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Session 1: "The Future for Transport Demand"

Dr. Kydes: Why don't we begin. Good morning, thank you for attending, and welcome to our session entitled The Future of Transport Demand. My name is Andy Kydes. I'm the only one at the table without a table name tag; it shows the importance of the people here; it turns out I'm the Senior Technical Advisor to the Office of Integrated Analysis and Forecasting. Now why is this topic important? I'm going, in the interest of time, to skip over a number of things that I had intended to say but I think it's important to launch this topic.

For developing nations, the way the future transport demand grows will have a large impact on the mix and level of fuels that are consumed for this sector. Historically with increasing economic growth comes greater demand for transportation services. Transportation and energy consumption grow faster than economic growth in the early stages of a country's development. Personal transport demand grows with per capita income typically. And freight transport energy consumption is linked to the consumption of industrial output. The use of non-motorized and public transport modes have often declined as countries have matured, often declining sharply. So is the past prologue, i.e., will the evolution of developing countries replicate the process and the history of the mature countries, or is it going to be something else? Can we even project those?

Let's start with the broad question of what are the determinants of transportation demand. And I've just picked a couple examples. I know that a number of my speakers are going to add to this list, but with the increasing demand for mobility of growing economy requires access to people, to markets, and to services including labor markets. And of course I think if you've been a student of land use and energy, you know that land use policies can greatly affect the mix and transportation services required and the energy consumption associated with it.

The second, I guess, part I'd guess is the issue of transport modes emphasized under development. In the beginning you have non-motorized modes dominating -- you can think of this as walking or bicycling, animal carts or whatever; then motorized modes; and then virtual transport with the internet because you can conduct business and information "transport" if you like via the virtual internet. And the way of course that an economy evolves will determined in large measure, at least be an important component of the consumption levels of transportation.

The next one will be…and this is my last point here, an important determinant is the way technology evolves for transport as well as how it's used. We only think of vehicle efficiency as a really key policy tool for improving efficiency. In fact that's only one component. Another component is in fact how full is your car, what's the load factor per trip on average that you're using. Taken together, technology efficiency combines both of those attributes and gives you a better measure overall, in my view anyway.

With that, I want to list essentially some of the questions that bothered me with respect to projecting transport demand forward the next 50 years. And the first question is "Is the past prologue?", i.e., can we take what we've learned over the last 50 years with regard to the evolution of transport demand, and apply it to the next 50 years? Is it even feasible, does it make sense, is there any way to really to do that plausibly? How will access to market services and people be provided in the future? Again, do we have a paradigm that helps us with them? How will urban form, i.e., land use planning, affect the future demand for mobility? Will the role of public transport continue to decline in developing Asian economies, for example? Will this now decline non-motorized transport disappear altogether with economic development? How dependent are we going to be on oil for transport? And finally, if we're really using vehicle efficiency as a primary tool in describing the future of transport, can we really tell a plausible story with regard to economic growth, mobility, and fuel consumption for non-OECD countries?

Now that's about all I had in terms of getting this session going. We're going to have the following order of speakers. I did this before I realized…of course that we're running 20 minutes late, so we're going to try and cut each of the sessions down a wee bit.

(Dr. Gruenspecht tells Kydes that the session need not be shortened.)

Dr. Kydes CONT: Oh, okay. Oh, well, I've just been informed by Dr. Gruenspecht that we're going to run 15 minutes longer and we're going to cut the lunch down, period, down by 15 minutes.

(**AUDIENCE**) Food for thought!

Dr. Kydes (CONTINUES): So, the presentations take precedence. Okay. At this point let me introduce the first speaker, and that will be Lew Fulton. Lew has worked in the international field of transport, energy policy, and policy analysis for over 20 years. He has served in positions in the U.S. Department of Energy and the Office of Policy from 1992 to 1996, and in the Independent University of Bangladesh 1996 to 1997. He's on his second tour of duty to the International Energy Agency in Paris, lucky fellow, and he's here in his role as a Senior Transport Energy Specialist, his first stint was 1999 to 2005. During 2006–7 he worked in Kenya with the U.N. Environmental Program on Developing and Implementing Sustainable Transport Projects. He's got a number of publications to his credit, either author or co-author, one of which is *Energy Technology Perspectives*, some of you may be familiar with it at the IEA where he is co-author of *State of the Oil in a Hurry*, and so on. He received his Ph.D. in Energy Management and Environmental Policy from the University of Pennsylvania in 1994. And with that let me introduce Lew.

Dr. Fulton: Thank you, Andy, and I'm really glad to hear we're going to skip lunch so we have like 40 minutes each to give our talks then right? It's really nice to be here and it's amazing how many people I recognize from the day except we all have gray hair now, but if you look in the book I still look really young so just look at me because the picture I sent in was the only thing I had with me at the moment, and I think it's ten years old.

Oh, we've got to get my talk up here, is that easy? Yea. So, I'm going to just hit on the high points of some of the recent work that we've been doing at the International Energy Agency. I will try to stick to 20 minutes, and there are really two key things for me to report on. One is the new World Energy Outlook as opposed to the annual energy outlook that the EIA does. The IEA does the World Energy Outlook, and it actually covers a lot of the same terrain; it takes a slightly different view on a few things and we came out with our most recent one in November. I'll tell you a little about that. And we have a biannual publication called "The Energy Technology Perspectives". We came out with that one in June of 2008; it kind of picks up from the World Energy Outlook; the WEO goes out to 2030 in its projections; ETP goes to 2050. And it looks in more detail, at alternative scenarios, low CO_2 scenarios, and in particular at technology, the role of technology and how we feel we need to improve technologies and commercialize them in order to tackle issues like climate change.

So here are the highlights from the World Energy Outlook. I'll try to go through these fairly quickly. A lot of these stories don't change that much over time despite the…you know…protocol and everything else where we're supposedly getting serious about cutting fossil energy use and reducing CO2 emissions. We still project that between 2005 and 2030 we're going to increase world energy demand by 45 percent. That is lower than what we projected last year in the 2007 edition. This is partly due to some higher price projections and maybe a teeny little bit of impact from policies that came in over the last year. The World Energy Outlook focuses primarily on a reference case projection based on policies in place as of the time of writing. And almost all of the increase in energy use is fossil energy use, or coal, oil and gas. A few days ago I read that the number one increase fuel in 2007 was coal worldwide. So things are not going in a good direction.

In terms of oil, almost all of the incremental demand will come from transport, and you can see from this figure that China represents nearly half of the expected increase in world oil…in transport oil demand. Here we have the change in oil demand, looking at a little more detail by region, and you can see that we actually expect oil demand over the next 21 years to drop in OECD countries, the wealthier countries. All the growth will come from the developing world. Of course, that's off of a much lower base and the totals are still going to actually be fairly similar between the developed and the developing world. But if you're thinking about growth, 9 million barrels a day from China alone.

What does this mean in terms of oil? Import dependence, we heard from Professor Nordhaus in the Plenary Session that maybe this isn't such a big concern, we may have a different view from some of our other speakers, I'm not going to get into it but I will simply report to you that currently different countries range anywhere from 40 to 80% imports…well, in 2030 the average will rise to about 80 percent with some countries up around 90%. So this oil import dependence just will keep getting worse if we don't change direction.

One of the reasons that energy use will keep growing is that we do subsidize all sorts of energy, all sorts of particularly fossil energy as well as electricity, and some countries a lot. Iran, as Professor Nordhaus actually cited, that's essentially this figure so I won't spend any time on it, but we're estimating that Iran spent $50 billion last year on subsidizing their own energy use, and the total worldwide subsidy was 310 billion in 2007. Here is the picture in terms of world oil production and where we think it's going to come from. If you look just at that dark green part of the bars, this is non-OPEC conventional oil, and it does basically decline over time – i.e. it has peaked. But we don't say that all oil declines because we're expecting to see significant increases coming from OPEC and in particular OPEC Middle East, and we get up to about 105 million barrels a day by 2030. That is significantly lower than what we said in our last year's projections where they were more like 115. And there's also other unconventional liquid fuel resources, things like gas to liquids, that could add beyond this. And there's the share in that line of the oil production coming from OPEC, it goes up over 50 percent by 2030.

Okay here is one of the major pieces of analysis that was done for this World Energy Outlook. It shows a reassessment of existing oil fields in the dark blue, and the decline rates that we expect to see from existing production. And it turns out that oil field production is declining in many cases faster than previous data had indicated. And so if we didn't add any more capacity we would get a picture something like this blue area which would be a very dramatic decline. So we basically have to replace all that lost production over the next 20 years just to stay even. And it's going to take a huge amount of investment.

We're concerned about the rates of investment on the oil side, particularly with this economic crisis, we're not getting sufficient investment in oil production facilities and we may pay the price in four or five years. But overall we do expect to see over the course out to 2030 that we will manage to keep oil, conventional oil production, on a slight rise, and then when you factor in non-conventional oil and natural gas/liquids we can get to the 105 million barrels a day that we project will be needed.

Now here is CO_2. Of course it's a very similar story to energy use - to fossil energy use - and it increases by, I forget the exact amount, but it's something like 50 percent between now and 2030 worldwide. And it's in absolutely the wrong direction. So here is the alternative…two alternative pieces that the World Energy Outlook produces; we show low CO_2 scenarios based on IPCC targets, a 550 PPN atmospheric concentration and a 450 PPN atmospheric concentration, and at least one way you can change the reference case in order to get to these alternative futures, and I think the simple messages here are that we think we pretty much have to stabilize global CO_2 by about 2020 in order to hit a 550 PPM [parts per million] atmospheric concentration . Eventually you're going to have to go down but at least out to the 2030 timeframe you'd have to stabilize. If you want 450 you'd better be going down fast after 2020. And in both cases the most cost-effective approach that we can find has on the order of half or more of the solution coming from energy efficiency improvements with some, actually quite a bit of nuclear, carbon capture and storage and a lot of renewable and biofuels, and if you don't get any one of those things, for example, if for some reason we can't really bring CCS online, you've got to do a lot more of something else. So by having the combination of different approaches it makes it a little easier, but the levels of investment and the numbers of power plants of different kinds that you need ever year are stunning, really, and I don't have that slide in here but I can share that with people offline.

I'm going to move on now to the other publication, the *Energy Technology Perspectives*, which as I said is where we take the WEO and extend it out to 2050. In fact this one is from June so it's based on the previous years WEO (WEO 2007) so the reference case out to 2050 is based on a slightly higher projection than the current World Energy Outlook. But we have two low CO_2 scenarios that are similar to the WEO 550 PPM and 450 PPM, we just happen to call them something else, we call them ACT and BLUE. If you can see there toward the bottom of the graph, ACT is what can we do worldwide to 2050 at up to $50 a ton CO_2, and BLUE is what can we do if we're willing to undertake actions that cost up to $200 a ton CO_2.

One thing that I think… where we get into a little of the modeling issues, you know, going out to 2050 its increasingly uncertain and we do basically straight-line a lot of the growth from 2030 on out, and what happens is you get a four-times increase in global GDP which drives everything else, and population is increasing by nearly 50 percent. Population gets close to 10 billion people. So these are your two primary drivers. And even in the referenced case, what we call baseline scenario in ETP, you get a lot of de-coupling of energy use from this GDP growth. Final primary energy and primary energy only grows by a factor of two. So if the reference case turns out higher…if we don't get this kind of decoupling in the reference case, we're going to find we're in even more trouble, so I think that's a key message right there. We calibrate to the World Energy Outlook in the transport side.

We have a model called the Mobility Model, MOMO, some people may know about it. It is not an optimization model but we can use it to do various "what if" analysis and we can build in our menu of options based on a separate cost effectiveness analysis. But one of the things that this does is it provides a fairly detailed projection by regions…I don't know if you can see the right hand side there, but those are some of the different regions…countries and regions that are in the model, it does cover the whole world in 11 regions. Including subregions in the model, there's a total of 21 countries/regions. Now here's a picture of historical car ownership per thousand people compared to income, and you can see a fairly tight correlation as incomes rise and car ownership also rises. Basically once a country gets to about $5,000 per capita car ownership takes off. Here's our same picture with our projections out to 2050. And through a combination of assessments about income distribution, and various other reasons why we might believe that the growth rates in the future are not as high as rates in the past, we actually end up with a number of the bigger countries , especially India and China are very much lower than the historical, if I go back you can compare them, historical trends, and then the projected trends. Again, if this turns out to be too low and if India and China follow something closer to the United States it's going to be not 2 billion cars but 3 billion cars on the planet by 2050. So these are the kinds of uncertainties that we really need to pay attention to.

We do have a higher case with a higher ownership and you can see the difference there, and that's sort of a 2 billion versus 3 billion car case. We also have a fair bit of fuel economy improvement in the baseline, mainly due to existing policies that are planned or in place around the world. And assuming that developing countries follow the trends in places like EU and Japan with strong improvements in fuel economy, if we don't get all of this we could have up to 25 percent higher energy intensity in vehicles in 2050 than in this projection.

Anyway, here's what we think needs to happen in order to cut the CO2, and this goes back to the whole economy, not just transport. CO2 from energy-related emissions goes from about 28 gigatons in 2005 up to 62 in our baseline, more than a doubling. We would like it to go down to 14, and in BLUE map we're able to get there… that's basically as far as we can go at $200 a ton; it's cutting it in half instead of letting it more than double. And to do this you're almost completely decarbonizing power generation, industry and energy use in buildings. They get very low, something like 75 percent reductions in CO2 in those sectors. Transport not as far, we're only about 25 percent below current levels in 2050. But if you don't do anything in transport you can't get there. You run out of things to do. And basically we have to do everything at the same time because we don't have that much time, so it's important to realize that we can't simply follow our way up the cost curve and save some things for 30 years from now. I mean there are some things we should do before other things, but we also have to appreciate the magnitude if we're really going to tackle this seriously of all the different things we have to do.

Now, here's our version of the mitigation cost curve that other's have also recently been showing. We do think there are a lot of efficiency options that actually have negative costs. As you can see, the left-hand axis is cost per ton and the right hand is the amount of tons. We need to cut 2050 emissions by something like 50 gigatons to achieve the blue scenario, and you can get up to around 35 which is the ACT scenario at about $50 a ton and then it starts to get a lot more expensive. In transport the fuel economy is down there, hybrids will cost something but if you do a social cost analysis, low discount rate, and also use a high oil price value (we used $60/barrel), but you're going to save a whole lot of fuel from efficiency across the board and the value of that fuel savings helps to keep the costs down. Bio fuels are there, and maybe we can have second generation bio fuels at under $100 per ton eventually, but there are just some huge question marks around biofuels that I don't have time to get into, and I'm running out of time here, but that's something we do keep looking at and trying to figure how do we get to a long-term sustainable picture on bio fuels.

And then out to the right here is where you do have really much more expensive transport options like electrification of vehicles - electric vehicles, battery electrics - and also fuel cell vehicles. Plug-in hybrids, if you do them at the relatively low range of travel on batteries, probably not that expensive. It all comes down to battery costs.

So we did a bunch of different scenarios about lowering CO2 emissions, I'll focus on this one here, on BLUE map you can see the first three bars are the reference case with CO2 from transport more than doubling by 2050. If we're going to change that it turns out in our view about half of it has to come from efficiency and a certain chunk from bio fuels, a certain chunk from electrification.

We did one scenario where we have about the same number of electric vehicles and fuel cell vehicles and then the two right hand bars show variations where we say one or the other of those technologies wins out. But it's hard to do this unless again, unless you have a combination of different things.

I'm going to just very quickly say that we have about 50 percent efficiency improvement for the entire stock of LDVs by 2050 and between 30 and 50 across all the other different kinds of vehicles out to 2050. We think new light duty vehicles can be 50 percent more efficient by 2030, and in fact we've now launched a new initiative called the Global Fuel Economy Initiative with some partners to try to make this happen around the world, to work with governments and try to achieve a 50 percent reduction in intensity. Incidentally that's a doubling of mpg in new vehicles around the world by 2030. We do think electric and/or H2 vehicles have to play a major role after 2030, maybe before in the case of electric, certainly plug-ins.

We have bio fuels reaching up to 12 percent of total liquid fuels share by 2030 and 26 percent by 2050, almost all second gen. We have similar types of numbers for the other sectors. But I'll just spend a second on bio fuels.

One of the things that comes out of this is that if you get a lot of electric and/or fuel cell vehicles, they are mostly going to come into the light duty sector. And you have a harder time de-carbonizing heavy vehicles - trucks, shipping, and air. And so we found that after 2030 where do you need bio fuels? You need it in the distillates and the jet fuels and things like that for these heavier vehicles. So almost all of our biofuels growth is in distillate substitutes after 2025. In other words, advanced bio diesel. So biomass to liquids, possibly algae derived bio diesels. Probably not oil seeds because they're just too land intensive, except maybe some jatropha or something like that. A lot of cellulosic ethanol, but we max out on cellulosic ethanol by about 2035 because we don't need more of it after that. We also use quite a bit of ethanol from cane. Ethanol from corn and other grains is phased out in this scenario by about 2040.

Okay, last slide, policies. Yea, we need some policies. And in the next ETP we're going to spend a lot more time talking about how do we actually make this all happen, and we're doing a very detailed road maps effort on certain technologies, what frameworks do we need, what has to happen year by year to make these things happen. But certainly we do need an international framework. We need a post-Kyoto system that works…that works for transport. Kyoto has not worked for transport, CDM really hasn't worked. There are very few transport projects.

We need carbon pricing, it's already been mentioned a couple of times today. And yes we do, we need the price signals but I just want to remind people that a $50 per ton CO2 tax comes out to about 12 cents a liter or maybe 50 cents a gallon. That will help but that is not going to single handedly turn this ship around. I think we're going to need sectoral policies that make this happen. And national measures should include fuel economy standards. I'm not afraid to say that standards work and we need strong standards around the world.

I think second generation bio fuels are going to have to play a role but we have to figure out, especially on this land use change issue, we've got to find a way to produce these fuels on land that is not competing for food or that doesn't cause huge releases of CO2 through land use change. Electric vehicles and fuel cells will play a role unless we are over-estimating the base case that maybe a way to do this without those advance technologies but we don't see it; we think we're going to have to go there. And we're really hoping that we see enough of a roll-out and testing over the next few years, that we're ready to go, that we can have high volume production, let's say, of electric vehicles in the 2020 timeframe. And the auto industry changes slowly, so these are going to be very challenging kinds of rates of change.

Finally, I haven't talked about travel behaviour. Things like land use, how we develop cities, will be very important. We do have some model shift in the ETP scenarios and we're going to look more closely at model shift policies in the next year. And if we can get some model shift, if we can get reductions in travel growth and more travel by more efficient modes, then that will also take pressure off technology solutions. And I'll stop there. Thank you.

Dr. Kydes: Thank you, Lew. Our next speaker is David Greene, and let me first get this presentation off and my presentation off. Is this your presentation, David? No, I don't think so, let's see. Oh, is this yours?)

Dr. Greene: Yea, that's it.

Dr. Kydes: Okay, let me just introduce you and we'll be all set. Our next speaker is David Greene. He's a Corporate Fellow of Oak Ridge National Laboratory, and he's a visiting researcher at the University of California–Davis, in fact at the Institute for Transportation Studies. David's been researching transportation energy and policy for over 30 ears. He doesn't look that old. And then he's authored and co-authored more than 200 professionally reviewed papers, won awards for best papers for a number of them, and of course he's been active on the Transportation Research Board and National Research Council for over 25 years. In fact, he's been so active he's been designated a Lifetime National Associate of the National Academies. He's also been recognized for his very good work on the various versions of assessment reports by the International Intergovernmental Panel on Climate Change (IPCC). In fact the IPCC actually won a Nobel Prize and David's been part of that team. David got his B.A. and his M.A. in Geography, and then he went on to Johns Hopkins University and got his Ph.D. in Geography and Environmental Engineering in 1978. David.

Dr. Greene: Thank you, Andy. I'd like to make two points. I think that's twice as many as Bill Nordhaus made and I'll probably make them half as well. Hope so anyway.

In my talk today, the first is that there will be a transition from petroleum for the transportation sector beginning soon, and that it will be substantially underway by 2030 and 2050. I'd like to explain why that's so, and hopefully help us understand what to expect from that. The question, of course, is transition to what? And you heard a lot about the possibilities from Dr. Fulton. The second is, the first is perhaps an old insight, I would say, and the second may be a little newer and that is to look at this question of these technologies that are available to deal with climate and oil dependence problems simultaneously, and to try to look at them from the point of view of technology's not being a sure thing but uncertain in success. And if we look at them from the perspective of not being certain of success, what kind of insights can we gain about which technologies are really critical to achieving our goals, focusing on transportation but putting in the context of the entire economy.

Now, my point about oil is deletion of conventional oil outside of OPEC, outside, combined with OPEC's market power, which I'm just kind of surprised we didn't hear anything about this morning, and long-term economic interests of OPEC require a transition from conventional petroleum to something, but what? All of the possible options have risks and uncertainties, whether it's unconventional petroleum, bio fuels, hydrogen, or electricity. And you've heard something about that already. Well given that we're making this transition to something, can we also at the same time achieve our energy goals which I take to be climate protection requiring a 50 to 80 percent reduction in greenhouse gases by 2050, energy security which we must set a quantitative goal for ourselves but I'll offer one and I have a paper coming out in Energy Policy that explains where this comes from, about an 11 million barrel per day change in the U.S. petroleum supply and demand balance. That means the sum of reduced supply plus…*increased* supply plus reduced demand of about 11 million barrels a day by 2030.

And sustainable energy, well that's a whole different subject but it's nonetheless important. I would agree with Professor Morris Adelman of MIT who said that the real problem we face over oil dates from after 1970, a strong but clumsy monopoly of mostly Middle Eastern exporters operating as OPEC. It's really all about OPEC, I think. You can see in this graph that there is a difference in the world oil market before and after OPEC. It's actually a very simple theory that explains what's going on here This particular equation was developed more than 50 years ago to explain the optimal price, the profit maximizing price for partial monopolists, which the OPEC cartel is in effect a partial monopolist. The P is the profit maximizing price, C is the marginal cost of producing oil, beta is the world elasticity of oil demand, mu is the OPEC…the *rest of world* response parameter but it's related to the elasticity of supply, and S is the one factor that I put in bold here because it's the fact that OPEC has the most control over and that is their market share.

Now, a very important fact about world oil markets that's almost always overlooked in analysis of the oil dependence problem is the factor that in the short run these price elasticities of supply and demand are an order of magnitude smaller than in the long run. And this means that the profit maximizing price in the short run is much, much higher than in the long run, and it also means that the cartel can operate anywhere in that space and prices will be quite volatile. And in fact if you plot the history of the world oil market, let's see if this works, okay, in this space as a function of OPEC's market share, and this being the price of oil, we see that prior to OPEC really taking active influence in the world oil market while it is nationalizing, while it is getting organized, that world oil prices are actually below the long-run profit maximizing price for a cartel. But then with the first price shock late in 1973 and continuing into 1974, we see prices jump up above that level. And then with the Iran/Iraq war to jump up again to near the short-run profit maximizing price, and at that time OPEC made a conscious decision to try to defend that price by cutting back on oil production year after year. In fact Saudi Arabia was producing in excess of 9 million barrels a day in 1979. By the time they reached 1985 they were producing just a little bit more than 3 million barrels a day, so it was clear there was no more cutting back to be done. When they gave up and others gave up, the oil prices collapsed in 1986. Many people said well there never really was a problem, OPEC was a mirage, never accomplished anything. But of course since they have most of the world's oil, they regained market share as world oil demand grew, and here we are back again in 2008 with another oil price shock, but very short lived. So we have to understand the market that way.

Another thing that is often overlooked is that this change in the world oil market was to a large extent supported by the peaking of U.S. oil production. And I'll just say peaking. U.S. oil production peaked in 1970 and despite discoveries of new oil, despite higher oil prices, despite tremendous advances in technology, it never again reached that level. We were the largest oil producer in the world then, and since that time we became unable to respond to cut backs by the cartel by increasing production. I don't usually like to say something is alarming but I'll say here that the rate of use of conventional oil should be alarming. I will point to cumulative production of conventional oil in 1975 of 710 billion barrels. By 2005, cumulative production was 979 billion barrels. One quarter of all the oil ever produced in the history of the world was produced in that decade. The National Petroleum Council report which came out in response to the Secretary of Energy's request to look into oil peaking estimated that in the next 25 years over a trillion barrels of oil would be produced. That's more than produced throughout the history of the world, and takes us to about two-thirds of all the conventional oil believed to be ultimately recoverable. That's not proved reserves, that's ultimately recoverable. So if this happens, we're going well beyond half of all the oil, and this is why agencies like the IEA began seeing a plateau rather than a peak in non-OPEC oil production starting right about now. However, as you saw, they and others, this is a projection from the same time period by Exxon Mobil showing the same thing, a peak in non-OPEC, or a plateau in non-OPEC oil production, with the gap being filled by something they call the Call on OPEC. This is no more than an assumption that whatever difference there is between world oil demand and what the rest of the world can produce, OPEC will generously supply. They show the same thing again last year, even at much higher oil prices. The main difference being that there is a slight upward trend in this plateau and that the colors are, I think, a lot more cheerful. And still a significant call on OPEC, and an increasing use of unconventional sources.

Now I think while the IEA does a very good job of analyzing this question of oil peaking and oil plateau, which I think we here in the U.S. should emulate that modeling work that they're doing, they do not model OPEC behavior. And so you see this graph which I stole from my friend Lew showing that OPEC production dramatically increases to 2030 to supply us with what we need. Well that's not going to happen. Insights here I think originally came from Professor Dermot Gately (PHONETIC) at NYU that OPEC could make more money by leaving the oil in the ground, and this was confirmed by an analysis by the Energy Information Administration published in the *2005 Annual Energy Outlook* showing that the less cumulative production OPEC achieved through 2025 the more their revenues increased. So all of this argument essentially is to make the single point that there will be a plateau or perhaps a peak in non-OPEC oil production, and that OPEC will not generously fill in this gap as the call on OPEC goes. We will call them and say hello, OPEC, please produce some more oil for us and they'll say well they'll think about it. And they'll leave it in the ground for future generations and make more money today. That means to achieve that kind of growth that we see in Lew's projection, we are going to have to transition from petroleum to something else.

So where does that leave us? OPEC doesn't fill the gap but something else has to. Well there are plenty of unconventional sources of oil. But we all know these have problems. Higher greenhouse gas emissions, capital intensive, environmentally challenging development and all of this in an uncertain policy environment, maybe that'll change soon. How large a role can bio fuels have? Well, we have the billion ton study in the U.S. that said 30 percent can be supplied by bio fuels but now we're beginning to question that as we gain a greater understanding of what the full ramifications of bio fuel use are. And I think as Lew also showed, focusing on cellulosic ethanol for bio fuels may not make the most sense.

What about hydrogen; what about electricity? Well, there are technological breakthroughs required and new infrastructure for hydrogen. I think actually it's the cost of the vehicles rather than the cost of the infrastructure that's the big challenge, but we will see.

So, the next question, okay, what should we do about policy and about technologies, and I'm going to focus on the technology part of it, my premise being that at the end of the day the solutions for both of these problems—oil dependence and greenhouse gas emissions—of course will require strenuous policies but will also require advanced technologies. So the goal for climate protection let us take as a 60 percent reduction in carbon dioxide emissions from energy use in 2050 and for oil security I'll ask you to take on faith my goal of 11 million barrel per day change in the supply/demand balance by 2030, two different time frames. And we know that we can't do this with business as usual, as Lew has pointed out, and we also know that current technology will not get it done. Now this is a rather busy slide but I'm actually going to ask you just to accept it on faith for now; there's a report coming out that documents all these assumptions for different kinds of technologies, which there are 11 here, and they are not very much different from what you'll find in the IEA's energy technology perspectives but they differ in some respects.

For electric drive vehicles, we believe that they could displace 13 quads of petroleum but they will increase electricity demand in 2050. In transportation, reduce overall energy intensity by 35 percent. That's less than Lew said but it's across the board improvement in all modes, shipping, air, everything, reduction in energy intensity.

Then there's building efficiency, industrial efficiency and so on and so forth.

And then the final category is advanced fossil liquids. Without carbon capture and storage, this should increase carbon intensity by about 15 percent. This is a mix of increased production of conventional oil from offshore and the arctic but with environmentally responsible controls. It's increased enhanced oil recovery, it is also some coal to liquids which will be a much greater increase in carbon emissions if there's not carbon capture and storage, and a smaller increase if there is. And it's also *in situ* production of shale oil. So it includes all those things which are rather nasty potentially from an environmental perspective but do increase U.S. domestic supply of petroleum.

These same 11 advanced energy technologies could have a different impact on petroleum use in 2030. Electric drive vehicles, because it would take them a while to get started, only two and a half quads of petroleum displacement in 2030. Transportation efficiency, again across the board, in-use fleet reduction of energy intensity by 16 percent in 2030, and then advanced fossil liquids additional domestic supply.

Now all of this is relative to the 2008 frozen technology scenario of the EIA. The frozen technology scenario says that we will continue the present policies, we will deploy all of the technology we have on the shelf but nothing new, nothing advanced. So no fuel cell vehicles, none of that. Now the key issue here is which of these technologies would actually be available to use? We don't know. There's uncertainty for all of it. So what we did was to find all the possible combinations of these technologies and see which combinations actually achieved the goals. Out of 2,048 potential combinations of eleven technologies, 144 could achieve both goals. That's about 7 percent. Remember these goals are 60 percent reduction of CO2 from energy, 11 million barrel per day change in the oil supply/demand balance by 2030. And almost every successful case included a majority of the technologies. This is very much like what Lew was saying, we're going to need most of these technologies. Most of them will have to be there and have to work.

Two of those technologies appeared in every successful case. I think you can infer from that that they are essential. Those are carbon capture and storage and advanced fossil liquids. That may sound contradictory; I hope it's a novel insight. Now we could say we don't know what the probability of success of these technologies are. But what if we wanted to be 95 percent sure of achieving both goals? What does the probability have to be for each one of them? It turns out to be 60 percent. We need to be more than 50 percent sure that we can successfully develop each of these technologies. But what if we pull out one technology? What happens to our 95 percent certainty? Well of course if we pull out carbon capture and storage or advanced fossil fuels, the probability goes to zero.

But the other two that are critically important are energy efficiency. Again, no surprise. Building efficiency and transportation efficiency absolutely critical. The other ones are also important, Significant reduction in the probability of success if we lose any one of those technologies.

So, getting back to the question of an energy transition for transportation, what does this imply? Well, we need carbon capture and storage. That's for sure. Second, we need to produce more conventional oil, environmentally and responsibly, especially the enhanced oil recovery and we need to work hard to improve technologies like *in situ* shale production. We need to reduce the energy intensity of new transportation vehicles by 30 to 50 percent by 2030, that's the same as Lew said, across all modes of transport, not just light duty vehicles. We need to achieve our bio-fuel goals but with the right kinds of truly low carbon bio-fuels and for the right applications. And we will eventually need advanced energy efficient technologies as well as hydrogen fuel cell vehicles, plug-in hybrid vehicles, battery EDs, and we will need to subsidize market creation for these technologies. And by the way, the study that the National Academy of Sciences did on fuel cell and electric drive vehicles as well as a study that we did at Oakridge for the Department of Energy, indicates that the real cost of this transition is in the vehicles and the extra cost of the infrastructure is relatively small by comparison, if we achieve the technological goals. So, I hope this provides some different way of looking at this transition problem for transportation, and I thank you for your attention.

Dr. Kydes: Our next speaker is Lee Schipper. As soon as I get his slide up we'll be in business. Lee's Project Scientist at Global Metropolitan Studies at the University of California at Berkeley, and he's a Senior Research Engineer at Precourt Energy Efficiency Center at Stanford University. He has worked on transportation issues around the world with particular attention to CO2 emissions, fuel and local pollution problems issues. He's devoted his career to problems of transport energy and environment. He's also served as the Director of Research for Embark, the World Resource Institute Center at Washington, D.C., and he was a visiting scientist at the International Energy Agency and a number of firms. He's spent most of his life, it looks like, at (Lawrence Berkley Laboratory for two decades. There are too many places to list on his resume, but let me just say that he's been around. His Ph.D.'s at Berkley in Astrophysics and then his undergraduate was a related B.A. in music from Berkley in 1968. And the one thing you should all know is that he wants me to take it easy on him because today's his birthday. (APPLAUSE)

Dr. Schipper: And that wasn't trivial because Andy actually switched the sessions around so I could still get home for my birthday. Thank you. What the CD doesn't say is that I've probably been stuck in traffic in more dirty countries wedged between polluting vehicles than anybody on the speakers' platform, but I see many people from those countries who will become…who will not be named [*tape fades out*]. I'm also, if awed by the fact that two of my unknown mentors in this business, David Chien and John Conti are here, who developed and run the NEMS model, what I'm going to do is tell you a little about the headaches that relate to both what David Greene and what Lew said. I worked with Lew for a long time at the IA. I was looking for a David Greene article. He's the most cited author in my class at Stanford, i.e., there are more David Greene articles on the reading list than anybody else, including my own, which shows you what a hard act they are to follow. Jake Precourt has given a very kind donation to Stanford to establish the Energy Efficiency Institute, and when you hear our director, Jim Sweeney, whose Schwarzenegger's advisors say we need markets and prices but there are market failures. And you see all these other economists try to get off, but George Schulz is the chairman of our board and believes this too. So we're trying to do something different.

In my Berkley hat I worry about the developing countries; fortunately for them they don't have to worry about me. I'll talk a little about the traditional approach which is very much what Lew and I worked on given at the IA, say a little about some of the data nightmares, and then what I call the blind side, why this is mostly not an oil market problem, if you want to do the model of demand in transport. I was going to wave all kinds of books including the ones Lew and I wrote together. You'll see them referred to. The problem is that our modeling's taking a left turn at the second part of the network there in Bangkok. That's a symbol, emblem of what the difficulties faced us in trying to understand the future of the transport markets. And my fundamental thesis is just to say transport problem more than it's an energy problem; the transport externalities are larger and more constraining than the energy ones, including carbon, and we may well see things that we would find unbelievable, things that Mayor Bloomberg even couldn't get to happen, will be happening all the way around the world because people in Bangkok have to buy products for their cars [*tape fades out*[.

Again, CO2 is … of the CO2 emissions about 27 percent is transport, bunker fuel is in the hatched area below; China's tiny, we're not going to die because China's going to get more cars. I think that is very much blown out of proportion, but what I would do is frame the oil and CO_2 problems differently for China and the developing world than the other countries. The basic approach is multiply the carbon content of fuels times the fuel per passenger on ten kilometer times the number of kilometers in each mode, which is the S, times total activity and that gives you total emissions or total fuel use.

And there's nothing special about that, it's not a model. It just reminds you you've got to think about all these different things. And matching NEMS (David Chien's work and all the things that Lew showed, people are doing things this way, thinking bottom up. We don't always know all the data and when I challenged the Washington Council of Governments to explain how they knew that driving was down, the answer is the model says it must be down because gasoline sales are down. But gasoline sales, how do they define traffic in the D.C. area? What gasoline stations do you count? And even more fiction shows up in the pages of the *New York Times* from the Oil Pricing Information Service. We're in trouble if we really want to know what's going on in oil and energy. It's like going to the doctor and saying I really feel bad but I can only give you last week's pulse and I borrowed David Greene's temperature, can you tell me what's wrong. That's how untimely our information is.

Every once in a while we persuade Congress we have a national household travel survey. Table VM1 has come out from DOT, we're roughly four years late when we finally think we know fuel and kilometers by vehicle type. And as I asked David Chien, I really want to know how axle impressions, which is the way we count in states, get turned into distances traveled. One of David Greene's seminal papers was his paper in 76 or 77 discovering that half the states counted VMT by dividing gasoline sales by assumed miles per gallon, because units cancellation gives you miles. And I did some work in Hawaii and discovered that's how they did it in Hawaii. Okay. Why does this matter? Well, a lot of the things that we’re trying to project are based on trends, and if we have very bad data for trends, even during a period of very disruptive prices, how do they know what’s going on? And I won’t go through all of the other problems, I’ll show them to you, okay. This is what I got from the VTS Website and the Oak Ridge Book on the VMT for the four main classes of road vehicles, cars, light duty trucks, combination trucks at the bottom, and medium size trucks at the bottom. And then on the right I’ve got the fuel that they put in for all the trucks combined, almost all diesel, light trucks and cars. And either the light trucks were driving in circles but not…the kilometers weren’t being counted or something else is wrong because how could all that diesel suddenly go down and appear as gasoline?

Now other countries, France, do yearly surveying and monitoring. They have almost made…some of them have actual travel survey panels that rotate. They keep a finger on their travel pulses. It’s funny that the country that lines up the day before there’s a four-cent a gallon gasoline increase doesn’t do this, and the countries that do this, France, Sweden and the others, don’t line up at the regular 20 cents a gallon increase in the taxes at the beginning of the year. So there’s something wrong when we’re worried about something so much we don’t actually want to look at it. And when you put the miles per gallon together, the U.S. which comes from the bottom there gets ranked high with Japan and Japan starts to spurt because a third of the new cars are about the size of this podium, the U.S. miles per gallon goes up, then goes down, and it goes up.

I would want to know what the trend really was because of five years of rising oil prices. We know something about how much the fuel…test fuel the economy of new cars improved but not enough [*tape fades*] to tell us how fast we’re really going. And that blue line up there is the rough on-road equivalent of the California standard, okay. The new café standard, by the time every vehicle is affected, will be roughly 28 miles per gallon on the road [*tape fades*] which is about where Europe on the road is today. And by the way, I'm counting diesel at its energy content, not its volume metric content, okay. All those great mile per gallon figures for diesel are mostly because of the high energy content. But that's … what? That's mpg, yea. I'm sorry, it's mpg.

And Lew and David Greene talked about technology, the key thing is not which one you like but how well they really perform. Okay. I hit a squirrel driving the Ford's zero emission vehicle car, and it was the first zero emission road kill. (laughter). The figures on the left are the test CO2 emissions from new diesel cars in Europe divided by the test CO2 emissions of new gasoline cars in Europe. Almost no difference. Lew and I have a paper coming out very shortly on this. The second group of bars are the on-road diesel emissions kilometer divided by the on-road gasoline emissions kilometer. Almost no difference. The third bar is the ratio of distances travelled by the average diesel car in the stock divided by distances travelled by the average gasoline car. Now there are a lot of reasons why the differences are small. The main point is that EU said we're going to put a lot of eggs in the diesel basket [*tape fades*]. And the result was both diesel and gasoline got better. Some of that might have been people migrating from large gasoline cars to somewhat less fuel intensive larger diesel cars. But there's no big hit.

And so when we look at all these things out there—plug-in hybrids—and everybody promises a big hit, I say look before you model. We need to have better on-road experience. And there's lots more of a system nature. Bus, rapid transit, some people call me the co-father of the Mexico City system which I was the first to suggest it which is now one line carrying 330,000 people a day, another line carrying 110,000 people a day. No one told me who the co-mother was, which was interesting. These are happening all over the world. You may not think it’s a big hit, but it’s faster than cars in the major cities, that’s the trend in some congested cities, which is important, much more important is shares in other parts of the world than the U.S.

There’s the ten kilometers, and by the way we don’t know our ten kilometers, we only know a certain class of trucks in interstate travel. And we’re very deficient in understanding exactly how we utilize trucks and rail. My point here is we need to understand the system effects of these alternatives to the way we’re doing business now and put them in the models. And it’s hard to do but I think Lew referred to particularly bus rapid transit and other kinds of things. On the other hand, in the time it takes authorities to create the bus rapid transit system in Mexico City, Washington, D.C. twiddled its thumbs over whether to have a street care or a bus line on K Street, and it’s still twiddling its thumbs. So one of the dramatic things about the developing world is things are growing so fast that if a decision for change is made within ten years that change may represent half of all the activity on the road because the demand for transport is growing so rapidly.

So let’s think briefly, traffic management at Stockholm, the BRT lines in Mexico City in the Upper Right, the problem which Freud described as a disease called Prius-envy. There are fourteen Priuses, if I walk around my block and broke. In the lower right hand corner is a true flex-fuel bio fuels vehicle that I rented in Sweden and the stuff comes from Brazil, some of the ethanol comes from waste from paper plants and they’ve done the analysis of how much CO2 there is the… in the … in the boat that gets it there. But the ethanol market in Sweden collapsed this year because the price of oil fell so much.

Again, the point of these driving factors is you want to understand what are the driving factors? My point (is that most of those factors there are influenced not by technology alone but by management, by the way the system runs, lifestyles, land uses. So if our model doesn't at least realistically take into account things that are not in the history, we are not going to do a very good job of even the base case. And some of the good things—bio fuels in Sweden, road pricing, the spread of hybrids, Hanoi where there's more than one motorized two wheeler per household—maybe a two-wheeler society you may laugh on it, I did cycle here in Washington for six years . The point is maybe that combined with long distance buses and rail will be the way Asia survives. There are all kinds of things. The point is that very few of these are on our modeling or outlook computer screen because there are few data, there's little experience, and again if we wait until the things are five years old and top up, we may have missed their inception.

Also remember that Americans in urban regions move about 16,000 kilometers per capita; Americans in general move 22,000; Chinese move only 4,000. Half of them move more and half of them almost don't move at all, and all or most of that is on foot. So what we're really talking about is the mobility ladder, whether urban or national, and how fast that will climb as an increasing share of the world's population can't move. And the motorization ladder. This is again, like Lew's diagram is in GDP per capita [*tape fades*[on the horizontal axis and cars and SUVs per thousand on the vertical axis, and my point which I think Lew made was that China maps into Korea which maps into Japan, but you can't move in the major Japanese cities and can you move in the Chinese cities now at 1/30th the car ownership level of Japan, and the answer is not really in Beijing, sort of in Shanghai if you know the way to go, but increasingly Chinese cities are now getting frozen at extremely low levels of motorization. China today, the last point there is 2006. China today is where the U.S. was in 1920. What that means…in terms of cars per capita, and still only two-thirds of those are really private cars. What that means is that China can look ahead and say look where the U.S. got, are we really on this path or might we choose something different? And again, I don't make the judgment for my Chinese colleagues but when they see this graph they stop and think.

This is Mexico City, this is the metrobus I told you about, the people in the cars are really pissed off, even though their travel times have been reduced slightly because the minibuses were taken off the route, and actually bought out and melted down. And in the CO2 calculation, the energy of the melting down is included, okay. There's the rough emissions from all the traffic in the corridor, and the difference between before and after is roughly 50,000 tons of CO2, a ten percent hit. That's not a lot, that's nowhere near what the two previous speakers said we need, but it was all a co-benefit. It wasn't done for CO2, it was done to move people faster and as a result the co-benefits were very large. Now if we hybridize (the 90 originally articulated busses using the Allison Hybrid Articulated buses that Seattle has, for an additional 20-30 million dollars we could have gotten another 3,000 tons of carbon every year.

So think about that. Fifty thousand tons of carbon essentially for free with a huge positive social and economic benefit. And if we only focus on the CO2 we get 3,000 tons more of carbon at a relatively high cost. At $85 a ton, which is the not the Nordhaus but the Stern Report price that is beginning to be profitable. But my point is that most of the changes are because of transport concerns and the one should not focus too closely on carbon.

Now there's the "Mal-asia". Just quickly, we looked at two different transport scenarios for Hanoi, and the point is that the difference in the different transport scenarios gives a bigger difference in CO2 than whether we have 30 miles a gallon of cars or [*tape fades*] 27. Yes you can imagine real, real mini cars at 50 miles a gallon but in a minute I'll point out that if you [*tape fades*] take the price of a car and cut it by two thirds you probably will get an income effect of more cars more than you'll get a savings effect. The point is the transport [*tape fades*] is the key to CO2 but CO2 is not really driving the transport policy. Mobility is. So we turn the thing around. We did the same thing in China; again the paper's on the web. The point I want to make is the second scenario is an energy-efficient China car with only a 140 million cars in China but eight or nine times more than today. And that's reasonable and the technologies are there and you can get some of the cars off the oil and on CNG and lots of hybrids, but you can't move in the city unless the city spends trillions of dollars on flyovers and all the things that actually don't make people or move out. Or you can try to think of the truly urban transport oriented development in which case the cars can't be big because [*tape fades*] can't afford them. They don't need to be fast because you can't go fast, and therefore it almost doesn't matter what you power them with. And we're only talking about maybe at most a tripling of China's oil demand in 2030. In fact, as recently as 2002, the increase in oil use in the U.S. for cars and light trucks was bigger than the total China demand for cars in that year. China's increasing quickly but they're still very low.

Finally, India. I've been cited as being worried about the Nano, which I call the "NoNo". Why? Because while the picture on the left says come and get your cheap two-wheeler loan, there's no sidewalk in front of that bank. So the point is not that Indians shouldn't have cheap wheels but why should cheap wheels arrive before there are safe streets, fast and there are some disasters that occur.

The government of Pune, India, introduced a short BRT line. The opposition party promised to have people line up hand and hand over the entire 19 kilometer route to protest it. So transport is very politicized.

My point is that however you look at it, it doesn't look to me like the rate of increase in automobile use will keep up for much longer the way current trends are headed because the transport doesn't work. It's not an energy issue. These

Nanos are tested at a CO_2 emissions of 110 grams/kilometer, I don't know what the K.G. Duleep would say but I would say it's going to wind up being 40 miles a gallon on the road, which isn't bad. But if you get 40 miles a gallon on the road instead of the present 25, but to three times as many cars what happens to total consumption? It goes up. Okay. And again we get the same sorts of numbers if you really focus on transport there is only a quadrupling in Indian fuel demand instead in CO_2. Those are not irrelevant to thinking about energy markets.

And so the conclusions are in order to think about the future, put energy and carbon down. No more ener-centricity and no more carbo-centricity. Think about cities, transport, land uses, how are developing countries changing. Okay. Where are the next 500 million urbanites going to be in India, China, Vietnam, and the rest of Asia? Look at the Latin American cities which have been stuffed up until brave mayors made changes in transport patterns. And some of those mayors almost got impeached for forbidding cars from parking on the sidewalks, okay. Doesn't sound like Washington, D.C. doesn't it? What's most important?

Second private motorization…what are the kings of motorization modeling, Dermot Gately, is sitting here…you look at the curves and the numbers are very believable except the question is where are the cars going to fit, where are they going to go. And I'm not saying that Dermot's work is wrong, it's been path-breaking. The question is when we look at the base cases, or look at Lew's stuff, are we talking about nanos, hummers or two-wheelers? Where will freight go? Where will the trucks go? We've got to ask those questions because again those constraints, those externalities, are bigger than even probably $100 a barrel. And then let fuel and energy enter the picture in terms of the kinds of fuels we choose, the fuel economy, and things like that.

So I'm advocating a new framing of the energy future in transport. Think about all the factors that affect transport, not just the energy market approach.

It’s important but it’s got to be broader. Think of the energy and CO_2 savings as first the need to [*tape fades*] avoid the snarls of all the Asian, Latin American, and African cities that make Washington traffic look like…look easy.

Second, developing a way of understanding if you decide to build a transit friendly city, and there are a few, what are the co-benefits for CO_2. Singapore’s a good example. And then also, and only then, then say okay now we focus on vehicle technology, vehicle size, fuels, and what do we get? And we need to “oh, shucks, we don’t have the data”. Lew is working on it at the IEA but there are no international country-by-country data on vehicle stocks because nobody counts what’s really active. On ton kilometers, on vehicle kilometers, on passenger kilometers, things are labeled that way and all the…in India and China, those road transport kilometer data are common carrier buses. They’re not cars. They’re not two-wheelers , and there’s no urban transport. And you’ve seen great models that are modeling something that’s actually quite unimportant these days. We need to know where people are going to live and we need a better approach at estimating what the CO_2 and energy savings wind up being in real systems. Until that time I will [*tape fades*] my usual surprise, the car that not only absorbs its own CO_2 but I’ve been assured by my former roommate from my old graduate student days at Berkeley, Steve Chu, that the grass can be turned into liquid fuel for a car. So it really is a perpetual motion machine. Thank you.

Dr. Kydes: Well that was informative and entertaining, I think that was true for all three. What I’d like to do now is invite first the speakers to ask each other questions, if there are any issues that they would like to raise. No? Let’s go to the audience. And then the audience, if there are questions that the audience would like to ask simply go to one of the standing mics, tell us who you are and ask a question.

Mr. James: I have a question. My name is Bill James with JPOTS

(PHONETIC). CSX Railroad commercials note how they came move a ton of freight 423 miles on a gallon fuel. April 22, we're going to break ground on a personal rapid transport in Cupertino that moves people at 260 miles per gallon. Why are we setting café standards at 28 to 40 miles per gallon?

Unidentified Speaker (on dais): I'll take it. Do we need a car… most people travel by car.

Male: Quite a [*UNINTELLIGIBLE*]

David Greene (on dais): Well, I think until you can change that paradigm then we have to address the energy use by the vehicles that people are using. I think there are lots of issues bound up in getting people to leave their cars and travel by some other mode. In the U.S. we have so far been relatively unsuccessful at doing that and lead most of the rest of the world. Maybe two percent of our passenger travel is by transit in the U.S. And the rest of the world has seen the same kind of decreasing in general, decreasing transit ridership rather than increasing. So it's a difficult thing to do. I'm not saying that it can't be done or it shouldn't be done but in the meantime we really need to address this remaining majority of travel and how efficient that is. So that's why we have to set efficiency standards for cars. And we also have to…I mean we are doing that at levels that can be met with proven technology that essentially pays for itself in reduced fuel cost to the owner of the cost. And we can go beyond that but so far that's where we are.

Dr. Kydes: Next question. That's it? Okay.

(UNIDENTIFIED SPEAKER NOT AT MIC): [*UNINTELLIGIBLE*] form of public transportation. Morgantown [*UNINTELLIGIBLE*] has delivered 110 [*UNINTELLIGIBLE*] but it's not covered by EOE or [*UNINTELLIGIBLE*] generally looked at.

Dr. Kydes: Next question is from….

Mr. Lythman: Hi, Mike Lythman (phonetic) from GE Energy. Question for David. In your analysis where you looked at the eleven technologies and their probability of success in meeting combinations of technologies and meeting the goals in 2030 and 2050, the assessment's sort of bleak, I guess, and I'm wondering if you tested slightly later goals. Right, there's nothing magic about 2030 and 2050 particularly other than they're easy numbers to think about. And so does the success rate increase? Do we have a rosier picture if it's 2035 or 2055? And how bleak is bleak?

Mr. Greene: I did not test goals at different times. I did test possibility of different levels of success. And yea, it's pretty much what you would expect but it doesn't change the basic picture. I don't' consider that to be bleak, I consider that to be a warning to us, I guess, that we had better work very hard on these technologies, and we better get busy proving things like the carbon capture and storage. And there's really no excuse for not getting going on that stuff. That's what I think.

Mr. Lythman: Thanks.

Mr. Willingham: Michael Willingham from Virginia Tech. David, in the context of your reference to OPEC's wanting to keep the oil in the ground until sometime in the future, then you outlined a whole series of options following that, how will those options affect OPEC's future? I mean how long are they going to keep it in the ground if all these other options are implemented?

Mr. Greene: Oh, okay, well they're not going to obviously keep all of their oil in the ground, but my point is they're not going to increase it at the rate that we would like to see. They are going to increase production at a much slower rate. And well, how long will they keep it in the ground? I'm not an expert on this and there's a huge debate over how much conventional oil OPEC really has. They won't tell us so that is part of the reason why there's a huge debate. The

USGS believes, though, that they have a great deal of oil, and I guess I put most credence in their estimates. So their oil will last well beyond 2050.

Unidentified Male Speaker: One thing that I think is interesting in looking at the different scenarios and the kind of ever-increasing demand for oil, reference case scenarios where OPEC has all kinds of potential for not quite going along at unit, they just don't quite grow it fast enough, you can imagine very high oil prices. But I do think that if we were serious and got on one of these low CO2 pathways and the way the oil demand looks out to 203 and beyond in those takes so much pressure off oil demand that I wonder whether OPEC really…how much of a factor OPEC is at that point. If you actually have declining global demand for oil, what do you think that means in terms of OPEC in the equation?

David Greene: Oh, well that's…I mean that's a very favorable scenario for our oil dependence. So by and large, these two goals of protecting the climate and reducing oil dependence are synergistic. They're self-reinforcing. And there's just this one area which is the advanced fossil liquids in which there's some conflict. And one of the things I didn't discuss in great detail but comes out of the results of our study is that the conflict is actually not very great. That's why you see the two of them appearing…or you see advanced fossil liquids appearing in most of the solution sets is that it is something that can be done at the same time we meet our greenhouse gas goals.

Mr. Bloom: Hi, my name is Aaron Bloom from the FERC, and one of my questions actually pertains to an earlier question about mass transit and why it's not maybe encouraged as much or promoted. And the problem seems to be that once you get to your destination after mass transit is that it's very hard for you to do your personal transportation which could be very short-ranged. What role do you think personal transportation devices, you know like a small two-wheel vehicle, will play in the mass transit world? How can you bring it with you so that once you get to your destination you can still travel the short distance?

Lee Schipper: One of my close friends with the same first name, Leon Hamui,), is the president of BICEKETAS, the cycle NGO back in Mexico City. And you can't take bikes on their metro but you can take fold-ups. When I decided to accept the half-time job at Stanford, I go to Stanford on BART and rail, and I can get a lot of work done because it's quiet. And there is a shuttle that you can park your bike at the station. I think the fundamental point is Stanford made the decision to make the station connected. Most Americans, because thanks to the household tax deduction, have no interest in all these things because they are living out there in the suburbs. And there is no energy intensive efficient, low-capital cost solution to everybody spreading out, where most of the world lives today they're living in that…there's a problem with polluting busses, they go into people's windows. So for most of the world, the issue is not getting the transit, it's make sure that once you're on the bus it cuts through the traffic. I think what we saw last summer, all those people who have said I'll never take transit, something happened to boost the share of transit several percentage points. Could it have been higher fuel prices? Something happened even before the housing mortgage crisis, fortunately the week after we sold in Cleveland Park, to lower the values of houses in the extreme suburbs compared to the market, as we discovered it was, in the newer parts of town. So while prices won't solve…oil prices won't solve this entire land use problem, I think we were beginning to realize we were wasting so much time because of where we were that we wanted to be closer in.

Now for Chinese cities, we're talking 50 percent non-motorized transport per trip, a couple kilometers at most, 30 percent bus, 7 to 8 kilometers a trip; ten percent car now, up to 10 to 20 kilometers, and the other 10 percent is some combination of electric bike, scooter, metro in the few cities that have them. The fact that China went from zero to 100 million electric bikes in six years suggests that there are these individual solutions. And one of the pictures I didn't talk about showed where roughly 10,000 motor bikes were parked at the Bangalore Regional Bus Terminal. And I know there's an old guy there that knows who each bike belongs to. So there are interim…or the thousands of bikes parked in two layers at the Copenhagen Railway station. So the answer is there are really nice interfaces between collective transport along with the stem of the…the stem of the tree and some form of individual transport along the branches. But it takes a certain amount of organization, higher residential densities, and having had a bike stolen once from Silver Spring, it also takes a bit of faith in the system, and a really, really good bike lock. But I think those things work, you can't force them. But we were seeing them peak at the highest transit share in probably 40 years. During the…when the world came to an end last summer.

Mr. Hui: Hello, my name is Dingcha Hui (PHONETIC), and I am a Ph.D. student at Northwestern University from China. And my question is specifically for Professor Schipper. And you know a lot of things about China but I want to say that because of the city…the city system was already frozen which means traffic system was not enough for the vehicles now in China, but in the meantime actually the amount of the people for the vehicles was not only for the transport tools but also because it's a kind of symbol for people's living standard increasing, which means people have this kind of analogical demand for the vehicles. So at this situation, can you give me some your ideas on the system for development of this transportation system in China?

Mr. Schipper: I was going to wave the book that we just published with the Energy Foundation in China. I'll be happy to get you a copy. It's in Chinese and English so you can read both parts of it. The answer is in part I can't tell

China what to do. What I can do, what Lew can do and David can do is show all of our experience and say here's kind of where you're going. Now in the specific case of the three cities that I know the best, Xian, which is surrounded by a 4 meter high wall, 4 kilometers square; Shanghai and Beijing.

Let me just tell the Xian story. We did this work when I was at the World Resources Institute. We were in a room with People's committee, all the leaders of the city were in the room. Now I don't speak Chinese but Weishiuen Ng who's Singaporean did. And rarely would foreigners, Chinese speaking or else, be allowed to hear the People's committee say let's tear down the historical wall, that will solve our problems. And what ensued was a one-hour argument among the leaders of a small town of 5 million essentially saying we're not sure what the problem is, we're not sure what the solution is, they're trying to get a metro on this axis and a BRT on this axis. The traffic is so bad that literally when you get to the north gate in a car that was sent to the airport for you, you call at friend at the south gate and say you drive out so we can drive in. In other words the problem is, as you say, the car took over so rapidly without anybody who was in a senior position having any real … I grew up in LA which gives me a certain qualification…. And when we worked with the leaders they…once we translated what we meant by stable transportation got really interested. They'd never looked at time spent in travel. They'd never looked at share of income spent in travel. They'd never looked at the effect of congestion and speed on both local air pollution and fuel consumption. And because most of the elite own cars, including some of these transport modelers, it didn't seem to be an issue. And then all of a sudden in five years it has become an issue. And several Chinese cities are sort of saying we're going to stop, we're going to change. But one of the pillars of China's industrialization, as you all know, is the auto-car. And in the end, I think Secretary Clinton said it politely but pointedly, what, a month and a half ago, she didn't say don't be like us. She said don't copy all our mistakes. Now that's a loaded phrase to say that living in a suburb in a 2,000 square foot home is a mistake. But in my view, if you do the calculation for 500 million Chinese in cities in 2030 or 2040, with one car in every garage, you kind of come…actually it winds up being only 2 million barrels of oil a day more, and not that much CO2. But what our China works suggests is you don't have functioning cities, you don't have the land to make American-style suburbs, so China's heading into a real…a real…real tough almost irreversible situation.

And guess who's following right behind? India and the new Hanoi master plan begins to foresee that side of development for Hanoi, for Vietnam, and Indonesia's already a basket case in all the major cities. So I think in the end what you said about the charm of owning a private vehicle, and even two wheels, is in fact so strong that it may…people want to buy these things. Now, whether they can use them is what we need to know for our look at energy and emissions. And that's the question.

And what Singapore has decided was you can have a car, we'll auction the car, the permit costs a lot. And you pay actually by the hour. The sign tells you whether you pay a dollar to come in or four dollars to come in. And we have to pay for the scarce road space. Everybody in the state says oh my God, but the fact is where it's been tried it works. Okay. And that paradigm shift, which I think applies everywhere in the world, is going to be very, very, very difficult. But I will be you anything that either Shanghai because it's really smart, or Xian because it's really congested and has 16 discreet entrances into the wall, will be the first in China to try something like that, and then very quickly that will be part of the north of Chinese cities.

The auto lobby is fighting in Mumbai. How many have been to Mumbai? How many of you have had an easy time moving about in Mumbai? Well Dullip (phonetic) knows his way around. He knows the three-wheeler drivers. I always have two extra hours to get to the airport from the edge of Pune. And to me, I see a real crisis in mobility, but I don't know how that will play out against the point you make which is individual transport is something wants to own. And so maybe we'll reconvene in 10 years, we'll have more data points, right? And the IA will have the numbers and we'll be able to see.

Unidentified Speaker: And we'll all have canes.

Mr. Schipper: And we'll all have canes. Right.

David Greene: I just want to add that on the other side of the coin, China has started a motor fuel tax and dedicating as we do some … most of the revenue from that motor fuel tax to what…to building new highways. So they are very much following this kind of model, I think, in funding and this system because the people want the cars so much, this will send fund. The system will pay for itself if they want to build the infrastructure, to expand it. And so on and so forth. That doesn't mean that they will or won't arrive at the same exact point we arrive at, as Lee pointed out, and it doesn't mean that they should. It doesn't mean that we should keep doing what we're doing.

Mr. Schipper: But they're trying.

David Greene (Continues): But we've got to change if we're not going to go that way.

Unidentified Speaker: And they're also building…they're going to have 12,000 kilometers of high speed rail in China by 2020 which will make it more high speed rail than the rest of the world combined. So they're doing a lot of things, they're doing a lot.

Mr. Hui: But I come from a city of Xi'an.

Mr. Schipper: Oh, my God! The terra cotta warrior. We'll talk afterwards, thank you.

Mr. Hui: Okay.

Mr. Schipper: [something in Chinese].

Dr. Kydes: This has been a very interesting session for you [the audience] because of your interest in staying and asking the questions and hearing discussions, but I've already taken 25 minutes from your lunch period, and I think it's only fair to close the session with an applause for the speakers.

Unidentified Male Speaker: Thank you.

Dr. Kydes: Thank you very much. I appreciate it, you've done a great job.

Unidentified Male Speaker (Continues): My pleasure.

Dr. Kydes: It's very helpful.

Unidentified Male Speaker (Continues): Fun to be on a panel with these two guys.

END OF SESSION.