAG could take on to help us out.

Mr. Nicholson: I think if there are specific questions that the Commission would want us to help answer through technical analysis and consideration by our stake holders, we could certainly do that. But I think we would need to maybe understand the specific questions. If it is an issue of how might we begin to reach a goal if one is suggested that might be one area that we could look at certainly in terms of value or reductions if there is.

Mr. Shore: Yes that exactly. If North Carolina were to have a goal of bringing back global warming emissions to 2005 levels how might that be achieved, what might the cost and benefits be if our goal were to be year 2000 levels of global warming pollution. How might that be achieved and what might the cost and benefits be?

Mr. Nicholson: I would think that would be a work that the CAPAG could certainly help with in terms of the technical information.

Mr. Shore: Thank you.

Mr. Garrou: Any other questions. I didn't mean to cut off the question period. Our next presenter this afternoon is Joseph E. Aldy who is a Fellow with the Resources for the Future and I hope I pronounced your name correctly.

Mr. Aldy: Thank you Mr. Chairman and thank you all for being here. It's a pleasure to be here to be back in North Carolina. I am at Resources for the Future which is a nonpartisan objective research oriented think tank in Washington, DC. We are primarily a group of economists who do research on environmental, energy and resources use and as I've tried to explain to some of my friends we are sort of like an economics department except that we don't have students. Instead of going into a classroom a couple of days a week to teach students we actually try to teach the (inaudible) world as a classroom and try to bring the lessons for our research to bear on ongoing policy debates. So it is a pleasure to try to contribute to your discussion here in North Carolina on what to do to address the issue of global climate change. I should also note about Resources for the Future that climate change is one of the primary areas of research interest with my colleagues. There's a good half dozen or so of us that do work on these issues. And at the end of my slides there is actually a link to our own climate change policy website at RFF and I encourage you to take a look at that and see the different kinds of work that my colleagues and I have been doing on climate change.

In my talk here today I am going to first discuss the primary determinants of mitigation costs and think about what are the kinds of issues one needs to think about to think about how the economy, how individuals, and how firms respond to a climate change policy in order to reduce their emissions of greenhouse gases. Through this discussion and subsequently in the presentation I'll be focusing primarily on carbon dioxide emissions given the prevalence and the economy and given that most of the economic models have focused on carbon dioxide emissions although the principles and concepts apply to all greenhouse gases. Then I'll discuss some of the cause implications of how we design our policy. I think this is very important and can actually provide policy context for a lot of the discussion this morning about technologies and options for reducing emissions by adopting those types of technologies.

Then I'll provide an illustration of some examples (Exhibit I) of cost estimates of various climate policy proposals for the United States to give you a sense of what the economic burden would be of undertaking some policies to move off of our current path increasing greenhouse gas emissions. Then I would like to close with a couple of comments on issues that I think merits further consideration when thinking about the design of policies to reduce greenhouse gas emissions.

When one thinks about the determinants about mitigation cost the first thing we need to think about is a reference of businesses usual emissions scenario. So I'm going to provide some comments on that. I'll talk about the ability to substitute to move from carbon intensive fuels to carbon lean fuels. I'll then talk about some of the substitutions

that is available when we think about energy used in technology and the opportunity for investing and adopting more energy efficient technology. I'll talk briefly about technological change and how this can affect the cost of reducing emissions and then the section where I'll talk about policy design issues.

When we think about a reference case or business as usual scenario this has to be basically the kind of action by which we are going to evaluate any proposed policy. One thing that is important to recognize is that business as usual does not mean no policy it typically means no new policies. So the idea that we have current policies on the books whether its on appliance standards, whether it's some states have renewal portfolio standards that would increase the amount of renewal power in the generating sector. These would all be incorporated and final assessment of what our future might look like if we don't implement any new climate change policies. After our county put us in a policy foundation we did need to get a sense of what the economy is going to do and how its going to grow and is it going to reflect basic fundamental forecast of economic growth and understanding of population growth over the long term. Then it also matters how energy intensive economic outlook will be. This has to do with both the technologies that are used and energy intensive industries but also relates to what we think the structure of the economy how it is going to evolve over time. Will we see more growth and energy intensive manufacturing sectors, will we see more growth and energy in lean sectors such as in high tax or in services. Then it is also important to recognize what we think the carbon intensity of energy use is going to be. This will depend a lot on what kind of fuels we use to power our economy. What's important to recognize when do these forecast of reference, or business as usual or what's often referred to as BAU emission forecast or scenario. It is important to recognize the existing policies and energy prices and innovation all matter. Expectations of energy prices matter. I am going to give you an illustration of the recent increase in energy prices that influence how we do a forecast of long term emissions.

One way is to think about where the future might be as we look at what happened in the past. From this table I provide evidence for North Carolina and for all states of what their emissions growth has been over the last 40 years and last century. This annual growth in carbon dioxide emissions and then it breaks it down by how much of that is comprised of the growth and population, how much more is the growth and income, how much the growth and energy has improved over time and decreased. And then how the carbon per unit of energy has changed over time. So we see here that North Carolina actually experienced a faster growth and carbon dioxide emissions over the last 40 years the last entry then all states did. They reflected at a faster growth rate above population and in income per capita. There is virtually no difference in the improvement and energy efficiency per year. Whereas about a one percent improvement in energy in energy efficiency per year over this period and very small changes in the carbon per unit of energy.

Now I also put in here the second set of rows, focus on 1973-1986. This is to give an illustration of what a high energy price looks like. I think one thing that's important to recognize is that first we see virtually no growth in emissions both for the US as a whole

and for North Carolina. They grew in North Carolina only two-tenths of a percent per year over the 73 to 86 period. What we want to recognize is that is basically negligible growth in North Carolina and the country as a whole more than just because incomes grew slowly, you also saw an increase in the improvement of energy efficiency. So when it shows that there is this potential that when we look at where can we reduce emissions it is not just that you have to grow slowly to reduce emissions. There are these opportunities to improve the energy efficiency of how we use energy to also improve the carbon intensity of energy we use to help reduce emissions even as you see both populations and incomes grow.

Now one thing I noticed that forecast of energy prices can have an impact on where we think the future is going to be when we think about forecasting future emissions. So this figure here shows the last five years of forecast for the nation from the energy administration and their annual energy outlook. Now the 2002-2005 annual energy outlook has very similar forecast for the next 25-30 years. The only difference between them is basically depending on what year you were looking at, whether you counted for the fact that you had slow growth in 2001 and early 2002 because of the short recession we had. What is interesting is they updated significantly the most annual energy outlook which came out about four months ago to account for the much higher prices for both petroleum products and for natural gas. What we see here is a slower growth rate and a diversion from the previous forecast. So we see that by the time you look at 2020-2025 emissions, they are about seven percent lower under our new forecast than they were by previous forecast we made. The good news is that we are actually expected to contribute less to climate change over the coming years. It doesn't mean don't do anything but it also means that if we want to propose a goal to reduce emissions to say current level or 2000 levels or whatever goals people want to imagine, the burden of doing so is going to be lower because there is already some built in in the economy. A slower growth rate because of these higher energy prices than we expect to experience.

When we think about what is the opportunity to substitute to carbon lean fuels obviously the cost of any mitigation cost are going to be lower, the easier it is to substitute you need carbon lean fuels. From the electricity sector and Dr. Rubin went into this in much detail this morning so I will not discuss this too much. Clearly anticipation that one would transition from coal to natural gas and then to renewable and nuclear power and relative cost of will impact a lot on where we are going to see growth in different categories of these fuels.

Transportation - that we have fewer substitutes available for us that substitute from gasoline or diesel to a non-carbon or to a low carbon fuel, there is potential to go to ethanol. But as we heard this morning from Dr. Greene the carbon savings are going to depend a lot on whether the ethanol has original corn based ethanol or whether it's cellulose. You're going to get a much bigger climate bang for your buck at least if you get cellulose to be concentrated with corn. One thing that is clearly important here is when we're talking about the kinds of technologies that use different forms of fuel. The existing capital stock is going to have a big impact on this. The timing is going to really matter because we're talking about investments and technologies that have very long life

lines. So when Duke Power is trying to decide on what power plant they're going to build next they have to have in mind that they want to be running this power plant for a number of decades. That's going to have an impact on what kind of decisions they make having expectations of what future prices are lived what kind of decisions they make. It helps to have not just what the sense of long term is going to be, but are you going to be regulating carbon dioxide just for the next five years or for a long time rising. It also helps to give firms that make these investments some lead time to make decisions. You don't want to impose a regulatory policy tomorrow that would impose really high cost for them to continue to run coal fired power plants. You want to give them time to transition to take advantage of the natural turnover and the capital stock as they invest in new technology to reduce their emissions.

When you think about improving energy efficiency, again I think what is important is recognizing that investment in energy efficients are going to reflect both expectations about prices, this is the one thing that people really respond to, this is a lot of what you have seen about responses to the increase and gasoline prices. I was reading yesterday that more and more people are taking transit in response to the high gasoline prices. We see fewer purchases of SUVs and low fuel economy vehicles in response to the high gasoline prices over the last year and a half. So people clearly respond to prices. Its also important that this was certainly eluded to this morning that there is not enough information in some of these markets and its useful to try to convey more information to consumers and to firms about energy saving opportunities for them to take advantage of some of these energy efficient technologies.

What is important and this is a caveat somewhat was said this morning, consumers care about more than just how much do they spend on fuel when they buy products. If you really cared only about getting from point A to point B with your car you would never spend $50,000 on a gas guzzling SUV. But I think you care more than just can the car get me from point A to point B and try to minimize my cost. There are other attributes to the vehicle that we care about. So it is important to recognize that when we think about what are the opportunities for energy efficiency one can just say if we improve fuel economy and have the pay back in so many years a lot of people are going to buy the car. I actually have to exception with claims that people under value fuel economy in the market as an economist. I am not out here trying to say whether people under value it or over value things in market, I'm trying to interpret their values they reveal in markets. So I want to try to take a diagnostic view on that and don't take the people under value or over value but I want to try to convey to them that with the right price signals to show that yes there are extra analogies such as the impact on climate, local air pollution, congestion, every route applies transportation appropriately that would then create the incentives for them to make investments and more energy efficient technologies.

As an example drawn by a one month old analyses by EIA, the dark blue columns are for the reference case out for the next 25 years. The other two columns reflect two carbon regulation policies so it would actually impose a cap and trade program on the US economy and then by virtue of the permit price would raise the price of electricity. What we see here under these three scenarios the differences and the use of different fuels in

the generation sector. You see where coal decreases significantly in part because it is the most carbon intensive fuel in the generation sector. You see a slight decline in natural gas and if you look at analyses EIA did six-eight years ago, you would actually see natural gas increase. Even though natural gas generates carbon dioxide emissions given how low natural gas prices were six-seven years ago you would have seen much more natural gas going into the electricity generation sector. Now with much higher natural gas prices forecast by EIA you don't see that kind of supply going to the generating sector and that's why you see a slight decline here in power generation. You see a slight uptake in nuclear and a lot of this has to do with where we think both policies and cost of technology is going to be in future with nuclear. But you see especially on the far side a big increase in renewables. You see a big uptake in the higher price, a big increase nearly doubling in renewables from what's forecast over the next 15 years.

The inside figure shows the decline in electricity energy consumption overall so the larger figure shows the switching from a carbon intensive generation fuels to more carbon lean and zero carbon fuels. So you see the fuel switching the insert shows the improvements in energy efficiency. One thing I've shown here is when you thinking about a policy, what can be a cost effective policy, you want to be able to take advantage of both your low cost opportunities for fuel switching and your low cost opportunities for energy efficiency. When we think about technological change its one thing in these models and how we look at the economy is always ongoing technological change even if we don't have changes in energy prices there is still going to be some change in technologies, whether it just turning over into capital stock you can't build a power plant today with the same technology 50 years ago. You can't buy a refrigerator with the same technology you had 20 years ago. You can't buy it and put it in your home today so we have this sort of natural improvement in our technology. But as we think about the impact of policies if you are able to put in a policy that imposes the price on carbon dioxide emissions on greenhouse gas emission that induces additional technological change. You'll see low carbon and zero carbon technologies coming off the shelf and being deployed in the economy. You also see the incentives for more R&D, more innovation if you try to define the next generation technologies that will be low carbon or zero carbon.

Right now we know that we have insufficient R&D, we have it for two reasons. One, if I make carbon dioxide I pay the price of zero for that. That means that I have no incentives to invest in R&D for a lower carbon technology to replace what I currently use. There is also the problem that I cannot fully capture all the benefits of R&D. This is a fundamental problem not just for R&D for efficiency or for the climate issue but all forms of R&D and that is the people who are the innovators can't always capture all the benefits. All the risks associated with it, people will try to mimic the new technology even though we try to protect this with our patent laws there are still opportunities to better try to take advantage of how you create a new knowledge. When we think about appropriately dealing with R&D incentives in the climate context we need to think about both correcting the fact that we aren't pricing the pollution like we should but also think about policies that might try to promote more R&D and address the fact that we are under investing in R&D irrespective of the impact of pollution on the climate.

One other thing to think about R&D isn't going to lower our cost of new technologies in the next two to three years. The payoffs for innovation, especially given the long life times of the capital stock are going to be longer term. But if we think we are going to eventually need to get to very low emissions or even zero emissions economy in the latter half of this century as many scientists and engineers have said in order to meet reasonable long term climate change goals, we need it. So I've undertaken that kind of innovation today creating the incentives for that innovation today in order to have those technologies we will need to invest in in the future.

The cost implications of policy design. I am going to focus on cost effectiveness and be very careful about how I use the word distribution impacts which I think are very important when we think about the political economy of these kinds of issues. A little bit on cost energy and then give some examples many of which I am sure you are familiar with on how we use market based policies to try to achieve environmental goals and cost effective matter. So when we think about cost effectiveness we're really saying here is given an environmental goal, say a level of emissions of greenhouse gases one wants to achieve, a cost effective policy minimizes the total cost of achieving that goal. Now one of the things that is necessary for us to be able to do, that is you want to be able to equate the cost that all the sources of emissions are going to face. So one way in which economists have often advocated for this is through either carbon taxes or through a cap and trade program. That is what a lot of my analyses will focus on.

When we think what are the characteristics of a cost effective policy we typically try to describe it by using the Ws, the where, when and what flexibility. So the idea here for where flexibility you want to be able ideally if you were designing a policy without the context of North Carolina, the US or the world, you would have every source of emissions to cover. The climate doesn't care if a ton of carbon is coming from Raleigh or from Beijing or from Delhi. It has the same climatic impact. So what is important is trying to be able to design into our policies where you are getting the biggest bang for the buck. You want to go after the lowest cost opportunities to reduce emissions.

When we think about when flexibility with timing, we don't have to reduce our emissions to zero tomorrow, we're talking about with the exception of methane, all other greenhouse gases have life times on the order of hundreds to even thousands even some of them tens of thousands of years. So the thing is that when thinking about the climatic impact you want to be able to design a policy that can get the emissions reductions going now but you don't have to have drastic emission reductions in 2006-2008. What you want to do is be able to get on the transition so that you are able to make more substantial reductions. Later we will be able to take advantage of the turnover in capital so I can have lower cost in generating the climate benefits.

The what flexibility means don't just focus on carbon dioxide. I am going to focus on that in my discussion of modeling results to illustrate this but you want to be able to cover as many of the greenhouse gases as possible and you want to be able to cover carbon sinks, the biological carbon sequestration. Again you will be able to take

advantage of low cost opportunities to be able to reduce your total cost of meeting your climate change or your emissions goal.

Economists have been saying this for 40 years now about the benefits of cap and trade or emission taxes in achieving a goal in a cost effective fashion. They incur fewer cost for meeting a given level of emissions then mandating technologies or mandating performance standards.

The distribution impacts, clearly when we think about how we are going to go forward with the climate change policy if an emissions tax or a cap and trade program is implemented its going to raise the price on energy. In fact the modeling houses I'll show will illustrate that. It's going to have a big impact more so on low income households because energy tends to be a bigger share of low income household budgets and so there is a concern that this policy could be regressive. It's also going to have a big impact on energy intensive industries and carbon intensive industries. Whether those who are generating energy or those who use a lot of energy. One thing is how do I address the fact that there are going to be winners and losers by this policy. Do you think about how do you design the policy, one thing that is appealing about both the cap and trade program and an emission tax is the opportunity to use the program to compensate losers. So if one were to have an emissions tax you could simply use the revenues from that tax. Use part of the revenues perhaps to offset the burden based 50s who are an industry that would be adversely affected by the policy. You could use it to help low income households.

I think another thing that is really important when we think about the benefits of emissions tax or if we were to auction off permits in a cap and trade program is that you are able also if you have additional revenues left over, you can use that to offset other taxes. So this is something that economists have been saying for a long time that the problem with the US tax code is that we tax a lot of goods. We don't tax bad we tax capital, we tax labor, these are good, these are important for growth. We don't tax things like pollution. These things are bad. We like less pollution more labor more capital. So if you were to have a policy where you said ok we're going to either impose a cap and trade and auction off the permits or we are going to have an emissions tax and get revenues from the tax we are now able to reduce our payroll tax for our tax on capital and be able to help offset some of the cost of the economy of opposing a climate change policy.

I think one thing that is important is that there has been a good bit of work that is shown that if you were to give away all of the permits that are envisioned under various cap and trade programs, the firms receiving those permits even though they are the ones that have to reduce their emissions, actually could be made better off. There has been several other studies that have shown that their inquiry values will increase in response to this policy. Now this is clearly contrary to our standard notion of the polluter page principle. This is actually a polluter winds principle happening here. Its because there is so much value in these permits that we give away even though we're giving them away for free, we're giving away a scarce asset because we're constraining the number of permits in the

economy. So this has the impact of actually they can buy and sell these permits and they end up basically having something given to them for free, that's a big asset. This is contrary to what we've done in other context, for example when we auctioned off the spectrum to wireless carriers, we didn't give away the spectrum to all of the wireless carriers they actually had to pay for it. The view was the spectrum is part of the public domain and for the wireless carriers to be able to use it they have to pay for the right to do it. In the context of our free allocation though you supposedly would have to pay for those rights to emit carbon dioxide and other greenhouse gases and it could actually benefit them substantially. That is why a lot of people have advocated for hybrids, part auction, part free allocation with so many allocations would be able to offset some of the adverse impacts on the effective firms and industries.

Cost certainty, there has been some concern that the cost are so uncertain with any form of regulatory policy, especially the cap and trade program that we really can't take the risk of adopting a policy and if things turn out to be a lot more expensive than we thought, end up really taking the economy because we implemented this climate change policy. There are a couple of different ways in which people try to address risk when designing climate change policy. One is actually instead of setting a hard cap a quantitative cap on the total emissions of the economy you're going to index your economic growth. You're uncertain about how much the economy is going to grow over time, this way you remove the uncertainty with economic growth by making your quantitative emissions cap a function of that economic growth. This is reflected in the Bush administration's voluntary goal. This is also reflected in some firm's voluntary goals that they've taken on for themselves. Probably because they're like we don't know how much we're going to grow over time, we definitely don't know how much we are going to grow because of mergers or divestures and so during it as a share of output makes more sense to us than a total aggregate quantity of emissions.

Another way to address cost uncertainty is to have a hybrid system that has both attributes of a cap and trade program and an emission tax. So the idea here is that you would assess total number of emissions that you allocated in the economy. You would do an auction or if you're grandfathering, and then you would allow at a predetermined price additional permits to be sold in the market. The firms would go to the government and they could buy as many permits as they want at that price. That effectively serves as a sealing price on the cap and trade program. And one can design this so that its an insurance mechanism. You can say well we expect prices to be say $10 a ton but we're concerned that if prices go over $25 a ton it could have an adverse impact on the economy. So we are going to tell all the regulated firms to sell additional permits at $25 a ton. If we're wrong about cost of emission reductions being much higher than we thought and the price in the market goes up, it will be capped at $25 a ton and these firms could be additional permits. If we're right and the prices never go high, we never trigger this and we end up complying with the original quantitative cap.

Another thing that is important to recognize is that we don't need to have complete and total certainty to take action. Firms make investments all the time in light of uncertainty. Uncertainty about energy prices are more bearable than what we will expect to see under

reasonable climate change policies, they also make decisions all the time of uncertainty in various forms of regulations whether its unconventional air pollutants, whether its economic regulations, whether they restructuring industry or not, all of the uncertainty with the competitive pressures both in other states and in other countries. So decisions get made all the time under uncertainty.

A couple examples on cap and trade as many of you know there is the acid rain experience which has been very successful by reducing carbon dioxide emissions from power plants and in the late 1980s we phased out lead and gasoline through a system that allowed trading among refineries that was very successful. Southern California has also started a trading program to deal with local air pollutants. With emission taxes we have less experience in the US for the most part we've done it primarily to yield solid waste where people pay through what's called unit base pricing. Pay for solid waste collection. I will note that this is part of the debate that Duke Energy has advocated for a carbon tax in lieu of a cap and trade program. This is part of the discussion among those who actively engage on the climate change issue on whether to go with tax or cap and trade in the future for policy.

In Washington especially in the Senate you've seen a lot of action with a variety of bills some of these are books on just the utility sector. These are being called the 4P bills, the four pollutants because they regulate carbon dioxide, sulfur dioxide, nitrogen dioxide, and mercury. There are two bills from the last several years on regulating utility sector emissions. There have also been several proposals to try to address emissions economy wide. Both the McCain/Lieberman bill that came out for the first time three years or so years ago then also last year follow up with the National Commission on Energy Policy by Senator Bingham is sort of advocating for an economy wide program based on their proposals and they're continuing to take comments and ideas for that. There is a lot of action going on thinking about national cap and trade programs.

When we think about the cost estimates there are a lot of models one can look at here and I actually don't want to say that the model results that I am going to be presenting from the energy information administration are the best models. But I think they have the benefit of having been very recently done to reflect the fact that we have new forecast to show much lower forecast emissions in the future. There are some models out there which are going to say that climate change policy is going to be an incredible burden on the economy. There are other models out there that say the economy is actually going to grow faster if we undertake a climate change policy. I have problems with both sets of these analyses but I think some of the assumptions that are being made by those that show very high cost make some assumptions in models that I can get to an (inaudible) aren't really associated with climate change policy per say but actually have a lot to do with how labor markets start reacting to climate change policy. Which I don't think is what we see when we get labor markets to respond to energy price shocks and that is how they get really big cost. My concern with these models that get negative cost for reducing emissions are doing so without fully appropriating all the cost associated with some of the policies they envisioned for reducing emissions.

So instead of going with the EIA model we should be honest it is probably on the conservative end that tend to show more cost and higher energy prices for giving levels of emission reductions than the typical model that's out there.

I'm going to present three cases here, the reference case which is consistent with a figure shown earlier. Then what is called cap and trade 2 and cap and trade 4 and I have these abstract names so if you want to look at the analyses, this is how they named the analyses. These are based on true variations of the National Commission on Energy Policy Proposal. And it shows what different kind of caps look like for the economy. This figure shows what the emission would look like under these three cases. The blue line on top shows the forecast emissions. The cap and trade 2 - the more moderate of the policies shows a slower growth rate but still shows that US emissions of carbon dioxide will continue to grow over the next 25 years. The cap and trade for the more stringent of the policies shows that by a decade from now carbon dioxide emissions will peak under this policy and that by 2025 they will return to current levels and continue to decline in the rest of the forecast period.

Emission scenarios are based on these carbon prices so this is price per ton of carbon dioxide. We are looking at very modest slow growing prices for the cap and trade 2 case and we see an increase in carbon price for the more ambitious case. GDP under these three scenarios – this is not a mistake in the figure, there are actually three lines there. But it shows here that there is very little difference in economic growth under these three scenarios. By the time we get to 2030 the most ambitious policy where we actually see emissions peaking in 2015 and declining and reaching current levels by 2025 and continuing to go down. By 2030 the GDP and the US economy is forecast to be about half of a percentage point lower. It's just half of a percentage point lower than it would be otherwise. This is much smaller than the uncertainty we're trying to forecast GDP out that far certainly but it shows that you can take reasonable climate change policies and see very little change in economic growth. I can use this model and say we're going to go and implement Kyoto when we started today. We're going to give the economy two years to get ready for 1990 minus seven percent. You would see a very big difference in this figure if we were to do that. So this isn't because all this model show very low cost, when it estimated Keota back in 1998 it showed very big cost for the economy. So it is just a function of the stringency of the policy.

To give you some sense of what the policies mean in terms of what you and I care about which is what happens when I fill up with gasoline or pay my utility bills. This figure shows the last 15 years the energy prices for the US and then shows the forecast for under these three scenarios. So we see here for gasoline it's a big increase in gasoline prices over the last three or four years. EIA actually forecast that once we get through this short term peak we should expect to see gasoline prices go down. We would see under these two different climate change policies a slight increase in gasoline prices. I think one thing that is important about this is that we see that the increase in gasoline prices is much less than what we've seen in the run up in the last four years. The increase occurs over a much long period of time so I'm forecasting thru 2020. So we are going to see an increase in gasoline prices over a 15 year period but much lower than the increase in

gasoline prices we've seen in the last three years. Another thing important is if we were to implement a climate change policy we actually know and expect that gasoline prices are going to increase. We could start adjusting and making decisions say what kind of car do I buy because I know gasoline is going to be a little more expensive now because of climate change policy. No one in 2001 could have forecast $75 a barrel oil and $3 a gallon gasoline and made a purchase decision to reflect that. Where now if they had bought that SUV in 2001 they are now paying a lot to fill up their tank, a lot more than they had anticipated. So the important thing to also recognize here is that with the climate change policy people can have expectations they can form that can help them adjust and adapt to the increase in prices expected.

This figures shows that for electricity again the increase is a little more substantial here but it is important to recognize this again forecast over a long period of time is also anticipated and as a growth rate between now and 2020 it is still a much smaller rate of growth in electricity prices than what we have seen over the last several years with a big increase in natural gas prices.

Finally this figure also shows the change in natural gas prices, again the increase under these two scenarios is much less than what we've seen in the natural gas market. A couple of comments I would like to make that merit consideration when thinking about the cost implications of climate change policies, one that I advise and know that you're already hearing this is to think what are other states doing, what can we learn from the other states and how they're designing climate change policies and taking action to address this issue. Second, think about what are some of your non climate change policies, what kind of impact they can have on emissions and then also think if we are going to do this for climate change are there ancillary benefits, are there other things that we value that we can address at the same time when we address climate change.

One as you know, the northeast states are moving forward with the regional greenhouse gas initiative. This puts the cap and trade program on their utility sector emissions. There are some other design issues that I think merit consideration, one is thinking about how stringent a cap to impose, one thing to think about how one allocates the permits across the effective utilities. The other is to think about the offsets. The opportunities that you should go outside the utilities sector to produce emissions. I think one thing that is of concern here is the concern about the emissions leakage. So this is the idea that you have in the northeast, they're putting a cap on the utilities sector emissions. They are already a net importer of electricity and there is a concern that if they make electricity generation more expensive in their home state that just creates the incentive for more generation outside of the region to then be exported into the northeast states. So I think it is one thing that's important to think about and we think about it also when we think about international climate change policy. Some countries take actions and some don't. The Europeans are very concerned about emissions they should give to the US right now because they have regulatory policy and we do not. This is the just taking the international context and applying it to the state level which is of importance.

California as you know has tail pipe standards - nine or ten other states have adopted their tail pipe standards conditioned on surviving the legal challenges. Then also it started to advocate and discuss and propose a number of utility sector policies. I think it is useful to get a sense of what those different types of policies may mean.

As an economists, I think about climate change as an alternate set of policies. I want to think about policies that both reduce my emissions, they reduce the effective climate change but I have to recognize that there is already climate change that is occurring, that has occurred and that will continue to occur. There is already enough emissions in the system that we know, there are some risks of climate change impacts in the future, we need to think how best to adapt to them. While a lot of people who worked on this issue talked about it like a big stretch of developing countries, we saw that low probability of catastrophic impacts that could be associated with something such as levees being breached in Louisiana. So this raise the questions of can we look at how people adapt and develop and rebuild New Orleans given that is in a very vulnerable area two natural disasters and things. How that influences how we want to think about things such as how do we douse our coastal environments for the potential climate change risk in the future.

None climate policies of emissions impacts – more than 20 states have renewable portfolio standards and these will certainly reduce the emissions in future generations in those states. Then there is the biofuels mandate. The Energy Policy Act last year actually mandated renewable fuels in motor gasoline. And again the emissions will depend a lot on whether or not we're using standard corn based ethanol or a more carbon efficient ethanol such as cellulosic. It's important to recognize what you are able to get in terms of emissions reduction and it also lowers your cost of any climate change policy you do want to propose because you've already taken some effort to reduce your emissions.

And finally on ancillary benefits one thing that is important is that if we do reduce our carbon dioxide emissions by reducing our coal consumption, reducing some of our natural gas and petroleum consumption, we're going to reduce emissions of local air pollutants and generate some important public health benefits. The higher gasoline prices that would be expected would help reduce congestion and lower traffic accidents. There is also the benefits of biological carbon sequestration could have in terms of various ecosystem services whether it's water shed protection whether it's habitant per species depending on how one goes about planting the trees and so on. And there are some things in which you can do which include and I put in quotes energy security because energy security means a lot of different things for a lot of different people. What we are talking about is being efficient how we use energy that should help us in that regard.

So to conclude I think when one looks at the economic literature on the cost of mitigating emissions one draws from it that there is no free lunch. It is going to involve real resource costs there is going to be real cost to the economy, to consumers, to firms but it's not like we will have to go back to the 1970s and deal with incredible slow economic growth, recessions, lines to fill up the car and things like that. But there is a middle ground that are the reason policies want to implement that can reduce emissions in a cost

effective manner that are consistent with where we need to be going to address climate change. I think it is important to think about how we design these policies and how do you create the incentives for people to invest in these technologies. I think the recent energy price shock show that reasonable policies are going to have an impact on energy prices but less than what we have been experiencing in recent years. We suggest that we are able to adjust to them and account for them without big impacts to the economy.

And finally I would suggest that we think about where this policy can go where policies can go. In the future total cost matter may be even more important when you think about how you get support for the distributional impacts of the policy.

To conclude my contact information is on the last slide and it also the website for climate change work address. I appreciate your attention and look forward to your questions. Thank you.

Mr. Garrou: Thank you very much Mr. Aldy. Questions?

Mr. Urlaub: I had a question, you showed a couple of scenarios projecting forward like gasoline prices, electricity, natural gas, is it correct for me if I wanted to glean a lesson or principle from your research analysis and presentation, if I walk away and think that if energy firms can come closer to an optimal portfolio mix, if the price in carbon risk which could mean pricing in anything like alternative electric generation options or if there are firms like a manufacturing firm, pricing in some kind of process innovation or product innovations or something like that. Is that generally accurate to take that away from your presentation and is that reflected in your results here.

Mr. Aldy: Well I think what one sees when one gets sort of inside the black box the model and you see what kind of behavior goes on. In these models we sort of have representative firms of different kinds, different sectors, the representative individual we see how they start their behavior. What you will see here is that they do start to change their mix in both how they would dispatch electricity. So you would start seeing where natural gas might be moving into base load and less into peak because it has a much lower carbon content than coal. You would start seeing also changes in where they do their investments in the long term planning horizon. So they start saying well we know that there is not going to be this price on carbon, this now makes nuclear more attractive than going with another coal fired power plant. So I think these are the kinds of things that when you start seeing it you will start seeing a change in the mix that better reflects the cost of generating power from these sources has on the climate. And that is why when economist advocate for cap and trade or an emissions tax what they want to do is price extra rights. But right now we know that that is something that is bad for the climate, it's bad for people and in the long term when we think about these different kinds of impacts climate change will have and no one is paying for that cost they are imposing on the planet and on society in the future. So the idea here is that if we are able to price it correctly and there is a lot of sectors that say what is the right price, one can do a full blown benefit cost analyses and try to come up with that. Before you put on that price you start getting them to change the fuel mix and the technology decisions they

make and they are indeed efficient. So it is not just what am I going to invest in for the next power plant but what do I do in terms of investing say carbon capture and storage which no one would ever want to do if they thought there would never be a price on carbon dioxide. So these are the kinds of things that I think start to influence the kinds of decisions a utility would make as they more forward in response to this kind of policy.

Dr. Eggers: Thank you for your presentation. Just recently one of the economic professors at my university was talking about how, he's a big fan of cap and trade as am I, but really how when we put some kind of safety valve on it we loose a lot of the potential benefits of having a market trading program. So as the economist stand before me and talk with a straight face about putting a safety valve on, I wonder is that really just for political reasons to increase certainty for industry to make it more palatable or is it because you think it is economically the best idea.

Mr. Aldy: Well I think both. So on the political point of that there are a lot of different models out there that will give you a lot of different estimates of prices. So some people who are skeptics of climate change policy will point to that and say prices are all over the map, we don't know what they are going to be. Some of them show that they can really be high cost and we can't take that chance to the economy that is what some will say. So one response on why this idea was first put on the table some eight/nine years ago was to try to address this concern. Now from an economic prospective why it's appealing, I actually don't think it breaks down the kind of market you're trying to create and the reason I say that it depends on what kind of price you have in mind for what you sell these permits at. So as I like to think of it as an insurance mechanism and the idea that we think prices are going to be at this level, say $10 per ton but we don't want it to go above $25 per ton. So that is what we're going to price these additional permits at. So if the market is working very smoothly, cost of investing in these technologies are at or maybe even below what we had originally forecast, we're going to see the market behaving down here. No one is ever going to go to the government and buy these $25 per ton extra permits or extra allowances. If they do I hope their share holders throw them out of their job because that's a very bad business decision when you just go to another firm and buy them at $10 per ton. So it is only when the prices are unexpectedly high when you have these sorts of shocks in the system that one would actually want to be able to have this insurance mechanism.

The other reason I've given the prospective of why it's appealing is that actually if you talk to a lot of economists, they actually prefer a price based approach to a quantity based approach. That is a carbon tax can have more appeal than a cap and trade program. And the reason being is that in the near term the absolute level of emission reductions isn't that critical for the climate. In the next 50 to 100 years how many tons will you net in the atmosphere aren't important but whether they're all being emitted in the next five years or spread out over time doesn't matter as much. So the idea is that there is an incremental benefit of reducing another ton is not that big for climate for any given year. If there is this risk that if I do reduce the amount of emissions that can occur through a cap and trade program that incremental cost may end up being really high by ending up having a really stringent cap. So the idea that you may want to have some of this hybrid

system that allows you to make sure you don't even experience these really cost because the incremental benefit of reducing another ton isn't that high in the near term. That's what the standard economic analysis will say on this. That's why at the end of the day you see more and more economists saying that a cap and trade or carbon tax or hybrid or both. The other thing I would say is that I like them both a lot more than standard commanding control kind of policies where I think you start getting the situation where the cost that different firms face can vary a lot and that means we are spending a lot more money for giving emission reduction than we would if we had either an emissions tax or a cap and trade program.

Senator Pittenger: Thank you Mr. Chairman. I am hesitant to make a statement because I would like to hear from the other four people who I think deserve equal time. You mentioned Duke Energy and I know Exxon too advocated caps. While I am a big supporter of nuclear energy I do think that the reference to that should be noted the fact that the nuclear energy doesn't create CO_2 emissions and it certainly is worth their advantage to say that.

Mr. Aldy: I think it's very true that as utilities come more and more sophisticated about this issue you will see different positions being taken and you see this some in California and partly reflect their current mix and where they think they are going in the future.

Mr. Profeta: Thank you. I will try and be brief. The Senator just mentioned Duke Energy is also in favor of cap and trade and they had a higher 12 percentage factor than any other utility in the nation. So it is not only nuclear as their advocating point. Just a quick question on the modeling data you talked about, the EIA model and how it was maybe being a little more conservative. What is really important in all these models is the assumptions that go in. Can you give any sense of what are the assumptions that go into that EIA model in terms of what price do we see coal gasification coming in and things like that we heard about this morning and is there any sort of tax feedback looped in that model where you would actually have a reduction in revenues and taxes raised as a result in the model in that model.

Mr. Aldy: To be honest this is the most recent version I have and they don't actually present this in their public report. So it's something I would need to go to the EIA modelers and get detail on how they model the tax issue. This is something if one were to read the economic literature for which I wouldn't recommend unless you got insomnia but if you were to read this literature there is a vast literature on basically the tax code and how you implement this thing and the tax effect. So there are different kinds of rules that get used in different models, some of them are this idea that well if we are going to see an increase in these permits being put out there and an increase in energy prices that's going to slow economic growth, that's going to slow the government revenues. One response is you decrease the amount of money that the government has to have to operate the model. You always have to have a balance in the model which also doesn't quite marry the railroad where we don't have balance in what our government is doing with our expense money in Washington. There is that kind of assumption that's being made in the model. All the models assume that you have to increase tax rate on goods to make up

for the fact that you've got slower growth which of course then just makes the economy grow even slower. That I think is very frustrating for me because the whole point of trying to put a cap and trade program on pollution is because it allows you to free up and reduce your taxes on goods like labor and capital and instead some of these models make these assumptions that we're just going to increase taxes on labor and capital. So what you end up seeing is that it is not the energy price that's sort of our first initial effect that's driving the economic cost it's the secondary effects that's based on the assumptions about how the government responds to the taxes and then how people respond to the supply and labor of the economy in response to these higher taxes. All of which you can address if you just want to do tax reform. I can tell you the exact same story if we have a conference on fundamental tax reform. So our issues that are important to think about that are related to climate change but there are smart ways to do it that aren't always captured in all of the models.

Mr. Stephenson: Could your elaborate on the depth of strategies what lessons have been learned from other states and what you think we've learned from Katrina? I assume you are not suggesting that we begin building levees.

Mr. Aldy: No I don't suggest that. One reason is that I realize we're looking at the agenda that it really didn't seem to be anything on adaptation. I think this initiative is getting more and more serious consideration at the international policy level. I think it's a little premature to say what we've learned from Katrina. I think we've learned a lot of the failures but it would be nice to think over the coming years we can learn about some successes on how to address this. I think what is important is that it shows that we are at risk of natural disasters and when we think about in the future with climate change that places whether it's the southern half of Florida, whether it's the Outer Banks that we have areas where we have economic development and economic activity that's very close to sea level or even below sea level in some cases and they will be more and more vulnerable. The idea then is to think of what kinds of actions are being done around in Louisiana. For example one of the things that's been talked about is really trying to regrow and redevelop a lot of the coastal weapons many of which were destroyed that served as a natural buffer and perhaps that's something that can be useful when one thinks about how to restore the Ecko systems in southern Florida and maybe there are some lessons to be learned from that. Right now its more to the question of can we learn from these experiences and recognizing that even a very wealthy developed country, we're going to have to learn to adapt.

Mr. Garrou: Thank you very much Mr. Aldy. We're going to change the order slightly because one of our speakers has to catch an airplane and that speaker is Margo Thorning who is Vice-President and Chief Economists of the American Council for Capital Formation.

Dr. Thorning: Thank you very much. It's a an honor to get to talk to you about some of the work that the American Council for Capital Formation has done on this very important issue and I have to say before starting I agree with a lot of the comments of the previous speakers and I think the difference I may bring to bear is a careful look at what

some of the array of models has shown about the cost of trying to a near term of emission reductions and also what's going on around Europe and how their system is working. So let me just say the American Council for Capital Formation is a non profit bi-partisan think tank in Washington. We also have a think tank in Brussels that is the International Council for Capital Formation and their websites have different sorts of economic analyses on this very important topic. Let's take a look at what some of the previous work has shown about what the cost to the US might be actually trying to reduce emissions. The chart (Exhibit I) I just put up is an array of different modeling from the past five/six years some of which was done during the Clinton administration. Looking at what it would actually cost if the US had ratified the Kyoto protocol and the number on the far left was produced during the Clinton administration by our Department of Energy suggesting that it might reduce the level of GDP by 4.2 percent in 2010 if we actually had implemented the Kyoto target. Various other models that I put up there are by work econometric forecasting by DRI/WEFA after they combined, by the Australian Bureau of Resource Economics, by DRI by Trouser Associates, by Professor Allen Mann at Stanford, the late Professor Mann, rich rituals all show substantial economic cost. Range depending on whether they used a microeconomic model. Which is better designed for measuring the near term short run cost of reducing energy and raising energy prices or general equilibrium model which is better at assessing the cost over a 30 or 40 or 50 year period after all factors of production have had time to change the capital stock. But the reason our Senate voted 95 to 0 to not support a Kyoto type proposal is that our Senate and House had before them these type of results, these modeling results. So they understood that they might not know exactly what the economic impact would be of trying to hit a target at a predetermined date but they knew it would be costly in terms of lower levels of GDP, lower levels of jobs and so forth.

Another set of recent model results looks at what the New England governor's plan would have cost the eleven northeastern states had they adopted it, had they chosen to go it alone. The New England governor's plan envisioned all sectors being included, not just the electric utility sector. They envisioned reducing the emissions in these eleven states to 1990 levels by 2010 then tightening the target so that by 2020 they reduced ten percent below 1990 levels and then they contemplated getting on a path after 2020 to reduce emissions to 85 percent below 1990 levels. Charles Rivers Associates, now called CRA International, modeled the impact of the New England governor's plan and concluded that compared to the baseline which Dr. Aldy talked about, we would see increase in those eleven states of electricity prices compared to the baseline of 35 percent, gasoline prices almost 40 percent and natural gas prices by 111 percent. Those eleven states in 2010 would lose almost 200,000 jobs because of course industry would migrate out of those eleven states. There would be carbon leakage and job leakage and productivity would be less because energy prices would have to rise to force down emissions. Household income would be about $2600 less and federal and state tax receipts would decline and as Dr. Aldy mentioned low income and elderly would bear a disproportionate burden. So this is what accreditable modeling result shows as the impact of states going it alone and so something for North Carolina to consider whether they want to go it alone because clearly there would tend to be carbon leakage. The unfortunate thing is because global emissions are going much faster in China and India.

By the year 2100 it will make no difference to what happens to concentrations of CO_2 in the atmosphere even if North Carolina absolutely shut down and didn't use any carbon. Some other recent results which contrast a little bit with what Dr. Aldy was showing previously this economic analysis of the McCann-Lieberman proposal and the Bingaman proposal was prepared again by Trouser Associates International Energy Modeling firm and the question is how much do less stringent targets, less stringent than the Kyoto protocol, how much do those cost? And clearly again GDP would be impacted approximately one percent less because energy prices under the McCann-Lieberman proposal would rise because that proposal envisioned reducing emission to 2000 levels by 2010 then in 2016 getting on a track to reduce to 1990 levels. We also assume that post 2020 they got on a trajectory to reduce emissions to 85 percent below 1990 levels because that is where IPCC scenarios suggest the development countries may have to go. So the targets will not stay the same they will be ever tightening and in that situation by 2010 GDP would be lower by one percent. Job losses for the US would be almost one million fewer jobs, household consumption would be about $725 less and again federal and state tax receipts decline. In the Bingaman proposal is a less stringent proposal than the McCann-Lieberman. The NCEP plan Dr. Aldy referred to has targets to reduce emissions intensity and those are less tight than the McCann-Lieberman. So the impact while negative is not nearly as great minus 0.2 percent of GDP and 230,000 jobs and smaller impact on household income. In 2020 of course the costs get higher because the targets are tightening. So these proposals are not as painful as the Kyoto protocol but none the less has cost. But when you look at it from a global prospective and try to look at the cost and the benefits because even if all of the countries that took on targets under the Kyoto protocol actually hit their targets, by the year 2100 it makes no difference. So Kyoto and these proposals are not enough in order to make a measurable impact on CO_2 emissions globally.

Another point I would like to raise with you is let's take a look at how European Union is doing with their emission trading system. The latest projections from the European Environmental Agency which we released in November of 2005 show that in fact the Union is not on track to hit their target even with the emission trading system that they put in place in January 2005. They are expected to be four percent above the earth Kyoto target, no eight percent below 1990 levels, so it would be four percent above 1990 levels. Many of the countries like Spain are expected in 2010 to have some strong new measures to be about 28 percent above their emission levels. So at the European Union unless they put in place much higher taxes to force down energy use, they have no prayer of meeting their Kyoto target and their current emission trading system covers 9-12,000 industrial facilities. Of course there are millions and millions of emitters in Europe and they simply don't have the political will to impose taxes on households and on transport. A large source of their emission growth is in transport to get emissions down to their Kyoto target. I believe given the recent evidence that the emission trading system has raised electricity prices substantially in the UK and in places like Germany that probably there is going to be a gradual evolution toward an alternative policy and most likely their attempt to get a target for the second commitment period is domed to fail, I think because they are not making much progress toward their current target. Industry is struggling, growth is only one percent in the EU verses about 3½ percent here, so I think cap and

trade in Europe is probably going to be slowly phased out and hopefully replaced with something that is more productive.

The reason why I think we need to look hard before a state like North Carolina would adopt a cap and trade system is that basically when you cap something you are forcing producers to go to end of pipe near term solutions and you're diverting resources from longer term research and development that could lead to the technologies that will enable us to move away from fossil fuels. Carbon caps really don't provide certainty. We already have uncertainty about energy prices in general. A current government could say we are going to put in place a safety valve of $25 a ton but this current government can't fine future governments. You really don't know whether the cap will hold, whether the targets will be changed because of the realization that energy use and economic growth go hand in hand and when an economy begins to struggle you will find legislators who are interested in their political survival making every effort to generate the kind of climate that will allow industry to growth. So I don't think it is accurate to say that carbon caps provide certainty and will therefore increase investment. I think quite the opposite is true. Also we can't really count on international arrangement, the economists are talking about international proposal with an international trading system so that we can find the lowest cost emissions and then purchase them so we would not have to make even more costly reductions in our already energy efficient economy. But you can't really bind, let's say we bought emission credits in China that were to come due in 25 or 30 years, what if China doesn't make those emission cuts, how are we going to enforce such a regime. I think there is a lot of uncertainty and probably its not very practical to think that we can develop an international trading scheme that would not be just plagued by fraud and abuse.

Well how can we reduce greenhouse gas emissions in a cost effective way? Clearly it is an important issue, not that there aren't many other important environmental and social issues but the guiding principle I think we should focus on is using cost benefit analyses to determine whether an approach, what is the net benefit in terms of environmental benefits, in terms of economic benefits and what does it cost. Bill an esteemed economics professor at Yale University issued a study in December 2005 an NVER research paper that stated the cost to the US of complying with the Kyoto protocol, the present discounted value is 5.5 trillion dollars even when you include all the possible environmental benefits and economic benefits. It's a huge cost and hardly any benefit so based on the preponderance of the research that I've seen I think we need to be looking elsewhere and a different approach to reducing greenhouse gas emissions. You've probably seen this chart before, the greenhouse gas emissions over the next 100 years are the developed country emissions are the ones shown in blue. As you can see the developed country emissions are pretty much flat and declining very slightly over the next 100 years whereas developing countries, India, China, Latin America, Indonesia places like that are growing much more rapidly. So the question is how can we approach the issue of climate change in a way that does some real good and doesn't materially impact US economic growth and global economic growth.

Take a look, I know these numbers are small and you probably can't see them, but as I say you have the slide presentation and it will also be I believe on your website. This chart shows the average life span for selected energy related capital stock and for example toward the middle you have residential, heating and cooling equipment. The average life span there ranges from about 10 to 20 years, so your average air conditioner might last 20 years. Your average truck and bus might last 15 to 30 years. The average piece of manufacturing equipment perhaps 15 to 40 years and of course electric transmission distribution equipment can last anywhere from 25 to 50 years. Power stations up to 50 years, the building stock can last anywhere from 40 to 120 years. So our capital stock tends to be very long life and we need to think of ways to pull through that capital stock more quickly so that we can actually put in place cleaner, less emitting, less energy intensive equipment. One thing we can think about doing and the ACCF has long urged, is to reform the US tax code so that depreciation allowances for these type investments are a lot quicker. One of the startling facts is for example if a US investor puts money in a combined heat and power facility which tends to be more energy efficient, after five years he's only gotten back 29 cents on the dollar in depreciation allowances. He's only been allowed to write off 29 cents on the dollar. In Germany that same investment investor's got 50 cents back and in China the investor's got $1.04 back so many countries have much more favorable tax codes to allow quicker write off which lowers the cost of capital for these types of energy investments. The US has one of the highest cooperate tax rates in the industrial world, 35 percent versus an average of for example 30 percent in the EEU and much lower elsewhere. So when you look at our high tax rate and our slow depreciation, US companies are very disadvantaged and we can take a look and gradually make some changes to the tax code without breaking the budget and perhaps North Carolina might also like to think about improving the investment incentives or improving the tax climate so as to encourage pulling through the capital stock a lot quicker.

Another important thing that I think to address the whole issue of how to reduce global emissions of CO_2 is to take a look at what countries like China and India are doing now in terms of replacing their capital stock versus what the US and a country like Japan is doing. If you take a look at the far left column you can see that China is using about 0.7 million metric tons, their current installed base, to produce a dollar of output. Their new installed base is using about 0.4 million metric tons for every dollar of output. In India a similar situation, they are not really installed bases it's just about as efficient as the Chinese. But if you look at the US we are using about 0.1 million metric tons to produce a dollar of output. In Japan much more energy efficient is using about 0.07. So if we could get into Chinese and Indian factories the kind of equipment that we already have with our current technology or that Japan has or that Germany has or that Australia has for various different production processes, we would see a material slowing in their energy intensity and a gradual reduction in the rate of growth in greenhouse gas emissions as well as other emissions. So the positive approach of trying to transfer the technology to developing countries in the Asian-Pacific partnership as an example of that you probably follow the agreement that was signed in July of last year between China, India, the US, South Korea, Japan, and Australia to focus on economic development and to focus on transferring technology so as to reduce greenhouse gas emissions. That could

be a very positive step forward that will help generate the kind of development and economic growth that will make a difference over time as Professor Aldy discussed. That's important how we do it over time, emission reduction don't have to ratchet down immediately right now. And just to drive home the point of how strong a factor economic growth can be in terms of reducing energy intensity, take a look at these data which we compiled from Energy Information Administration document. As you can see the red bar which is the US, we've reduced our energy intensity by 12.2 percent over the 1997-2003 period so we've reduced our energy intensity much more rapidly than has the EU. Even though the EU has a mandatory required Kyoto target we're doing much better and the reason is we're growing, they're not growing. And we also have population growth. They don't have population growth. We're doing very much better at reducing energy intensity with our 3½ percent growth rate. They are only growing at 0.1 percent on the average and they're not pulling through on their capital stock as fast. The bar over on the far right is the data from 1993-2003 so that's a longer time period. I will correct the slide so you will have the correct numbers, I apologize for that. So the point I'm making is that economic growth can actually be a really strong positive thing to improve environmental quality and let countries continue to grow, continue to prosper and gradually become less and less energy intensive. Of course at the same time we have to continue with research on alternative technologies and ways of slowly moving away from fossil fuels if that is what the science indicates is necessary.

To sum up, I think a state like North Carolina would be good to focus on using cost benefit analyses before you adopt any mandatory policies or further policies to address greenhouse gas emission reduction. I should point out that the state of Maine last May 2005 passed legislation requiring the use of cost benefit analyses for any policies to address climate change. I think it also would be very good to reform the US tax code to speed up depreciation and perhaps also take a look at the tax code in North Carolina. We're moving barriers to developing world access to more energy and cleaner technology by promoting economic growth and economic freedom can be a really positive thing. There is a new study by Dr. David Montgomery and Roger Bate which is on the ICCF global website which shows the countries that tend to have the criteria that indicate they're economically free, like low trade barriers, protection for an electoral property rights, lack of subsidies for domestic industries, low level of corruption. Those countries tend to grow faster and tend to be much less energy intensive.

Furthermore increasing R&D for new technologies is essential. We probably need to be spending more than we are to encourage reductions in energy intensity, developing sequestration through both natural and man made technologies. By the way, carbon sequestration has been used very effectively to enhance oil recovery so I think that it is not clear that we need a cap on carbon to encourage carbon sequestration and some industries have been doing that for some time and hopefully that will continue. Also, plus promoting nuclear power for electricity generation, expanding bilateral cooperation with developing countries which the US has 13 or 14 partnerships with other countries to work on various aspects of climate policy including the science, new technologies and other aspects and then promoting a truly global solution such as the Asian-Pacific partnership. This climate change is a global issue, it's not a local issue and as Dr. Aldy

pointed out it really doesn't do very much good for one small locale to focus on reducing its emission in isolation. We need a global approach and one that will not reduce our economic growth.

I just want to add in 2005 the US actually used less energy than before and that was in response to the higher prices that we're seeing and that was the first time in 20 years we've used less energy when we were in a period of strong economic growth. So I think the fact that energy prices are high and not predicted to go down any time soon for natural gas or for gasoline is going to be a really strong incentive to encourage investment in alternative technologies and energy efficiency. Thanks and I will be glad to answer any questions.

Mr. Garrou: Thank you Dr. Thorning. Questions?

Dr. Smith: I appreciate your comments on technology and certainly technology is going to be a very integral part of how we move forward. But I think policy development is going to be very critical. I am curious, my experience in looking at coal fired power plants and the lives of coal fired power plants is not one where accelerated appreciation or amortization is going to drive them off the market. We're actually seeing a converse because the utility industry has continued to pop up and maintain a lot of the old coal fired power plants. I'm not sure that just changing the tax code for them is going to get them out of the market and that is what has precipitated a lot of the discussion about new source review and other things like that is they came to Congress years ago and said that they were going to have a discrete life and at some point would be rolling the fleet off. But the fleet hasn't rolled off and as a matter of fact you're seeing a lot of the coal fired power plants are actually going beyond what was originally conceived and then now they're making significant investments and retrofitting those plants and keeping them going for the foreseeable future. So I guess it would be helpful for me to understand what examples do you have of the fleet turnover in the coal fired power plants or is there an example of how that would happen? And I have one quick follow up to that.

Dr. Thorning: I think the fact that natural gas prices have risen so much in the last several years has probably encouraged people to go back and retrofit a lot of coal plants that might have been scheduled for retirement and the fact that it's been so difficult if not impossible to build a nuclear power plant in the US over the last 20 years has also perhaps encouraged the extension of life of these coal fired plants. But I think a lot of utilities do have new coal plants on the drawing boards of course because of the change in energy prices and if depreciation could be speeded up so that they could get their cost back faster I think we would find them putting in place much more efficient plants that had a much higher ratio of energy efficiencies. So I think it would certainly make a difference over time, maybe not immediately, but they have to supply their markets and we are going to be needing more energy not less and I think we have estimates of 30 trillion over the next 15/20 years in energy investment here in the US. So anything we can do to encourage people to take the risk to put in place cleaner less emitting technologies whether its coal or other fuel sources should be encouraged.

Dr. Smith: I guess I understand that the new plants to meet new demand but I'm not sure that that's necessarily taking the existing fleet off the market and that's one question. Another quick question I had was on your chart that showed sort of the growth of the developing nations and developed nations if there is an amount of CO_2 loading into the atmosphere that causes the dangerous changes to the environment that many people are concerned about, there is a total amount of that pie that can be done, let's say there 450 or 550 parts per million in the atmosphere. I guess my concern is that the developed countries have already eaten up a significant part of that pie and now we've got the developing nations coming in behind as they grow and they catch up with their standard of living and so it's a little disconcerting that you seem to be implying that there may not be as much responsibility with developed nations to decrease their share to make some head room for the rest of the world to develop. And I'm just curious, did I miss something there or what are your thoughts on that?

Dr. Thorning: I think you have to look at the whole issue and perspective. The developed countries are responsible for the strong economic growth and have pulled through economic growth and developing countries. So when the industrial countries maintain a strong economic base and are able to provide markets for developing countries we're in effect pulling them along with us so you have to think about what near term emission reductions in the industrial countries would do to our ability to be a strong engine of economic growth and most of the studies I've seen including Dr. Aldy mentioned is costly to reduce emissions in the near term. So we want to balance the need to move it forward in terms of being more energy efficient with a desire not to throw the baby out with the bath water and strangle economic growth. The hope and the thought is that as we continue to spend on new technologies and on new research gradually we will be able not only in the developed countries but also in the developing world to consume more and more energy. China for example has 40 nuclear power plants on the drawing boards. Of course they also have 400 coal fired plants on the drawing boards. So I think that it is probably premature with the sciences not well enough understood to know exactly what sort of target would be needed. We still need to do further research on that but the point is, without strong economic growth we will not be able to continue to provide a market and to be a force for positive change.

Mr. Shore: First of all I want to thank you for your last slide. I think the way you presented those government policies that could move us forward in aligning economic growth and reducing global warming pollution is good for us to consider. So I appreciate those thoughts and then I want to try and uncover a little bit of where the truth lies. I know we can cut the data and force them to confess in whatever outcome we want, and so there is a difference in between your presentation and of Dr. Aldy in the economic impact to GMP and yours showed a more significant impact. So I wonder if you can comment, and I think his went out to 2030 and showed a very small impact of capping carbon emissions, he had a $50 per ton level. So could you comment on his presentation and that analyses where that very small effect on GMP and if Dr. Aldy could also then comment on your slides that showed the bars that had the one to five percent impact on GMP that would be great.

Dr. Thorning: Of course I haven't really studied Dr. Aldys' model but just in general the assumptions going as one of the members of the Committee pointed out, assumptions going into the model are very important, the type of model whether it's a macro economic model that's geared to measuring short run frictional cost or whether it's a general equilibrium model or whether it's a bottoms up engineering model but assumes basically that if the technology is there it will be adopted and that the reason it has not been adopted is that there is lack of information or people some how don't know about it. So I really would have to study his results but I presented to you an array of models from different groups, academics, consultants, the government and they all showed either using the two types of macro equilibrium models quite significant cost to near term emission reduction. So obviously the longer you give to reach a target, if you give 20/25 year to reach a relatively easy target that will cost less using anybody's model. I was focusing on trying to explain to you why the Bingaman proposal for example cost less than the McCann-Lieberman and why Kyoto cost much more than either of those two.

Dr. Smith: Dr. Aldy do you have comments on the difference in how the numbers were presented.

Dr. Aldy: No. I think one thing that is important about the model that I used, the results that I presented, I didn't actually do the modeling analyses it was from the Energy Information Administration. I think this is actually useful and contrasting the cost of the stringency of different kinds of policies because the bar figure that Dr. Thorning presented at the beginning the highest cost model results for Kyoto was actually from EIA, their 1998 summer 1998 analyses and they showed on the order of about 3½ to 4 percent decrease in GDP in 2010. All I'm using is the same model but updated to basically late 2005 versions that they just published last month. So it is the same fundamental basics, a lot of the same fundamental assumptions, the big difference is that if you look at implementing Kyoto and how it was modeled in EIA, that was the scenario in which they assumed that all emission reductions to satisfy Kyoto would have to occur within the United States in the energy sector on carbon dioxide emissions exclusively. That analysis you're talking about reducing your emissions about 17 or 18 percent from the current levels over a period of about 10 years. Now the two scenarios that I presented in my presentation showed that with the more stringent case you had emissions reaching current levels peaking in ten years and reaching current levels in about 20 years. So the thing is that it's a very different profile of the emission reductions required under the policy cases that I presented today and then what was assumed in the EIA analysis of the Kyoto protocol from ten years ago. And a lot of the variations you'll see in those economic analysis have to do with how much of Kyoto do you think would be actually achieved domestically, how much can be achieved through taking advantage of international emissions trading and other kinds of mechanisms, clean mechanisms things like that. So there are differences across the models and the kinds of assumptions they make but I think in this case it really illustrates the stringency of your target. I mean do you really want to reduce emissions drastically. I don't think that you are going to be able to get there without imposing substantial cost in the economy. But if you take a recent path of slow down growth, peak in the decline, then you can do so without a big burden to the economy.

Dr. Thorning: Let me point out that there is a new EIA study I'm not sure if it is the same one you're referring to, it comes from Salazar Requested same study. But if you look in the back of this study it points out that a proposal a little bit more stringent than the Bingaman proposal the contrast that the Bingaman type intensity target a little bit tighter than Bingaman with a high technology scenario. The high technology scenario actually increases GDP whereas the Bingaman type proposal reduces GDP and electricity prices actually fall into the high technology scenario and they rise under the Bingaman proposal. So I think it's clear that a focus on encouraging even more than we already do more investment and development of technology which I know North Carolina is well able to do – its likely to lead to less pain and more gain in terms of environmental benefits.

Senator Pittenger: Thank you Mr. Chairman. Dr. Thorning we've had several references today and on previous meetings of what other states are doing particularly today several references to California. What role have they taken and Governor Schwarzenegger in terms of mandates on CO_2 emissions.

Dr. Thorning: Well that's a good question. And I was invited to be on a panel with Governor Schwarzenegger on April 12 out in San Francisco. The climate action group had a symposium to discuss the path forward for California and as you may know the target action team proposed similar targets to Kyoto protocol and they advocated about 43 different mandated measures to reduce greenhouse gases. It was very interesting because there were ten people on the panel and then Governor Schwarzenegger and when the moderator rolled around to the Governor and said well Governor what do you think ought to be done here and Governor Schwarzenegger said in his wonderful Australian accent "well you know I think we had better hold off on putting caps on carbon emissions because we don't want to scare the business community out of California". And of course the audience who had been assembled expecting to hear we're going to go forward and we're going to implement these type caps in the near term just about fell out of their chairs because it was very clear that the Governor had begun to think about what near term caps and high renewable targets might do to the already somewhat difficult business climate in the state of California. So I think they are taking a much more careful approach in term of what sort of policies they are going to adopt on climate change.

Mr. Profeta: Apologies for keeping this going but a lot of people have raised the assumptions question and I wanted to go back to it. Also, I was at the California Climate Action Registry Conference last week where Terry Tamlin who is head of Environmental Policies spoke and did advocate for some caps. Also AB32 which was introduced in California last week that has caps incorporated so I would agree that there is a political process in California that is underway but I think the Commission should do some fact finding about what is going on in California because there's a pretty influential situation.

Dr. Thorning: The Governor was quoted yesterday in the press as saying he thinks we should encourage more energy efficiency and drive more energy efficient cars and there really was no mention of cap and carbon.

Mr. Profeta: OK I will concur to the Commission to do some fact finding. I want to go back to the assumptions since I raised the issue earlier and we got into it a little bit and other than the slide on the Kyoto protocol all the modeling results were presented from Trouser Associates study and I'm wondering if you could answer some of the same questions I had for Dr. Aldy about the assumption that went to that study particularly about the question of what happens with tax revenue and whether taxes should be increased, what is the coverage of the model of other gases besides CO_2 that also contributes to greenhouse gases. What price point in terms of a carbon market, certain technologies, cleaning coal gasification are soon to penetrate the market?

Dr. Thorning: You may have to keep going over those. I'm not sure I got them all down but the first one the question of what happens to revenues. All of the studies I'm aware of assume revenue is recycled. Taxes are not just raised and then the government takes more revenue, they are all recycled. By the way if you take a look at the studies that are on the ICCF Global website on impact on European countries of trying to actually meet Kyoto targets and even tighter targets all that revenue is recycled, so that is a pretty standard assumption. And the price of carbon emissions I think under the EIA estimate was assumed to raise as high as perhaps $350 a ton of carbon and its less for some of these other simulations ranging down to 90 or $100 a ton on carbon.

Mr. Profeta: What price did IGC penetrate? If it were 300 would that seem about right?

Dr. Thorning: I really honestly would have to look that up and get back to you. I'm not certain. I hesitate to answer that. If I can get your contact details I'll try and answer that. But technology is assumed even under the base case forecast, we assume substantial new technology and it's driven through even faster under the carbon cap scenarios.

Mr. Profeta: My apologies I know this is long but the last one is what is the assumptions that there is non CO_2 gases in the …..

Dr. Thorning: Most of the studies only look at CO_2 because that's 85 percent of most of the greenhouse gases so all the studies that I'm aware have just looked at CO_2 not tried to factor in methane and the others. It's just too complicated, it gets too expensive to do the modeling at least for the resources we have. I apologize I've got to go in about three minutes.

Mr. Karl Hausker: If the Chair will allow a question. Just wanted to first of all observe, I just flipped through the executive summary of the California action plan on my left and it confirmed what I thought I remembered when I first read it which is there are no Kyoto style caps in the proposed actions in the California plan. It's a sector by sector portfolio of policies covering all sorts of things. I think that's very important to remember along with the fact that in my experience there is only one group of states that have actually proposed capping their emissions. A group of northeast states have been floating the idea of an emissions cap that would start at the power sector maybe go to the rest of the economy but that is only based on power plants in their states and people who look at that

recognize that that's not going to be particularly binding. My point here is we've had two very excellent presentations on the economics of climate change mitigation however they are very limited relevance to what North Carolina is considering which is looking at a full catalog of options that have tremendous co-benefits across different sectors. The discussion of national or international cap and trade have very limited relevance to what California has proposed, the plan that Connecticut put forward, the plan that Maine put forward, Rhode Island the plans that are being developed in New Mexico and Arizona because they do not contemplate state wide cap and trade. Instead they look at specific policies that create many benefits for the state, air pollution reduction, water pollution reductions, GHG mitigation, economic development, quality of life improvements, that's where we should have our focus and not on economic analyses of national or international cap and trade.

Dr. Thorning: Let me just respond to that. All of the programs that could be contemplated to be mandated if they were truly energy efficient, you wouldn't need to mandate them the market would take care of addressing that. And just one more word on California's plans, they have aspirational targets to reduce greenhouse gas emissions to something like Kyoto levels and they also have a proposal to require 20 percent of all electricity to be produced through natural gas by 2010 or 2015 so they are approaching this with a commanding control approach basically but they do have aspirational targets. But Governor Schwarzenegger seems to be pulling the state back from that type of approach. Thank you very much.

Mr. Garrou: Thank you very much Dr. Thorning. We have decided that we will have one more presentation this afternoon. We don't want to wear everybody out. Our last two speakers have agreed to come back at our next session. So we will hear from Dr. Whitehead this afternoon and then we will hear from the other two speakers at our next meeting. So Dr. John C. Whitehead who is an Associate Professor at the Department of Economics of Appalachian State University, welcome Dr. Whitehead.

Dr. Whitehead: Thank you and while my presentation (Exhibit I) is being pulled up Joe mentioned that he works at an economics department with no students, I work at an economics department with a lot of students and finals week is coming up and so I appreciate this little vacation from that part of my job.

My task is to talk about what might happen, what the cost might be if climate change is not mitigated. First of all, I want to lower expectations I don't have any clear answers and the previous two presentations and the ones this morning did a real good job of laying out what actually might happen on the cost side and with technology. On the benefits side and the opposite of the cost of not doing anything, those are the benefits of mitigation. On the benefits side there is a lot of uncertainty about what might happen and so in my outline here I have a lot of qualifiers, economic uncertainty, a partial list of potential impacts, the evaluation of these potential impacts and if you will bear with me I just want to sketch out a real quick economic model of what might be going on here. First of all this first picture is what we call a damage function and on the vertical axis we have temperature and other physical aspects of global climate change and on the

horizontal axis are the potential damages of those. Right now it is difficult to determine what these might be if we're thinking that temperature increases and temperature leaves a sea level rise. These damages might be the impact on home owners at the beach, it might be an impact on people who like to go to the beach, and if sea level rise erodes the beach and makes it more difficult for the beach to handle storms then home owners and beach goers will respond to that in one way or another. It's difficult to say how that might be so I've drawn three pictures, three lines and each of them imply a different set of behavioral assumptions. Right now there have not been a lot of studies nationally or in North Carolina about what these lines might look like. A lot of what I have to do is guess work here. On top of the damage functions, evaluation functions turning these behavioral responses into dollar and cents estimates that can be compared to the cost estimates that we've heard in the previous two talks. On the horizontal axis here I've gone to damages again, two arrows indicate that the damages might be small and the cost of the damages depend on again a reaction function that might be concave or convex. So those are my apologies for some of the numbers that I'm going to show you. It's a lot of guess work and a lot of piece mill adding up of various types of things.

Potential damages I'm going to talk about are in two main categories – human health and environment and Brian was going to talk about agricultural and forest today and he's been bumped and so you can look forward to that. The evaluation methods I'm going to use, first of all I'll admit that these are back of the envelope calculations the numbers that are plucked from the literature and I applied those to a very rough estimate of what the damages might be, multiplied and then added up. In economics we call this the benefits transfer approach. Back in the old days they called it plain estimates off the shelf. But they are just back of the envelope calculations. The scenario that I'm going to look at is that the magnitude of the damages are estimated as an annual one percent change and the one percent change might be the lowest damage that we might face. These damages can be scaled up in parenthesis. I say down if I've overestimated the damages by simple multiplication assuming that the two lines in the damage function and evaluation function are linear. If you see a one percent change in your handout, if you think that the actual change is ten percent you simply multiply that by ten percent to get an idea of the magnitude of what those numbers might be. All the numbers that you will see are in 2005 dollars.

In terms of human health there are more sectors in the economy or four types of damages that I'm going to consider. Heat related deaths, storm related deaths, non-melanoma skin cancers and drinking water and there are other human health related impacts that could be considered. They are not considered simply because I either ran out of time or was not familiar enough with the literature to find those estimates quickly. In terms of heat related deaths, again the scenario is there should be a one percent increase in heat related deaths. The numbers that I'm using is first of all an estimate of the total deaths in North Carolina from heat. Over 24/25 years is 161, one percent of the annual heat related deaths almost seven per year so one percent change of that is 0.671. There's the potential damage for one percent increase in heat related deaths in North Carolina. Now the value that's going to be attached to that is known as the value of a statistical life and here's another mistake in the slide on emission that $4.54 should be millions. That's millions of

dollars. The value of a statistical life, non economists are very used to talking about this, we have no problem, the non economists may get queasy about it and for good reason. It may be a little more iffy to talk about the value of statistical life but we think that economists in general think that its important to at least get a handle of what this number might be otherwise decisions are made that might impact lives and those decisions might use an implicit value of life that ranges anywhere from as low as $100,000 to as high as a good portion of annual GDP. So what we're trying to do here is just get a handle on what statistical life might be. Not to say that everyone's life is worth 4.5 million dollars. The idea is that people everyday reveal something about the willingness to accept greater risk, risk of death. You cross the street when you shouldn't, when cars might be coming down, you drive recklessly. These behaviors reveal that risk taking behavior is an economic behavior. The idea with this value-statistical life is that some people take more risky jobs and the compensation for that is a higher wage and you can use that behavior and those numbers to get a handle on what this number might be so this 4.54 million is a summary of a bunch of studies like this that look at people's behavior towards risk taking; so just a simple multiplication of this one percent change in heat related deaths and the value-statistical life, at least the annual damages of about $300,000.

Storm related deaths - again the scenario is a one percent change in storm related deaths. The value-statistical life 4.54 million again, the hurricane death estimate here is from the past ten years from the National Hurricane Center's website of freshwater, inland, perk related deaths in North Carolina. So the number there of one percent increase is 0.91 for deaths, the search and rescue estimate, the idea is that if climate change increases the number of storms, the coast guard has more problems to respond to in the ocean and has more trouble saving lives. Of one percent increase of fewer lives saved in North Carolina is 1.74 adding those together, multiplied by 4.54 gives us a damage estimate of 8.31 million.

Now the skin cancer estimate is the only dollar value where I'm not following the state of methodology. This is from a study that was published about 15 years ago and in reading the study I was having a hard time pulling out that one percent estimate so just looking at the numbers from that study and I've scaled it down to North Carolina. This was a national study and the idea is that to reduce the risk of a non-melanoma skin cancer people would use more sun screen. If you use more sun screen that cost money and that money to defend yourself from an environmental threat could be used for something more fun like a movie ticket or a round of golf. So in that sense this is a cost of the increased risk of the skin cancer. Scaling that down to North Carolina highlighted here is the 25 million dollar estimate in 2010, I just went with the lowest number they had here to be conservative.

Drinking water – the global climate change could lead to salt water problems in coastal areas and other contaminations of drinking water. So the scenario here is that North Carolina households experience the drinking water contamination episode for one week and this is one percent of North Carolina households. So in 3.1 million households each one percent change in that number is 31,000 households might experience a drinking water contamination episode. Again the defensive expenditures methodology is used to

attach a dollar value to this, the idea is that if your drinking water has problems in your home then you go to the grocery store and buy several gallons of bottled water to avoid the contaminated drinking water. From a literature view that I conducted about ten years ago the average defensive expenditures is about $6.50, just a simple multiplication of households times the damage and we've got 200,000 dollars annual damages in North Carolina. Again let me emphasize that the numbers I've just run through the sectors of the behaviors that we talked about is only a partial list of some of the things that might happen, they were the ones that being time constrained that I was able to pull out relative quickly.

Turning to environment - I want to talk about wetlands, tourism, commercial fishing, hurricanes, biodiversity and again there are some other things that could be included in this list that I'm not including. Sea level rise and other aspects of climate change could impact coastal wetlands in North Carolina. Again the scenario is a one percent change in coastal wetland acreage. The estimate of coastal wetland acreage that I have is from the US Geological Survey - 5.42 million acres, a one percent change, one percent loss of coastal wetlands would be 54.2 thousand and the value per acre here is from studies that might look at the effect of coastal wetlands on property values. The idea of wetlands provides storm protection and provides water, wildlife habitant, water quality improvements and this does increase coastal property values. The estimate of value per acre is about $70 and this is from a study that looked at a large number of these coastal wetland evaluations studies. So multiply the one percent change again times the value per acre gives us damages of about 3.8 million.

There are many types of coastal tourism in North Carolina. The type I'm focusing on is just beach trips. The scenario is that beach erosion causes reduction in beach days and again the magnitude of the damages is one percent change in the number of beach days in North Carolina. According to the National Survey of Recreation and Environment, the survey conducted in 2000 there were 28 million beach days enjoyed in North Carolina so one percent change there would be 280,000 fewer beach days. Then the value per day that I'm using is from a study that was just recently published in Marine Resource Economics by some researchers at East Carolina. The conceptual idea is that people are willing to pay to go to the beach and if the cost of a beach day increases, they might choose to pursue some other activity and so the cost of cost increase that might lead to another activity is about $23 from their study. So multiply 23 times 280,000 gives me damages of about six million per year.

Commercial fishing – The idea here is that global climate change might lead to more storms, reducing commercial fishing and economic activity warmer temperatures might lead to stock changes and so considering a one percent change in the dockside value for the expense or value of commercial catch leads to a damage estimate. The annual excess or value of finfish in North Carolina, which is Flounder, Spot and other commercial fish is about 45 million dollars. The annual excessive value of shellfish that's our shrimp and crabs is about 71 million dollars. A one percent change in those add up to about one million dollars each year.

There is a lot of debate about the impact of climate change on hurricanes and again I'm trying to avoid all of that by just applying the one percent rule. So at the National Hurricane Center I looked at the damages inflicted in North Carolina for the past ten years from hurricanes, the annual average hurricane damage is 360 million and a one percent change in that is 3.6 million. I should say that the National Hurricane Center typically takes their damage estimate and doubles it to reflect insured losses and uninsured losses and I'm not doubling this number. For most of these estimates I'm trying to remain as conservative as possible. So 3.6 million dollars are the damages for hurricanes.

Biodiversity – The scenario I'm looking at here is an increase in the probability of extinction for coastal threatened and endangered species. These numbers are from a study that I conducted about 15 years ago and the idea is that habitant loss and other impacts of climate change leads to this increase in extinction risk. So looking at the North Carolina population in scaling the numbers I had way back when down by one percent gives me a cost for each individual in North Carolina of 42 cents for this biodiversity loss. Again scaling it down by survey response rate of 35 percent and then taking a product of all of, that gives me a damage estimate of 1.26 million dollars.

There are still some other things that could be included in this list that I'm not including because I ran out of time or I wasn't as familiar with the literature as I could have been. So to summarize these impacts – the health impacts mostly are from the skin cancer benefits. The estimate that I departed from the one percent methodology, the second biggest category are the storm related deaths, and then little slivers of heat related deaths and the drinking water benefits. In terms of environmental impacts the losses to the tourism industry are large when lands and hurricanes are the next largest and then biodiversity and commercial fishing are about pie size wedges.

The total impacts of each one percent change in North Carolina in millions of 2005 dollars are for health, about 34 million dollars and to the environment about 17 million dollars. Let me again say that these are the impacts of each one percent change and if we think that the total impact of some magnitude of climate change in North Carolina would impact the economy at the rate of five percent, a simple extrapolation of this number by multiplying by five would be the best estimate that I would have today. To put this in context the 50 some million dollars of annual valuation of those damages is about 0.2 percent of state personal income and dividing that by the number of households in North Carolina that's about 16 dollars. Now if we think that most of these damages occur in eastern North Carolina and on the coast then the dollars per household should be increased by a scale of five to ten depending on how far away from the coast the damages are. The bottom of the slide is my email address and website in case you would like to contact me with any questions.

Mr. Garrou: Thank you Dr. Whitehead. Questions?

Dr. Riggs: Sea level doesn't work alone it works in concert with the storm dynamics and the history of storms over the last half decade five/ten years has been one of increasing

frequency and intensity. If we just take the last few years and the records of Ivan and Wilma, Rita and Katrina we're looking at 50 billion dollar storms and I think your numbers are off by one or two orders of magnitude. These events are not local events these are events that have impact large regions, not just states but the whole country and a part of the country. If we just look at the Noah data, the billion dollar climate disaster map that they just came out with, North Carolina is one of the three states that's painted black on here with 21 to 25 number of events between 1980 and 2005. I think that your numbers are very misleading, if a Katrina or Rita or Ivan were to come across North Carolina coast today, we're looking at a massive disaster that's orders of magnitude bigger than what you're talking about.

Dr. Whitehead: Yes, that's why I've tried to emphasize that these numbers are for each one percent change and so as soon as I get better information like you've just given me about what the magnitude of the physical impacts might be then I have a multiple to attach to that one percent to get a better estimate and so it's real important and let me emphasize that again. These numbers for each one percent change in these sectors – this is not the bottom line estimate of the cost of doing nothing – the bottom line of the estimate of the benefits of mitigating climate change. This is a number that give us something to multiply by if there are larger magnitudes of impacts as Stan points out.

Dr. Eggers: Thank you for this. I think this is a valuable start on a way to think about this. I think at this time it's not substantial useful because it is very limited and you're just beginning in your approach and I think anybody who might say ok a dollar and twenty five cents per household per month probably some things are missing. So I am going to suggest a few things that are missing, crop loss, so we've got a lot of people who say CO_2 will increase the rate of plant growth but there is also data that it will increase several types of diseases that plants get so we have crop loss in the net and I've got some data on that if you would like. Also infectious disease like malaria and (inaudible) fever so that's also health related and cost of control of disease vectors like mosquitoes; so not just direct cost but also cost of applying more pesticides and house related illnesses as a result of that which is harder to get a handle on. Certainly a lot of it is non-monetizable like biodiversity. Also decreasing ecosystem services as a result of storms which we really should be talking about billions, with sequestration alone in the United States is estimated back of the envelope to be worth 60 billion dollars a year so losing ecosystem services is major. Pollination is estimated to be worth 40 billion dollars a year, pollination services not from European honey bees from native bees of various sorts. So that would be something to take a look at. All the different ecosystem services that you would find like in the natural step for business are somewhere else listed. Also I think it's important to think about psychological effects, stress effects and we can map those into money, you know one of the first times that was effectively done I think was with a joint study between Duke University and Chapel Hill where they looked at the health effects of living near hog farms down east. They were able to statistically significantly quantify negative impacts on people's psychological well being on their mental health. And that maps into productivity and also increased costs of medicine and just frankly decreased quality of life in ways that are very important so I applaud you for looking for an easy knob to turn on climate change and I would encourage you to just really round

this out and be qualitatively honest in your assessment about a lot of non-monetized effects.

Dr. Whitehead: Yes I was right with you until you used the word honest. I'm trying to be very honest here and …

Dr. Eggers: I didn't mean to imply that you weren't – in terms of omitted things.

Dr. Whitehead: Healthy it meets my lists – the others that was in gray that showed up on the printout so I recognize that this list of impacts that I have is not complete. It's just items of others that could be a number of things there. I appreciate your comment I think you're right and to emphasize that in terms of agriculture I think Brian and my talks are companion pieces and it's a shame that he's not coming right after me to present his estimates right after mine so I think a lesson from today to take home is not that here's the benefits of mitigation in the previous two talks of the costs and I'm going to compare these two numbers. That's not it – the idea that I'm trying to present is that this is a way of thinking about what the benefits might be and this is the way economists thinks about these things and these benefits on the cost of an action are all over the place and some of the things might be things we haven't thought too much about. We need to consider all of these things, monetize them, find the actual damage magnitude like Stan points out and then add those things up and then compare them to the cost.

Ms. Choi: Could you just comment real quickly on how adaptation would play into this model in some of the things that Dr. Eggers talked about. I guess we are currently adapting anyway to some of the changes in our environment. We spray for bugs those kinds of things, how does that adaptation play into your model?

Dr. Whitehead: In terms of the sea level rise and tourism cost and homes at the beach one of the decisions that society might have to face is whether to retreat from the beach or to harden the beach so both of those decisions have cost and benefits. Both of those decisions represent adaptation to sea level rise.

Ms. Choi: Are they reflected in this model this cost?

Dr. Whitehead: No this is again one of the others that's not included here. Yet none of these adaptations or changes in behavior are well quantified in what I'm doing, its a very rough cut of one percent change, no more no less.

Dr. Everett: I wonder if not being an economist these kinds of things scare me, but I wonder if there are any benefits that we would see in any of these categories that you've outlined here. For instance, tourism, I might go to the beach if it was warmer in April than it is today. Commercial fishing or sport fishing is it better in Florida than it is in North Carolina? Biodiversity – is there more biodiversity in certain arenas as it warms? So I think there is a missing piece to this whole discussion about some benefits to coal related deaths versus heat related deaths and the same is true through this whole presentation. I wonder if anybody looks at that other piece of the pie.

Dr. Whitehead: Considering that the one percent change I'm looking at would be a one percent net change and if there are other benefits of warming then that might lead to a scaling down of the one percent. Again it's a question for a scientist who is not an economist to determine what those things might be. And it's tough for an economist to deal with those sort of issues.

Dr. Riggs: The answer to your questions is yes. As the barrier islands collapse the fishing is going to get awesome and the pollution is going to away, Pamlico Bay will be a very clean water body, there are some benefits but the cost is going to be astronomic.

Dr. Whitehead: Yes and I presume that most of those wetlands were created when these rivers basins drown as sea level rose.

Mr. Garrou: Thank you very much Dr. Whitehead. That concludes our presentations for today. To remind you all we are going to have to take a hiatus. We have no ability to meet because we don't have a facility and we don't have a staff while the legislature is in session. So we will have to wait until, one would hope, early fall. George is going to talk to us about that.

George Givens: This Commission is about predicting what will happen when and what the consequences will be so I am about to make a few predictions for your benefit about reliability and so doing can be gauged by my best ability to figure out just exactly how much material we could cover at any given meeting. In other words like all predictions it comes with some caveats. This is the last meeting that's scheduled it will not be possible to schedule another meeting until after the session adjourns. We note within just a few minutes it will begin and we know within just a few months of when it will end. If I had to guess I would guess that this Commission will not meet before August and more likely in September. On behalf of the co-chairs I will continue to welcome input as to how we ought to proceed when we resume. I reiterate what was said before the Division of Air Quality is anxious for the involvement of those of you who are able to participate in this CAPAG process during this time. As I told you on the first meeting and as you are aware this Commission is currently scheduled to expire on 01/11/2006. This Commission does not have the authority to go to the General Assembly directly, however, my sister commission or the commission which I'm also counseling, the Environmental Review Commission, does have that authority and it is my intention to take to them a recommendation that this Commission be extended into the 2007-2008 (inaudible) of the General Assembly with the interim and final reporting dates which we're still discussing with the co-chairs. I have little doubt that the ERC will recommend that to the 2006 regular session and I assume that the 2006 regular session will be amenable to that extension. Probably it will be packaged in with other items and just move forward I hope without controversy.

Mr. Garrou: Thank you. Mr. Nicholson.

Mr. Nicholson: Thank you Mr. Chairman I just wanted to quickly reiterate the comment George just made about continuing to seek interest from members or staff or recommended individuals and I think a particular comment is we were very impressed with the presentations today. I think they did lay a foundation for us and for the Commission members on the potential for measures in North Carolina that have economic benefit in their own right. Not necessarily as an offset to damage from sea level rises just as has been explained but I think there is a very large list of potential measures you heard quite a number of them today especially lined out in agricultural and forestry presentation and hopefully that will stimulate some thoughts and you will make some suggestion to us on other specific measures that you want us to look at. So we significantly invite you to do that in the near term and we'll definitely put them on the list to look at. We look forward to both your participation and suggestions. Thanks.

Mr. Garrou: Other comments or anything else, if not we are adjourned. Thank you very much for your patience.

Meeting adjourned at 4:19 p.m.

Respectfully submitted,

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John Garrou	Thelma T. Utley
Co-Chair	Committee Clerk

LIST OF EXHIBITS

EXHIBIT A	**Meeting Notice**
EXHIBIT B	**Meeting Agenda**
EXHIBIT C	**Visitor's Registration**
EXHIBIT D	**Handout provided by Senator Pittenger to Commission members from the Wall Street Journal – Scientists' Report Doesn't Support the Kyoto Treaty**
EXHIBIT E	**Handout provided by Dr. Sethu Raman – A Newsletter of the State Climate Office of North Carolina**
EXHIBIT F	**Solutions – The U.S. Electric Power Sector and Climate Change Mitigation Book from the Pew Center on Global Climate Change**
EXHIBIT G	**Legislative Commission on Global Climate Change Presentations** **Dr. David L. Greene** **Dr. Edward S. Rubin** **Dr. Marilyn A. Brown** **Dr. Dennis W. Hazel**
EXHIBIT H	**North Carolina Climate Action Plan Advisory Group – CAPAG Report to Legislative Commission on Global Climate Change**
EXHIBIT I	**Legislative Commission on Global Climate Change Presentations** **Dr. Joseph E. Aldy** **Dr. Margo Thorning** **Dr. John C. Whitehead**