Assessing Low Carbon Fuel Standards:

Implications of New Congressional and State Efforts to Cap Carbon in Gasoline

with

Michael Canes and Edward Murphy

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Michael Canes and Edward Murphy

April 16, 2009

Jeff Kueter: Good morning. I am Jeff Kueter, the President of the George Marshall Institute and I want to thank you all for coming this morning to be part of our discussion of some new research that the Marshall Institute released earlier this month looking at a national low carbon fuel standard. What we have discovered in the course of doing that research is that not many people understand what a low carbon fuel standard (LCFS) is. So, our purpose was to educate the broader public and our policymakers about an LCFS, what it means for them and how they might think about it as they begin to evaluate national climate and energy policy. We undertook this work last fall to examine the economic, environmental and national/energy security implications of an LCFS. The project was principally directed by my two colleagues who will brief their results of the study today. I worked on some national and energy security implications. The results are two main studies, *Economics of a National Low Carbon Fuel Standard* and *National Security, Energy Security, and a Low Carbon Fuel Standard* as well as the summary, *Economic, Environmental, and Energy Security Consequences of a National Low Carbon Fuel Standard*, all available on the Marshall Institute website.

Just briefly I will summarize some of the key points that came out of the work that I did, but the focus today will be on the work of Drs. Murphy and Canes. I think generally, though, if I were to summarize the conclusions of both studies, it is that the claims in favor of a low carbon fuel standard are largely overstated. From the security side, that overstatement is reflected by two basic conclusions. One is that we tend to overlook the offsetting actions that will take place once a standard such as this is put into place and that some of the justifications are based on a set of misguided assumptions. I will talk about the latter first.

The justification from a security perspective for a low carbon fuel standard is that it will reduce our imports of petroleum from parts of the world that are otherwise hostile to U.S. interests and by reducing these imports we improve our energy security and energy independence. What advocates overlook is that the oil market is fungible and that so long as demand for oil internationally remains strong, and all projections indicate that it will remain strong, those countries that provide petroleum will remain very

[*] The views expressed by the authors are solely those of the authors and may not represent those of any institution with which they are affiliated.

profitable places to be. Furthermore, if you are concerned about your petrodollars funding terrorist activities or actions hostile to the United States, you have to take into consideration the motives of the people that provide funding for those activities and how they prioritize those activities relative to other things on which they would spend their money. I suggest that if they do believe that financing terrorism is a priority, they will continue to finance terrorism even if their revenues from petroleum do decline. But more significantly, what you will see is that those countries where oil demand is projected to rise over the course of the next few decades will probably more than offset any decline in demand here in the United States that might result from a notional low carbon fuel standard. The bottom line is that there is little evidence that there will be trade offs inside of petroleum producing states in a declining revenue scenario.

The second point that I would bring to your attention is that the reasons for U.S. engagement in the Middle East will persist, regardless of our demand for petroleum. The study documents a few reasons why that would be the case. So long as we have security interests in the Middle East that are separate from our energy profile, Israel being a notable example of that, the United States will be involved in Middle Eastern politics and have reasons to remain committed to that region. That suggests the flexibility that energy independence advocates claim is an outcome of a low carbon fuel standard is not great.

The third conclusion is this notion of offsetting actions, and that is particularly important for considerations of energy security. Here I want to spend just a moment talking about what energy security means, because the term lacks precise definition. A consistent set of themes that come out of the literature indicates that energy security is characterized by the pursuit of diversification of supplies, improving the reliability of those supplies, and ensuring that the supplies that you are trying to diversify and make reliable also are abundant. So if one evaluates the low carbon fuel standard in that context, the offsetting action that it generates, namely the decline in the use of Canadian tar sands or the further exploitation of U.S. shale reserves, would indicate that it may in fact reduce our energy security, because it eliminates a source of diversification that is both reliable, in terms of the source of supply, and abundant, in terms of the aggregate amount of resources, in pursuit of an environmental outcome that, as Mike and Ed show and I discuss briefly, may not be as strong as the advocates claim.

But the real purpose of today's discussion is to talk about the economic effects and then put in the context of some of the environmental outcomes. That is the work principally that Mike Canes and Ed Murphy did on behalf of the Marshall Institute, and we thank them for their efforts. Mike and Ed's biographies are in the study that they did, so I won't provide an elaborate introduction to their backgrounds. Suffice it to say they are both noted economists and have both worked in the energy economics business for many years. Mike Canes is now at the Logistics Management Institute, having served at the American Petroleum Institute for many years. Ed Murphy worked at the American Petroleum Institute where he ran a number of major programs for them and

is now retired. I thank both of them for helping us with this project; I think they have done a fine piece of work, and with that I will turn the podium over to them.

Michael Canes: Thank you for the kind words, Jeff. Welcome to all of you. I am pleased that you came out so early in the morning to enjoy breakfast and hopefully enjoy something of what we have to say, too. Ed and I had to figure out how we were going to divide up the presentation since the two of us did the study and the presentation is not that long, so we divided the slides in half and I will do the first half.

A little context: as we all know, the notion of controlling carbon and dealing with climate change has become more prominent in the last few years and now there is quite a bit of activity aimed at that. There is a wide variety of ideas, plans, approaches and policy proposals to deal with it and a low carbon fuel standard is one of them. My understanding of the context of a low carbon fuel standard is this. A cap-and-trade system or a carbon tax would would set a price on carbon and thus get people to start economizing that commodity. This is the usual argument for how you go about inducing change on the part of consumers and investors. But the feeling on the part of some advocates is that if you did that, the impact on oil and gasoline prices would be limited and demand is fairly inelastic in that sector. So, you should do more than that. You have to reach the transportation sector and you can't do it just with prices; they won't do enough. A low carbon fuel standard is the approach needed to get the transportation sector to make a serious reduction in carbon emissions.

By this way of thinking the idea is to set a standard for the lifecycle greenhouse gas content of motor fuels, below that of gasoline. To meet the standard, people will have to find a low carbon fuel or set of fuels somewhere and they will have to combine it with gasoline in some fashion; that is, they will have to offer some combination of the two. By doing that, we will get a carbon content on average that is below that of gasoline and then we will ratchet down the standard over time. In this way people will have to substitute ever more of the low carbon fuel for gasoline and thus we will reach the transportation sector and force it to reduce carbon beyond what mere price increases would do. That is the general context of a low carbon fuel standard as I understand it.

Ed and I, as economists, said all right, we understand what is involved and there are fuels out there that might have lower carbon content than petroleum, so let's take a look at what that means in terms of economics. What would be the cost of that, who will bear those costs and what will be the likely outcome of such a program? That was the approach we took and that is what the methodology of our study is.

Rather than keep you in suspense – which you are probably not in to begin with – I give you the bottom line conclusions up front. We assume that, on a national level, a 90 percent carbon standard is set. Given that, we think the standard will be enormously costly. We estimate it will cost at least $65 billion a year by the time we get to a 10 percent standard, which comes to $570 per year per household. We will talk about how we get to that number and why we think it might be even more than that.

We estimate the cost of carbon removed by a low carbon fuel standard at $457 per ton. That is a minimum estimate and when it is compared to estimates in the literature of the social marginal cost of carbon, it is about ten times that, if not more. If it is compared to alternative means that might be used to remove carbon from the atmosphere, it is also at least an order of magnitude greater.

MAJOR CONCLUSIONS

- We estimate the cost of carbon removed by an LCFS at $457/ton. This is 10x the estimated social cost of carbon and also of alternative means to reduce these gases
- An LCFS imposed within the US will be largely offset elsewhere, raising the cost per ton even further
- A state or regional LCFS would be even less effective than a national but costly for that geographic area's consumers
- An LCFS is inefficient in the sense that it subsidizes GHG-producing fuels
- We find little justification for an LCFS policy at either the national or state levels

A low carbon fuel standard imposed within this country would be largely offset elsewhere, raising the cost per ton even further. In other words, there will be offsetting actions taken elsewhere in the world; the economics suggest that is what will happen. The $457 per ton estimate assumes a closed economy. If the wider world is considered, the cost per ton is probably going to be much higher. A state or regional low carbon fuel standard would be even less effective than a national one, because of the reshuffling of fuels among areas that would take place, but it still would be quite costly for consumers in the geographic area where it is imposed. As economists, we also observe that a low carbon fuel standard is an inefficient tool because it subsidizes a greenhouse gas-producing fuel. It will result in subsidies to a so-called low carbon fuel, but a low carbon fuel is not a no-carbon fuel, it is just a lower carbon fuel than gasoline. So you are actually subsidizing greenhouse gases with this approach. This is not an efficient way to go about curbing carbon emissions.

We find little justification for a low carbon fuel standard at either the national or state levels, but as we see from the list above, not only are there proposals to do this, but they are starting to gain momentum. The Waxman-Markey proposal, the American Clean Energy and Security Act of 2009, recently introduced in draft form, contains a low carbon fuel standard.[1] It starts at about the level that we are at now and then very gradually ratchets down over quite a long time period. By 2030 it reaches a 10 percent reduction level. But even starting at today's average carbon level, if we were going to otherwise expand tar sands use for purposes of making motor fuels for U.S. consumption, the fact that their lifetime greenhouse gas emissions are higher than those

[1] The final version of HR-2454, the American Clean Energy and Security Act, did not contain an LCFS.

for fuels from conventional petroleum implies that the standard would have an impact almost immediately.

LCFS PROPOSALS

- Waxman/Markey "American Clean Energy and Security Act of 2009"
- S.1324 of 2007
  - Sponsored by Sen. Obama, co-sponsored by Senators Reid & Harkin
- HR 2215 of 2007
  - Sponsored by Rep. Inslee plus 22 co-sponsors
- Northeast – Mid-Atlantic regional LCFS
- State of California
  - Part of AB32 implementation
- Minnesota
  - Senate File 13

In 2007 then-Senator Obama introduced a bill, S-1324, which contained a low carbon fuel standard. It was co-sponsored by Senators Reid and Harkin. HR-2215 of 2007, sponsored by Representative Inslee, was another form of a low carbon fuel standard which had somewhat different targets than did the Obama bill, but amounted to the same kind of thing. There were twenty-two co-sponsors for that bill. There is a regional group of Northeast-Mid-Atlantic states that is thinking about imposing it collectively. But the one that is the furthest along has occurred within the state of California, under its Assembly Bill 32. There are all kinds of programs to reduce carbon in the state and they are close now to putting an LCFS into place. It is the kind that I described: a 10 percent reduction, to come down 1 percent per year between 2011 and 2020, so that by 2020 a supplier of fuels must achieve a 10 percent reduction in the carbon content of fuels sold in that state.. Actually it is closer to 10½ percent by 2020. Minnesota has a bill as well called Senate File 13 and they are starting to think seriously about imposing an LCFS in that state.

Figure 1 shows that how fuels are scored with respect to greenhouse gas emissions has a great deal to do with which fuels will qualify and which will not qualify. Being Washingtonians near Capitol Hill, you will understand immediately that there will be a great deal of pressure from various groups as to how their fuels are going to be graded with respect to a low carbon fuel standard. If you follow California politics, you know that that is already going on out there. In any case, the estimates on the figure were made in 2007. They've since been revised a little bit, but nevertheless they were made in 2007 by the Environmental Protection Agency (EPA), which scored them under a life cycle greenhouse gas accounting framework. At the bottom on the left is cellulosic ethanol and at the time it was given an 80 to 85 percent reduction relative to gasoline. Everything is relative to gasoline here: the zero line along the horizontal axis is gasoline, so fuels to the left are better than gasoline in terms of carbon standards and fuels to the right are not as good as gasoline. The best of them are the last three on the left: cellulosic ethanol, then biodiesel and sugar ethanol. As you move to the right, you get

corn ethanol, which is given about a 20-25 percent reduction relative to gasoline, liquefied petroleum gas, then methanol which gets a little bit of a break relative to gasoline, and so on.

EPA Estimates of Alternative Fuel Lifecycle GHGs, Relative to Gasoline as of 2007

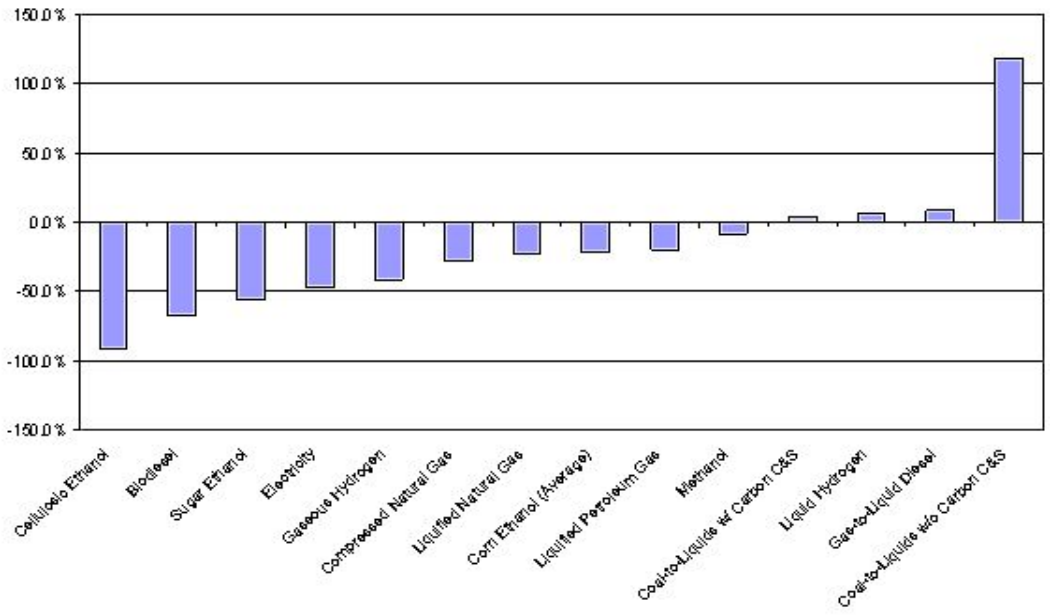

Figure 1

However, there has been an important reconsideration in the case of ethanol and biofuels generally. The reconsideration is important because, at least in our estimation, ethanol is probably the cheapest way to go about meeting a low carbon fuel standard. There are lots of alternatives, but in the end, to meet a 10 percent standard or something close to it, ethanol is the least costly fuel, at least from what we know of the technologies today. That could change; it may be different next year, but right now that is our best estimate.

The fact that there has been reconsideration of biofuels since 2007 is very important. Land use issues have come under consideration. What is believed now is that if ever more acreage is planted with corn to produce ethanol, it is being taken from somewhere. The question is what is it being taken from? If it is forest that is being cut down to plant the corn, then that is reducing greenhouse gas-absorbing timber, so we have to score that; it has to be part of the ethanol calculation. Both corn ethanol and cellulosic ethanol were re-scored by EPA and by the California Air Resources Board (CARB) as a consequence of considering land use, and that is at the heart of a fight in California over how ethanol is going to be scored.

Reconsideration of Biofuel GHGs since 2007

- Land use issues
  - Corn ethanol may generate more GHGs than previously estimated
  - Cellulosic ethanol also may generate more GHGs than previously estimated
- Nitrous oxide issues
  - Fertilizer-related emissions may be higher than previously estimated
- Lifecycle GHG models are being recalibrated
- It may be that no currently available biofuel would enable fuel sellers to meet the emission reduction goal

Others have raised nitrous oxide issues, whether the fertilizers related to the use of ethanol are such that the carbon-absorbing aspects of growing corn are offset because nitrous oxide is being released from fertilizers. So there is recalibration of the greenhouse gas models and it is a little unclear what biofuels will or could meet a low carbon fuel standard.

Economics of LCFS is similar to CAFE

- Sellers must meet an average carbon standard
  - Can sell more low carbon fuel
  - Can sell less high carbon fuel
  - Some combination of the two
  - To induce consumers, cross subsidize from high to low carbon fuel
  - This means that a carbon-producing fuel is being subsidized, which is itself inefficient
  - GHG outcome depends on elasticities of demand and supply for low, high carbon fuels

So how will an LCFS actually work in practice? To understand that, it is helpful – at least it was helpful to us – to look at how the Corporate Average Fuel Economy (CAFE) standards work. They have been analyzed in the economics literature going all the way back to 1983 when they first came in. There is a very important article by an economist named John Kwoka who said that if you put in CAFE, it is not at all clear what actually happens to the amount of mileage driven, because there are several different ways in which the auto manufacturers can meet the standard. They could offer fewer low-mileage cars, but they could also offer more high-mileage cars to meet the average. You could actually end up with more cars on the road than you had before. It would all depend on the demand elasticities for the high fuel mileage cars and low fuel mileage cars and the supply elasticities. Kwoka indicated it could come out in either direction, depending on what those elasticities look like.

The same is true for a low carbon fuel standard. It could be met in a number of ways. Fuel sellers could offer more low carbon fuel to the market while keeping the

amount of high carbon fuel the same as before. Or they could reduce the amount of high carbon fuel, or some combination of the two. But how do they induce consumers to buy the new mix? Somehow consumers have to be induced to buy the low carbon fuel. The answer is that there has to be cross-subsidization. If sellers want consumers to buy more of the low carbon fuel, which may be a more expensive fuel to produce, then they are going to have to subsidize it. Where will the wherewithal for the subsidy come from? Sellers will have to charge more for the high carbon fuel because they will want to discourage its use and also the premium earned will provide the wherewithal to subsidize the low carbon fuel.

So there will be cross-subsidies, just as there were in the case of automobiles when for a time low mileage cars were earning nice margins, but were subsidizing high mileage cars. The latter were not very profitable for the auto companies, but these companies had to induce people to take the high mileage cars. For the same reasons, the low carbon fuel will have to be subsidized, which is economically inefficient if the purpose is to reduce carbon. The overall greenhouse gas outcome depends on the elasticities of demand and supply for fuels. There could be more fuel or less in total. Some work has been done on that. The general conclusion is that you would probably end up with less fuel at a higher price, but it could go either way, at least in theory.

Literature Estimates of 90% LCFS Costs

Fuel price increase	$.13 - $12.67/gal
Annual cost to consumers & producers	$80B - $760B
Annual tax revenue loss	$1B - $16B
GHG Emission Reduction	12-45%
Cost per ton of carbon removed	$307 - $2272/ton

Table 1

Table 1 summarizes the results of work published in the economics literature. It was done by three economists at California – Irvine, and was published by the National Bureau of Economic Research (NBER). The economists went through several cases and looked at different elasticities of supply and demand for fuels, for the high carbon fuel gasoline and the low carbon fuel, which in their case was ethanol. They graded ethanol at 75 percent of the CO_2 content of gasoline. In fact, that is optimistic, but they looked at alternative cases. They looked at a 65 percent case and they looked at an 85 percent case. The 85 percent figure might be more realistic, but to achieve a 90 percent standard with a fuel that has 85 percent the lifecycle GHGs of gasoline implies that that fuel will have to take up a very large portion of the market. In our analysis we grant ethanol 75 percent. In order to meet a 90 percent low carbon fuel standard with ethanol, 40 percent of the market has to be that fuel and 60 percent regular gasoline. So that is how much of the market is taken if you score it at that level.

As to the annual cost to consumers and producers, the estimates range between $80 billion and $760 billion, depending on fuel supply and demand elasticities and how ethanol is scored for carbon emissions. There is a tax revenue loss because ethanol receives subsidies under federal and many state tax codes. Greenhouse gas reductions are achieved – this is a closed economy type analysis – but the cost per ton of carbon removed in this analysis varies between $307 and $2,272 a ton. If you follow this issue a bit, you will recognize that these are astronomical numbers compared to other alternatives to reduce greenhouse gases.

My last message on this is that even if you are a very strong environmental advocate, even if you want to reduce carbon and you are willing to go to a lot of different measures to get it done, this is a very wasteful use of resources. You could take the resources that would be used to reduce carbon at $307 to $2,272 a ton and get reductions that would be an order of magnitude greater. So if you advocate an LCFS because you want to see the environment improved, you are making a mistake. This is a very poor alternative. Now I will turn it over to my colleague Ed for the rest of the presentation.

Ed Murphy: As Mike said, my name is Ed Murphy and I am the second author of this study. I too was shocked, particularly at the cost per ton of greenhouse gas reductions, particularly when you compare that, as I will later on, with both the actual cost imposed by greenhouse gases as well as the alternatives available.

We Independently Estimated the Cost of a 90% National LCFS

Principal assumptions:

- Must reach 90% the GHGs of gasoline by 2020
- Ethanol is the lowest cost means of meeting the standard
- Ethanol generates 75% the GHGs of gasoline
  - Hence, ethanol must make up 40% of US motor fuel supply
- Cellulosic ethanol no more costly in 2020 than corn ethanol
- Imports of ethanol expand to meet mandate

We tried to do our own estimates, nothing really sophisticated and frankly nothing that really takes into account all of the demand/supply acts that are likely to occur. By the way, we hypothesized a 90 percent reduction in greenhouse gases in gasoline by 2020 and we assume that ethanol is the lowest cost means of meeting the standard and ethanol generates 75 percent of the greenhouse gases of gasoline. Thus in order to do that, ethanol would have to compose 40 percent of the gasoline market in 2020. That would be roughly a tripling of what's projected at that time.

This is, it turns out, a very conservative estimate because we have reason to believe that that 75 percent is much too high a figure and that the greenhouse gas reductions from using corn-based ethanol in particular, but even cellulosic-based ethanol, are

much less than was originally thought. We assumed, again conservatively, that cellulosic ethanol would be no more costly in 2020 than corn ethanol. That in effect assumes a very rapid and substantial advance in the economics of producing cellulosic ethanol; it is an event that has not occurred yet and there are some quotes that the scientific advances in cellulosic ethanol are always about five years on the horizon and have been about five years on the horizon for about twenty years now! So we are making a somewhat heroic assumption that by 2020 cellulosic ethanol is going to be competitive with at least corn-based ethanol. We had to assume this, we had no choice, because of the amount of ethanol that is involved, that we would see imports of ethanol expanded to meet the mandate.

Estimated Cost of a 90% US LCFS

- $65 billion/year by 2020
- $570/household in that year
- $457/ton of carbon removed
- Numbers are comparable to those in the literature
- Costs would be higher still if impacts on food prices were considered

When we did that, we got costs which frankly are comparable to the study by Holland et al. We got a cost that is on the low side, again because we made some very conservative assumptions. We didn't look at all the supply and demand impacts and so we did expect it to be on the low side, but it is also quite high. $65 billion a year would be the cost in 2020. That compared with Holland et al. having – of course depending on which supply and demand elasticities they chose – anywhere from $80 to $760 billion. So our costs are lower, still extremely high, but lower than what is in the conventional estimates. That $65 billion would work out to $570 per household. In particular, focus on that $457 for each ton of carbon removed. Again, to compare that with the Holland et al. study and conventional literature, we are talking there about anywhere from $300 to $2,200, so our numbers are on the low side. We expected to be on the low side, but they are still extremely high. We have not considered a problem that has come up in the last several years, which is the cost of food prices and the impacts that that would have on consumers. This is just looking at the cost of ethanol; it is not looking at the secondary impacts at all. So we think it is very conservative; it will turn out to be a low estimate. And, of course, it could be substantially higher.

We also haven't looked at the "reshuffling" issue and this is important. This assumes that the United States is independent of the rest of the world, which is pretty much what had been assumed in the literature up until now. That, of course, is not the case. Crude oil and petroleum products are widely traded throughout the world and changes in the prices are going to induce increases or decreases in the consumption of fuels and supply of fuels elsewhere.

International context of an LCFS, or "Reshuffling"

- Reduced petroleum imports into US will lower price elsewhere – increasing demand for the high carbon fuel
- Increased ethanol imports into US will raise price elsewhere – reducing demand for the low carbon fuel
- We estimate at least 2/3 of US LCFS carbon reductions would be offset elsewhere
- Hence, cost of carbon reduction through an LCFS = 3 x $457/ton or $1371/ton

Reduced petroleum imports in the U.S. will lower the price, while increased ethanol imports will cause higher prices, so we should expect to see that. We have seen some very convincing evidence of the demand elasticity of gasoline in the last six months or so. We would expect to see that if the gasoline demand were to decrease in the U.S. that some of that, maybe all of that, would be made up by increased gasoline consumption elsewhere. Likewise if the U.S. were sucking up all of the available ethanol throughout the world, we would expect to see increases in the price of ethanol, and that in turn would drive down the consumption of ethanol outside the United States.

How much would that impact? It is extremely difficult to say. We did some estimates. We think possibly two-thirds of what would otherwise be the U.S. low carbon fuel standard reduction would be offset by changes elsewhere. In other words, we only end up with one third of the savings. If you go back to that $457 estimate we had, that was in a closed economy. If we don't have that closed economy, which, of course, we don't, the actual cost to saving a ton of carbon emissions is going to be at least three times that $457, and remember, that $457 was a low figure. So we are talking somewhere around $1,400 a ton for reducing carbon.

Comparison of Costs: LCFS v GHGs v. Other Reduction Measures

- LCFS: $457/ton - $1371/ton
- Marginal cost of GHGs (Tol):
  - mean literature estimate = $16/ton
- Other measures to reduce GHGs:
  - McKinsey & Co. study: 250 measures under $50/ton
- **LCFS is at least an order of magnitude more costly than both**

To put that in some context, in a closed economy it would be $475 and in an open economy with trading it would be closer to $1,400 at least; using the data in the literature, the cost would be even higher. The best and perhaps the only study of the costs of greenhouse gas emissions that has been done was done by Richard Tol and he

made a mean estimate of $16 a ton as the cost of greenhouse gas emissions, the cost in terms of climate change. He estimated with a 95 percent probability that that cost would be less than $62 a ton, so we are virtually certain that it is less than $62 and I would say the mean estimate is around $16. There is a lot of uncertainty there and maybe the bare estimate to focus on is the 95 percent. In any case, as you can see, either the mean estimate or the 95 percent probability estimate is an order of magnitude lower than that, either for $457 or certainly $1,400.

We looked for some other estimates and we were particularly interested in the study that McKinsey had done. They found 250 measures that, if taken, would cost under $50 a ton. If they were all taken, that would result in a savings of three to four and a half gigatons of CO_2 emissions by 2030. To put that in context, the Energy Information Administration (EIA) is projecting CO_2 emissions in 2030 of seven gigatons, so for less than $50 a ton a ton, McKinsey is saying that that EIA projection of seven gigatons can be reduced by at least half and maybe 60 percent. So there are many, many cheaper alternatives to reducing greenhouse gas emissions. There are some questions about the McKinsey study. In fact, a large part of those will result in actual savings so I tend to question if they could result in savings right now. I don't want to say the McKinsey study has answered all the questions, but they certainly have identified many measures that cost less than the low carbon fuel standard would.

State or Regional LCFS

- Even less effective than national
  - Largely results in reshuffling of fuels within the US
- California fuel market somewhat isolated
  - Could increase motorist costs even more
- Minnesota – small part of national market
  - Little effect, consumer cost of more than $500 million per year.

We know that there has been some interest at the state and regional level. Here the problem of reshuffling, of shifting high carbon fuels from one area to another and low carbon fuels from one area to another, becomes much more important. California is a little bit isolated, so there is some possibility it could be expensive there; there is some possibility that it would be more workable than in other areas, although it could transfer some of the low carbon fuels, particularly electricity and hydrogen and what not, to California and so the net effect could still be negligible. We focus a fair amount on Minnesota because there is legislation actively being considered there right now. Minnesota is a very small part of the market; I think it is about 2 percent of the total gasoline sales in the country. That goes totally for gasoline, which we think is pretty much entirely composed of E-10 now. In other words, almost all of the gasoline that can be mixed with ethanol is mixed with ethanol at the 10 percent level. That still leaves only about 3 percent of the ethanol market. So relative to the national market,

Minnesota is a fairly small player and can make changes which are not going to dramatically change the demand-supply equations for the national market.

We made some estimates of what the effect of a low carbon fuel standard in Minnesota would be and we found that that consumer cost of that would be $500 million per year. That works out to $260 per household in Minnesota. Again, that is a low estimate; it did not adequately consider changes in demand and supply. Most of those costs assume the subsidy would fall on the consumers of conventional gasoline and also that they would get a waiver, which is not at all clear, to use E-20. As you know, right now you can't use more than 10 percent ethanol to gasoline unless you use flex-fuel vehicles. Minnesota has requested that be increased to 20 percent and there are studies being done right now to see what the impact of that would be. Actually I think it is unlikely, in light of those studies, that they will get the waiver. Given that the magnitude we are talking about is so large, let's just assume that they get the waiver so they can use E-20. You still have to find a way to get all that additional ethanol consumed presumably as E-85. What we find is that the people at the E-10 level, at the E-20 level, are subsidizing the people at the E-85 level because of the reduction in fuel efficiency in those vehicles. They have to be paid that 34 percent loss in miles per gallon that they experience in using E-85 in their vehicles.

Winners & Losers under an LCFS

- Winners:
  - Low carbon fuel producers & distributors
- Losers:
  - High carbon fuel producers & distributors
  - Consumers
  - Taxpayers
- Environment
  - Not clear that LCFS will reduce GHGs at all but even if so, much cheaper means are available and hence monies spent could have achieved much more elsewhere

When we look at this, who are the winners and losers in the LCFS game? The winners are clearly are those producing the low carbon fuels, be they corn ethanol or cellulosic ethanol, and the distributors. The losers are largely consumers and taxpayers. We assume that most of these costs will be passed on. Most of the subsidies are paid by consumers and most of the subsidies to biofuels would be paid by taxpayers. So the big losers would be the consumers and taxpayers with the winners, of course, being the ethanol producers and distributors. It is not clear where the environment comes out on this. It is very, very difficult to make a definitive statement that it is going to do anything for the environment. It is extremely clear that it is going to do pretty close to nothing for the environment at the state level. And at the national level, even for the cost we have estimated, you have to make some fairly heroic assumptions about the willingness of the rest of the world to react to lower gasoline prices or their willingness

to continue to consume biofuels even though the prices start to go through the roof. It is not at all clear that the environment is a winner in this. And I think there are some cases to be made that the environment is a loser, particularly when you start to look, as the literature has recently done over the last year or year and a half, at the land use changes which are starting to trouble quite a few people. It is not their area of expertise. In fact, what we had hoped was that we could come up with a fuel, be that ethanol or some other fuel, that we could say we are reasonably confident is 75 percent or 80 percent of the gasoline emissions. We really couldn't do that and we got to a point in the paper where we said, if we can't get a fuel that has lower greenhouse gas emissions than gasoline, then this whole thing sort of blows up.

You all know the story about the economist trying to open a can on a desert island; his answer to the problem is "let's assume there is a can opener." So being good economists, we said we would just assume that ethanol had 75 percent of the greenhouse gas emissions. There is no justification for that, and as I said, the most recent evidence is that that is much too low a figure, and that on a life cycle basis, including land-use changes, nitrous oxide emissions and so on, that ethanol, and particularly corn-based ethanol, could actually have higher emissions than gasoline. So it is not at all clear what, if anything, this does for the environment. We made some very heroic assumptions and even those we recognize may be understating the cost to the economies of the world for reducing greenhouse gas emissions.

Summary & Conclusions

- Not clear which alternate fuels will reduce GHGs relative to gasoline – depends on how EPA scores lifetime GHGs and on relative costs
- An LCFS will distort fuel markets, forcing cross subsidy from high to low carbon fuels
- It will impose very high costs on motorists and taxpayers
- The cost per ton of carbon removed will be much higher than the social cost of GHGs and those of alternative means of reducing them
- An LCFS is economically inefficient because it subsidizes carbon-producing fuels
- There is very little social justification for an LCFS

First, it is not clear which alternative fuels will reduce greenhouse gas emissions relative to gasoline. In that case, this is a game that is being played in Britain about what they are assigning greenhouse gas emissions to be. It is a game that apparently the Minnesotans want to play, to just assume that there are certain reductions, and frankly, it is a game that the Waxman-Markey bill is playing. They just assume that no matter what we find out in the future, corn-based ethanol reduces greenhouse gas emissions, so science be damned. So it is not clear which alternative fuels reduce greenhouse gas emissions. It certainly true that an LCFS will distort markets, forcing cross subsidies from high to low carbon fuels. This was the work that Mike mentioned

by Kwoka in 1972. In some senses it is an underappreciated piece, because he accurately analyzed the effect of the CAFE standards and what was going to occur and that in fact was exactly what did occur. This is a similar approach. Holland and the other authors took that analysis and applied it to low carbon fuel standards. But we know what happens when markets get distorted and we know ultimately that that system is subject to explosion. It will impose very high costs on motorists and taxpayers. The cost per ton of carbon removed is much higher than the social cost of the carbon and much higher than the alternatives that are available for reducing greenhouse gas emissions. As Mike mentioned before, an LCFS is inherently inefficient because whatever the fuel is that is being subsidized, be that corn-based ethanol or cellulosic ethanol or whatever, that fuel itself is producing greenhouse gas emissions. A more efficient approach would be a tax on those greenhouse gas emissions regardless of where they came from and not to subsidize fuels that have greenhouse gas emissions.

So we find that there is really no justification for an LCFS at either the national or the state level. Thank you, and Mike and I would be happy to answer any questions.

Kueter: Thank you gentlemen for a great overview of the study. The only thing that I would point out is that in the longer document that they prepared, there is a very interesting comparison of alternative fuels and the hurdles that some low carbon fuels would have to cross in order to become commercially viable. I would commend you to take a look at that as it feeds into the notion of what the commercially effective alternatives are. Mike and Ed will be happy to take your questions.

Questions and answers.

Question: First, I would like to thank you for giving us important information. What I found most shocking was that I didn't realize that EPA's life cycle carbon methodology actually amounts to nothing but a bunch of numbers for about ten cases. To me that is like doing law enforcement on the steel industry based on the fact that you are in the steel industry and what you pay depends on the industry you are in and not on your actual emissions. I hadn't really imagined that the EPA would be on the verge of doing something like that. Because the real CO_2 is a matter of how you produce the biofuel, which varies a lot from company to company, and also what your feedstocks are. The Department of Agriculture knows how to measure things like carbon in the soil. Obviously it depends on individual agro-business, what the land use implications are. Instead of doing that on an industry aggregate basis, if you have any kind of a rational incentive system, you are going to look at what the individual company is costing you, if you know how to measure it, and the USDA does. Apparently EPA hasn't cranked that in and that surprises me and that is part of the debate. You have to make sure that people don't do stupid things because they don't know what other agencies do. There are two numbers which stick in my mind as questions. You said to meet these standards, it would take 40 percent of something, let's call it ethanol for now, and you said the cost would be very high, $65 billion a year. Now if I ask 40 percent of the

U.S. liquid fuel requirement and I think $65 billion a year, then I remember there was a $700 billion a year number I heard a while back that had something to do with paying for oil imports or something. From the viewpoint of national security, $65 billion wouldn't be a lot to pay for 40 percent of your supply. I think it is important to remember the carbon dioxide implications here might be penny-ante, but we need to pay a lot of attention to the national security aspect. I wonder, is it as good as you said, $65 billion a year for 40 percent of our liquid fuel supply?

Murphy: I have to go back and look, but in my recollection, about half of that ethanol would be coming from outside the U.S. We made the assumptions that ethanol is viable and that ethanol is coming from outside the United States. I think the point that Jeff made is that you really get very little energy security for that. You are not really enhancing the energy security of the United States with that LCFS.

Question: Do you think 40 percent of our fuel supply doesn't matter for national security?

Murphy: No, I am not saying that. What I am saying is, you are not getting 40 percent from the U.S., you are getting maybe 20 percent from the U.S., and you are still dependent on world markets for a large part of your petroleum.

Canes: Just a couple of comments. First of all, about setting standards and what counts and so on, those were EPA's numbers from 2007. There is a model that Argonne National Laboratory produced called the GREET Model – I don't know what the acronym stands for – but basically it is a model that tries to estimate life cycle greenhouse gas emissions from different energy sources. In California they have adopted that model with some modifications; it is called the Modified GREET Model or something like that. I should add that there is more than one model; this is one of the most commonly used models, but there are others. I think the EPA would probably use a model like it to assign a value to a particular kind of fuel. Now, could they have an appeal procedure where someone could come in and say, "I produce this fuel, but I can prove to you that I have lower greenhouse gas content on a lifecycle basis than what your model estimates?" That is a possibility, but it gets to be very complicated if you do that. A variety of fuel producers will claim to be exceptions to the rule and you will have to judge them on a case-by case basis. That would be a high transaction cost method, but there would be reason to approach the problem in that way. It will be tedious to go through the individual applications to deviate from the standards used but it can be done. The methodology of doing so remains to be worked out over time, but you raise a good point on that.

Would it be worth $65 billion to have 40 percent corn ethanol in the United States? If what you are trying to do is reduce gasoline consumption or motor fuel consumption in toto, there are more efficient ways to go about it. A straightforward tax on motor fuels would keep the money within the United States, and the revenues could be used for a

number of different purposes including reductions of other taxes. This approach would induce all kinds of substitutions instead of forcing a particular fuel, whatever is scored best by EPA, into the market. You would get a wide variety of changes on the consumption side and in the technology of vehicles. You would get alternate fuels as well and you would get a much more efficient use of resources than this particular approach. I agree that there might be reason to want to reduce imports of gasoline. There is a cost to such imports, but you could reduce them a lot more efficiently than this method, if that is what is your objective is.

Question: Does the 40 percent figure represent 40 percent of supply or 40 percent of BTUs?

Canes: 40 percent of the gallons.

Question: So it's not 40 percent of our energy consumption, but 40 percent of the gallons. I didn't understand the 90 percent figure on the screen, because there is a 10 percent reduction in carbon content, right, so what is the 90 percent?

Canes: The idea of the 90 percent is that by a certain period of time – in California it is 2020 – the average carbon content of the fuel that you, as a seller, are putting on the market must be 90 percent that of gasoline. If you do that, you have achieved a 10 percent reduction from an index of 1 for gasoline.

Question: I have a question related to the previous question. You cited a 75 percent reduction of the greenhouse gas emissions of gasoline for ethanol – is that on a per-gallon basis or is it on a BTU basis?

Murphy: A per-gallon basis.

Question: So that really isn't fair. I mean, it takes a certain amount of energy to move a car a certain distance, so you have to burn more ethanol.

Murphy: At a low percent, that ethanol has been used in the auto industry for decades, essentially as an octane enhancer. There are some benefits to ethanol at low concentrations, E-10 and below. You do get reduced carbon monoxide and improved octane. So there are some benefits. Above the E-10 level, those benefits stay but they don't get any better and you start having all the other problems, the loss of BTUs and caustic effects on the fuel system and so on.

Canes: I am not 100 percent certain, but I think that this is on the gasoline gallon equivalent basis. It is not a straight gallon; it has been adjusted for the energy content of the ethanol. On that chart, you also have electricity and other things shown which have different energy contents. They are all shown relative to gasoline.

Question: I do know that the Waxman-Markey bill specifically says that this will be done on the basis of energy content rather than physical volume. If it were 75 percent by volume, then it would be physically impossible to meet the standard with only 75 percent, so I assume it is gallons of gasoline equivalent.

Question: I want to comment on the national security issue. Our national security interests in the Persian Gulf preceded any increase in dependence. If we want to reduce imports, then the Senate and House can open up production here, because every barrel that we produce is one you don't import and you create jobs here. Listening to this presentation, it seems to me that what we have is an anti-mobility bill that would penalize domestic oil production and reward the insatiable greed of ethanol producers. It's a simple as that, in my opinion.

Question: Senator Specter has said that we have a really serious life or death national security problem in the Middle East and we shouldn't play games with this. If we are serious about it, we will do everything we can, which includes domestic production, which includes domestic biofuel production and includes electricity. And we have to go as fast as we can on all these things because we are up a creek right now with regard to the Middle East and we have to play our way out of it with everything we have. So we do not disagree with what you're saying about domestic resources.

Question: We aren't going to have peace in Middle East, regardless of oil. Even if the world gets off oil, period, the Middle East will still be a national security problem. The two are separate.

Question: I work with Argonne National Laboratory, but I have nothing to do with this particular program you are mentioning. The ideas that you presented have been around in the McKinsey studies and others even before you wrote this study. By any chance do you know whether the California groups were exposed to these ideas and whether they explicitly rejected them in their evaluation? You present a quite rational case that what they have selected is not the desirable way economically to proceed.

Canes: Well, of course we agree on that. Here we have to figure out what is going on in California. I am a Californian originally, but I haven't lived there for years and I don't follow the politics from day to day. But I can surmise a little bit. In California they have believed for a long time in the notion of technology forcing. If you go back many years, they wanted zero-emission vehicles and the idea was to bring about technology advances in electric vehicles to get there, so they tried to force it. They found that it would be pretty costly and wouldn't work out quite the way they hoped and they ended up backing off. I think that may be still somewhat in California's mind. I think the idea again is to try to force the technology forward. They are less interested in ethanol out there, so they have been pretty strong in including land-use aspects and making ethanol having to defend its position. But I think they are giving electricity pretty good grades on carbon, probably because they still want to try to move in the

direction of an electrified vehicle fleet out there if they can. They believe by putting a standard like this in place, they can force technological advance as well as achieve the goal at somewhat less cost than what we are saying. But we think we have chosen the low cost alternative to meet a standard like this so that other ways of achieving it like battery-powered cars or fuel-cell powered cars are going to be even more expensive than the numbers we have shown here.

Murphy: I think Mike is correct. The other thing that is happening in California, though, is they all are aware of and discuss at some length the reshuffling issue, and apparently the implicit assumption is that other states are going to follow in California's direction, so over time the reshuffling issue, at least within the United States, is going to be less. In the case of Minnesota, as Mike says with California, they merely are providing huge subsidies to cellulosic ethanol. Cellulosic ethanol is considered, on the basis of the scientific evidence, at something like 10 percent of the greenhouse gas emissions of gasoline. Effectively that is a huge subsidy to cellulosic ethanol in Minnesota.

Question: That discussion of California provides a segue for me: I was wondering if you had come across research and analysis or commentary on how successful an LCFS program would actually be in terms of driving technology? Or would it just end up like the electric car programs and peter out?

Canes: That is a good question but it is a very difficult question to answer. They are in a hurry in California. I think the first year in which you have to start reducing the carbon content of fuel is 2011 or 2012 and by 2020 you have to achieve the 90 percent standard. You're on a ramp the entire time, about 1 percentage point a year to get down to that 90 percent level. That is a very short time period to bring about radical change in technology. Anything is possible, but I am skeptical that we can achieve things that we don't already understand in such a short time period.

Question: Did you look at the Charles River Associates (CRA) analysis of the Lieberman-Warner bill from last year? In that, they had a low carbon fuel standard and one of the things that CRA concluded was not just that the program was costly, but the virtual timeframe of it was, and as you got further out and you allowed more time for vehicle electrification, the cost of the program, which was very expensive on the front end, got less expensive in the future. So I wondered if a) you looked at what they did, and b) whether in your analysis, you looked at a longer timeframe for the same sort of program and what that might do to mitigate those costs.

Canes: No, I wasn't aware that Charles River had analyzed the low carbon fuel standard, and what you report about what they had to say makes sense to me. With a longer time period, perhaps other alternatives would come to the market that would be cheaper and so would cut the cost. But you start from such a high cost basis that it would take a tremendous technical advance to get to a point where you might consider something like this to be more or less equivalent to what the McKinsey Company study

showed, that there are carbon reducing options in the $50 per ton range or below. All I can say is that directionally the CRA analysis sounds right and I guess the Waxman bill recognizes that by taking a longer time period, perhaps you can cut the cost some. Nevertheless, I am reluctant to conclude that this is likely to be an efficient method of reducing carbon, even in a 2030 timeframe. Remember, it forces cross subsidies; it results in subsidies to low carbon fuels. That is not an efficient way to go about reducing carbon in the atmosphere.

Murphy: As Mike said, the longer the time period, the more one might be optimistic about the technology developing in that time period to be able to do what you want to do. But to assume that is going to occur is somewhat heroic and that is one of my concerns about the Waxman-Markey bill. When the time period is longer, implicitly the assumption is that the technology will develop to meet those standards. But long before that occurs, industry is going to be taking actions based on what they think the regulations are going to be. And that more or less guarantees that we are going to have the high petroleum prices in the 2030 period in Waxman-Markey, regardless of whether or not the technology comes along because the investments are not going to be made that would have prevented that from occurring.

Question: Are these costs on top of the 36 billion gallon program we already have on the books for the Renewable Fuels Standard (RFS)?

Canes: It is a vast expansion beyond that.

Question: How big an expansion is it? We are moving toward a national E-10 standard already. If we had E-10 nationwide right now, how far does that get us to the 10 percent reduction in carbon content?

Canes: The market for gasoline is about 140 billion gallons, so 10 percent is 14 billion and 40 percent of the market is 56 billion.

Kueter: Gentlemen, thank you very much for your insights and thank you all for joining us this morning.

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