Transportation Energy and Environmental Policy for the 21st Century

August 24-27, 1999
Asilomar Conference Center
Monterey, California

UCD-ITS-RR-99-23

Edited by:
Richard Counts
Graduate Research Assistant, ITS-Davis

Sponsors:
U.S. Department of Energy, Office of Transportation Technologies
U.S. EPA, Office of Mobile Sources
The Energy Foundation
University of California Transportation Center
Toyota Motor Sales, U.S.A. Inc.

With support from:
American Council for an Energy Efficient Economy
Argonne National Laboratory
Oak Ridge National Laboratory

Host
Institute of Transportation Studies, UC Davis

Steering Committee

Jeff Alson, John DeCicco, Mark Delucchi, David Greene, Larry Johnson, Barry McNutt, Phil Patterson, Danilo Santini, Dan Sperling, Tom Turrentine

CONFERENCE SUMMARY
TABLE OF CONTENTS

Ferdinand Panik, DaimlerChrysler
The Fuel Cell – A Powertrain Stretched between the IC-Engine and Alternative Forms of Energy

Jim Patten, Cummins Diesel
Prospects and Fuel Requirements for Diesel Exhaust

Andrew Burke, ITS – UC Davis
Ultra-Clean Vehicles: Technology Options and Policy Considerations

Session III Policy Implications of Transportation Pathways

Chair: Dan Santini, Argonne National Laboratory

Speakers:

Steve Gougen, Department of Energy
Transportation Fuel Pathways: A Potential Future Scenario

Jason Mark, Union of Concerned Scientists
Environmental and Economic Analysis of Transportation Fuel Pathways: Overview of Issues and Results, and Discussion of Policy Implications

Lew Fulton, Energy and Environmental Analysis, Inc.
Lifecycle Analysis Versus the Kyoto/IPCC Accounting Framework: Overview of Issues and Results, and Discussion of Policy Implications

Session IV Environmental Policy and Technology Change

Introductory Speaker: Mike Walsh, Editor of Car Lines and Consultant
Global Trends in Motor Vehicle Pollution Control – Into the New Millennium

Chair: David Greene, Oak Ridge National Laboratory

Speakers:

Steve Plotkin, Argonne National Laboratory
Policy and Technology Change, Lessons from the Clean Energy Future

Craig Marks, University of Michigan
PNGV – A Government-Industry Partnership Experiment

Tom Wenzel, Lawrence Berkeley National Lab

The (Unexpected) Success of Emissions Regulations in Advancing Vehicle Technology

Paul Leiby, Oak Ridge National Laboratory
Policy and Technology Transitions

Alex Farrell, Carnegie Mellon
Historical Patterns in the Science, Engineering and Policy of Vehicle Emissions

Session V How to Market Clean and Efficient Vehicles

Chair: Tom Turrentine, ITS-Davis

Speakers:

Ben Knight, Honda Motor Company
Short and Long Term Approaches: Striking a Balance

Kenneth Kurani, ITS-Davis
Social Marketing of Clean, Safe and Efficient Vehicles in America Thus Far

Session VI Idea Development for Programs, Research, and Policy Break Out Sessions

Moderator: Barry McNutt

The conference participants separated into five sub-groups of their own choosing, after which the following summaries of these break-out discussions were presented to the conference at-large:

Break-Out Groups and Summaries:

Group 1: Theme: Modeling Gaps in the Transportation Community and the Need for More Data Types

Group 2: New Fuel Economy Standards (revisions to CAFE)

Group 3: Public Education

Group 4: Political Atmosphere and How it Affects the Regional Environmental Movement

Group 5: Hybrids, from 2000-2020

.

<u>Session VII Toward a Sustainable Transportation Future</u>

Chair: John DeCicco, Environmental Protection Agency

Speakers:

Chris Grundler, Environmental Protection Agency
Michael Love, Toyota Motor Sales, USA, Inc.
David Hawkins, Natural Resources Defense Council
David Rodgers, Department of Energy

The theme of this section was for the speakers to discuss the results of the conference and make their case for the next century, with specific regard to two matters: a) What are the policy steps that will guide us to a sustainable future?; and, b) How do we foster the progress we have seen in the last decade and keep pace with the growth of transportation demands?

Session I Lessons Learned: Lessons from 30 Years of Automotive Energy and Air Quality Policy: An Interactive Round Table

Introductory Speaker: Phil Patterson, Department of Energy

Chair: Jeff Alson, Environmental Protection Agency

Round Table Participants:

Linda Lance, White House Council on Environmental Quality
Kelly Brown, Ford Motor Company
David Hawkins, National Resource Defense Council
Clarence Ditlow, Center for Auto Safety
Greg Dana, Association of International Automobile Manufacturers

Introductory Speaker: Phil Patterson, DEPARTMENT OF ENERGY
The Transportation Energy Future is Uncertain: But It Is BIG

Two important trends are going to determine the amount of transportation demand growth that the world will experience in the future: population and GDP growth. The current world population of around 6 billion is projected to reach 9 billion by the year 2050 with the rate of such growth eventually slowing down over time. Perhaps surprisingly, the world's largest energy user, the United States, comprises only 5% of the world's population, and that small proportion will decrease in the years ahead. At the same time that the US population will be growing at a slower rate than that of the rest of the world, the average, projected world GDP growth rate of 3.2% will exceed that of the US at 2.8%. More than any other single factor, actual GDP rates will determine the amount of increases in transportation demand in the decades ahead for the world. What is more, since the growth rate of world GDP is slated to catch up with that of world population growth over the next 50 years, the world GDP/capita in 2050 will equal that of the US in 1965. One can imagine that the magnitude of the transportation needs and demands of 9 billion people living at US 1965 levels of income will be very large.

While there are different scenarios that are projected for what actual relationship the increases in GDP/capita will have on the increases in world vehicle demand, we can predict a range for the world's total vehicle population in 2050 of 3 to 4.5 billion (as compared to .8 billion today). The difference between these two projections is that if the world tends to follow a US model in terms of vehicle demand growth as a function of GDP/capita, then the world could very well end up with a similar vehicle ownership rate as the US had in 1970 for a world total of 4.5 billion vehicles. By contrast, if the world follows a more European model in this regard, this could result in 1.5 billion fewer cars by 2050 or a 1955 US ownership rate with a lesser total of 3 billion vehicles.

In parallel with the above projections, it is also predicted that the world's oil use will more than double in the next 50 years. If so, then half of the world's total oil reserves will likely be depleted in about 30 years. Theory holds that after half of a resource is consumed, its price will continue to rise thereafter if the demand for that resource continues. As a result, we can project a continued rise in world oil prices after the year 2028, and this is based on oil reserve estimates that are higher than many of those in the literature. Yet, even in the face of these projections for oil reserve depletion and rising prices in the decades ahead, the fact still remains that the total amount of oil that has been used to date is only a small fraction of all the world's various fossil fuel reserves. These various reserves include in addition to conventional oil, unconventional oil, conventional and non-conventional NG, and coal. The reserves of dirtiest of these fossil fuels, coal, is equivalent to more than 50 times the total number of barrels of oil that the world has consumed so far. The bottom line is that world is not going to be running out of fossil fuels for a very, very long time.

Another reason for us to be wary of our continued use and dependence upon oil and fossil fuels has to do with the substantial costs that the U.S. incurs to ensure that its supply of oil does not threaten its national security interests. For example, the Strategic Petroleum Reserve Program has cost the U.S. $38 billion since 1976. What is more, our military expenditures spent in relation to defending our oil supplies in the Middle East (i.e., the Gulf War, et. al.) are estimated at $32 billion per year. The latter figure translates into about 12 cents on every gallon of gasoline purchased in the U.S. To say the least, part of the price of today's "cheap" gas prices are these large, unperceived and largely unpublicized subsidies of the oil industry.

While OPEC was able to create the infamous oil and gas shortage of 1973 which rocked the U.S. energy stage, people often say that today OPEC is, by comparison, powerless to create such an energy crisis again. However, there is good evidence to suggest that OPEC is still a power to be reckoned with. The EIA has concluded, for example, that OPEC's actions have increased world oil prices by 50% over the last 8 months alone, and, that OPEC has pledged to reduce production by 1.7 mbpd. What is more, the non-OPEC countries of Russia, Norway, Mexico and Oman have also pledged to cut production by an additional 0.4 mbpd. This total of 2.1 mbpd represents 3% of the total world oil production.

EIA also did a study in 1999 to project the prices that OPEC will demand for oil in the future. In essence, it will make good business sense for OPEC to sell less of its oil than it can, albeit for a higher price, so that it can actually make more money while keeping more of its oil in the ground as reserves. The gist of this prediction is that it will be in OPEC's reasonable business interests in the future to put a squeeze on supply in order to increase their profits, raise their prices, and prolong the life of their reserves. The only conceivable aspect that could challenge this business model might be if cost competitive alternatives to conventional oil could help keep oil prices down.

The most likely next alternative to conventional oil will be natural gas (NG). A concern with this alternative energy source, however, is that NG reserves are mainly in Russia and the Middle East, so NG does not appear to offer much energy security advantages over oil. So, while only 50% of our current oil use is from imported sources, increased future imports of natural gas might have to come from these imported sources to an even greater degree than our current oil purchases do.

Turning to the topic of greenhouse gases and global warming, the evidence to date indicates that atmospheric CO2 levels have risen since the pre-industrial age from 280 ppmv to 360 ppmv. Further, the global mean temperature is said to have risen 0.3-0.6 °C (0.5-1.0° F) and the sea level has risen 10-25 cm (4-9.9 inches). To put these kinds of changes into a geological perspective, the global mean temperature difference between normal and ice age eras is about 5 – 6°C. If we continue on our present path of energy use for the next century, it is uncertain what the effects will be on the world's conditions. Some of the worst projections indicate that by 2100 the global mean temperature could increase by over 5 °C and the world's oceans could rise a full meter.

A phone survey conducted by the Opinion Research Corp in 1999 contacted over one thousand people and asked them to rank the following transportation problems in order of importance for the U.S. in the year 2020: traffic congestion, deaths and serious injuries in vehicle accidents, availability and/or price of gasoline, local air pollution from vehicles, and global warming or climate change caused by vehicles. Not surprisingly, congestion was the highest ranked concern overall with climate change last. However, it was encouraging to see that all of these factors, including climate change, were at least recognized as a major problem in the future. On another positive note, the poll indicated that the second greatest concern to people was local air pollution.

Addressing the popular issue of congestion, it is evident that many of the perceived solutions to this problem, such as building more roads and further de-concentrating land use, will generate even more energy use and thus exacerbate the other projected problems of local pollution and climate change. Another such clash of values is that some people seek to buy larger (and thus less efficient) vehicles in order to enhance their driving safety, and this is actually becoming a rather common practice today. On a positive note, however, with regard to local air pollution, there are strong incentives to improve this problem and our vehicles and fuels have been getting cleaner.

If the US is going to meet the Kyoto Protocol goals of a 7% reduction in its 1990 levels of GHG emissions, then we are going to have to make substantial reductions in the emissions from both light vehicles and air travel sources between now and 2020. However, at the present rate of increased emissions from these sources, we are not going to be able to meet this goal. Three ways that we can reduce the demand for travel are: a) population concentration; b) mass transit; and c) tele-everything. But there are problems with trying to reduce demand in these ways. A recent survey showed that people strongly prefer to purchase larger, detached homes in suburban areas that require longer commutes, rather than buy smaller townhouses for the same price which are located close to work, shopping and public transport. What is more, people tend to generally think that in the last century, the automobile, highways, and suburban growth have all been good things for society.

The idea of reducing our energy consumption by shifting toward mass transit is no longer valid in most cases. The reason is that while autos and aircraft have become increasingly more efficient over the last 25 years, mass transit has, in most case, become less efficient. Lastly, it appears that very little overall gains could be achieved toward the reduction of VMT even if we could get people to conduct more of their business and personal affairs via the internet or phone.

One of the solutions that is often touted for our energy efficiency problems is the increased used of diesel vehicles. In that regard, surveys indicate that only about 17% of vehicle buyers would be willing to spend an additional $1,000 for a diesel engine that improves their fuel economy by 50% and is equally as clean, powerful, odorless, and smooth running as a gasoline engine. The top three reasons why people tend not to like diesel vehicles are noise, fuel availability and odor, while a much smaller percentage of people expressed air pollution as a reason for their dislike. The latest in diesel technology, however, has solved several of these problems. By comparison, when people were asked about their interests and preferences for hybrid vehicles, they seem to prefer a hybrid to a diesel, and, they also indicated a preference for a cheaper, charge sustaining hybrid model.

Another way that we can reduce our oil use and carbon emissions is through the use of alternative fuels. One alternative is to produce Fischer-Tropsch (FT) diesel, but the disadvantage of this option is that it is likely to be produced from cheap natural gas and will be mostly imported. It is also high in carbon content. Ethanol, by contrast, has a comparatively low carbon content, but its ability to act as a substitute for a large fraction of transportation oil use will be limited by the land requirements needed to grow the necessary biomass crops. Hydrogen, in turn, would require a cheap and renewable means of producing electricity in order for it to be become a viable alternative to oil.

If we compare the various policies that have been utilized to date with the aim of reducing our oil use and carbon emissions, CAFE, or another new fuel economy standard, will likely be the most effective policy, and this policy also has had very high public acceptance. Also, while light truck gas guzzler taxes have not yet been tried, this policy could prove very effective as well. When people were asked what type of tax they would prefer if the national government determined that it was important to reduce GHG emissions from vehicles, 17% preferred a 25 cent/gallon gasoline tax while 70% opted for a 3% tax on new vehicles. Americans are obviously fairly strongly opposed to gasoline taxes, even though both of these tax schemes would raise about the same amount of revenue.

Closing Points

a) The demand for transportation will continue to grow at a strong pace.
b) While fossil fuels are abundant, the most cost effective substitutes for conventional oil (FT diesel or methanol) pose similar problems for national energy security and are also high in carbon content.
c) The solutions to the some of the most serious, perceived problems with transportation, such as building more highways to reduce congestion, are likely to only increase both our energy use and emissions.
d) Although conventional oil production will not likely peak for another 20-40 years, price shocks and associated economic losses will continue to be a threat.
e) While it is unclear what the exact or actual impacts will be from global warming, its economic and environmental damages could be significant.
f) If we are concerned with the transportation sector’s impact on GHGs, then we need to start acting now.
g) To act effectively in that regard, consumer/public preferences for advanced technologies and environmental policies will have to change.

h) Without a change in consumer/public tastes, we can anticipate an increasing demand for larger and more powerful vehicles which will only increase the transportation sector's contribution to global warming.

Round table Discussion:

Session Chair Jeff Alson began the Session by explaining that the purpose of the round table discussion was to look back over the last 30 years on the debates and decisions that have been made regarding air quality, tailpipe emissions, vehicle fuel economy, alternative fuels, and motor fuel taxation with the idea that these lessons of the past may be able to assist us in the future. After an overhead slide was presented which outlined and highlighted some of these aspects from the last three decades, each of the round table participants made their initial statements as follows:

Linda Lance stressed that regulation of the auto industry to encourage better fuel economy and lower emissions is necessary in order to level the playing field among the manufactures. At the same time, she noted that regulation by itself is not sufficient to accomplish the goal of developing cleaner, more efficient transportation. The policy issues involved in this area are very emotional and are some of the hardest policy nuts to crack. Part of the difficulty in this process is a lack of effective communication and coordination between the regulators and the private industry, which include the auto makers, energy providers, and environmental groups. For this reason, she thinks that dialogue among these entities is tremendously important.

In her experience, there are only two ways to make any headway on a difficult issue like this: either the private industry must be strongly committed to the changes desired, and/or the public must demand it. In this case, we have the problem that private industry is not pushing for greener cars. At the same time, while the public wants clean air, they do not care about fuel economy because they do not see the connection between the two. With this in mind, the best way for us to move forward is to determine how money can best be spent to most effectively educate the public about clean air and fuel economy issues and policy implications. She also indicated that there is a need to maintain communication between the technical analysts and the policy makers.

Kelly Brown began his discussion by explaining that he didn't get into the automotive business by accident – he loves cars and he always knew that he wanted to work in the auto industry. Over the years he also became interested in environmental matters and he decided to merge his two interests in his career at Ford. One of the important lessons he has learned is that environmental issues tend to be run by lawyers, and, that lawyers and engineers, such as himself, do not think alike, nor do they address environmental issues in the same way. Historically, the environmental debate was a hostile topic both inside and outside the company and there was resentment between automakers and environmental regulators. In the last five years, however, he has seen a significant change in this regard such that automakers and the public have both become more aware of environmental transportation issues with the result that the industry has begun to implement changes to address these concerns. The most effective way to address transportation environmental issues is to foster cooperation and avoid battles between private industry and the regulators. The industry is now faced with the challenge of determining how to respond to the public's environmental concerns while at the same time accommodating the increased demand for SUVs and light trucks.

David Hawkins agreed with Kelly Brown's remarks that the issues in this arena are more ones of policy than technology. He thinks that we need to first set our policy targets and then figure out how technology can meet those standards. In that regard, he thinks that technology forcing policy standards have been very effective in the past, but getting such policies in place has been very difficult. However, he doesn't think that we have set the right policy targets yet in order to establish the environmental standards that we need. The regulatory areas where there has been the least amount of success involve policies which improve or rationalize automobile use, and traffic congestion is the symptom of our failure in that area. By way of a failed regulatory attempt, he recalled that in 1973, EPA adopted regulations which would have imposed parking surcharges in the 13 largest cities of the U.S, the proceeds of which would have been used for transit improvements. It only took Congress six weeks, however, to repeal those regulations by federal statute.

Recently, we have been faced with new issues involving diesel and fuel economy which need to be confronted. He acknowledged that fuel economy policies are difficult to pass because they lack public and therefore political support. However, he also thought that the continued message from the environmental community that climate change is an air pollution problem, combined with better cooperation between business and environmentalists, would help to solve these problems.

Greg Dana explained that he will begin his new position with the Alliance of Automobile Manufacturers soon and that his environmental career began with EPA in the 1970's. He recounted that the whole concern over transportation air pollution and air quality perhaps started when an LA city councilman began writing letters to the auto industry in the 1950's to inform them that there was an air pollution problem being created by cars. Nearly 12 years later in 1966, the first emissions standards were finally passed to address this once denied problem.

He disagreed with Linda Lance in that he doesn't think the public is aware of how much cars have changed or how much their emissions technology has improved. In fact, he thinks that one of the problems that the industry faces is that most of its consumers don't know anything more about their cars then where to put the key.

Mr. Dana thinks that private industry is more concerned with transportation environmental issues now, and he thinks that there have been two policy areas which have not worked very well. For one, in 1990 the California Air Resources Board (CARB) set a zero emissions vehicle standard for 1998 only to be repealed essentially in 1996 when it became evident that the battery electric technology just wasn't available yet to meet those regulatory demands. Secondly, while CAFE had a significant positive impact in the beginning, it did not have the impact that it could or should have had because it doesn't make the consumer part of the regulatory equation. While consumers may have had an interest in fuel economy when CAFÉ first went into effect at the time of the '70's oil crisis, the fact is that today's consumers are not interested in fuel economy – rather, they want SUVs and trucks. As a result, there is now a disconnect between the consumer and the policy goals that CAFÉ was intended to promote. The solution he proposes, and which would get consumers involved in fuel efficiency goals, is to impose a gradual increase in the gasoline tax. By this means, the public will be involved in our fuel efficiency policies. By contrast, today it is just too inexpensive to drive for consumers to care about such issues.

Clarence Ditlow said that there are five things that he has learned from the past: 1) Money counts, so the support of big business is important; 2) A crisis helps, such that things like oil shocks tend to raise awareness and mobilize players; 3) It takes a law – change wont happen voluntarily and legislation is therefore absolutely necessary; 4) Knowledge enables – thus, information needs to be made available to the public, policymakers, and others involved; and 5) How bad does it have to be in order for people to act? This isn't clear, but since projections of future detriment are often inaccurate, they should be used with caution.

He further stressed that regulation works. He cited the example of how the auto industry mobilized a multi-million dollar campaign to pass state seat belt laws when they were strongly encouraged to do so by federal law and regulation. In that case, and in line with the above points, a law started the process and the determination and dedication of big business made it happen. In the same way, if we want to get gasoline taxes imposed, then the auto industry has to be interested in achieving that goal. He also thinks that the more the public knows, the better the decisions that will be made.

Lastly, concerning "how bad does it have to get", he recalled that in 1974, people were talking about buying two 1974 cars because they thought the 1975 cars would be so bad as a result of the regulations being imposed. Then, when it turned out that the new cars weren't so bad after all, the auto industry officials, which had so vehemently opposed the new regulations, had to later retract from their prior admonitions of the gloom and doom that the new regulations would wreak upon the industry.

After the participants made their above initial statements, the Session became an interactive discussion among the five participants, which discussions are summarized below:

Kelly Brown made the point that there is a distinct technical difference between controlling emissions and fuel economy since the former does not impact the operation of the vehicle while the latter does. He recalled that in the mid '80's when emissions standards were essentially stable, the auto industry flew through technological innovations such that drivability came back while emissions were lowered. The weight of cars was significantly reduced as well. In some cases, a full 1,000 lbs. was reduced from some of the full size cars and most consumers didn't even notice. Weight reduction was a very effective means of increasing fuel economy without any negative impact on performance or operation. However, when the industry tried to improve fuel economy further, that did affect vehicle operation and performance and the public reacted negatively. The result was that people switched to vans and trucks to become the station wagons of the '80's. He concluded by saying that there is a disconnect in fuel economy laws when they force automakers to give customers product features which don't mean anything to them. This results in CAFÉ standards coming between the automakers and consumers.

Linda Lance thought that some important questions regarding emissions and CAFÉ standards needed to be answered before any new legislation is developed or enacted, namely: Was it necessary to push the auto industry on emissions and CAFÉ ? Was that push beneficial? Where would we be today if we hadn't made that push? And, are there fuel economy standards that can be developed which make sense for both the industry and society?

Kelly Brown responded that if vehicles are only made more efficient without also increasing the price of gas, then people will just drive more. Greg Dana agreed and said that to really make a difference, we need to increase the cost of driving at the same time that we increase the fuel economy of vehicles.

Some discussion followed on the question of whether different vehicle types could be made more efficient, and whether public education about fuel economy and efficiency can change consumer choices. This led to comments by David Hawkins that the only way that any gas tax could ever get imposed would be as a result of a public education campaign designed and funded by environmental groups, energy advocates, and automakers alike. To date, automakers have often verbally supported gas taxes, but then they fail to support those words with actions. He thought it is time for the auto industry to be held accountable for their verbal support.

> *Editor's note: To date, the auto companies have said that they would prefer a gasoline tax to CAFE.*

Clarence Ditlow responded that automakers have not dedicated sufficient resources to promoting fuel economy and increased gas taxes. This dedication is necessary in order to create public demand for more fuel efficient vehicles since without such public demand, regulation can not be successful. Further, the technology is available, but it is simply not being used by the industry. The discussion then recognized that the two major problems in trying to promote better fuel economy is that the oil industry is opposed to such change and there is no powerful lobbying force to support gas taxes. On the subject of trucks and SUVs, the question was posed whether it is possible to technologically accommodate consumers' desires for such larger vehicles and still increase fuel economy.

The idea of a gas guzzler tax on SUVs and trucks was raised to help shift consumer demand by making consumers more aware of cleaner alternatives. It was stated that such a tax would have to be enormous to be effective in that regard.

David Hawkins then raised the point that the environmental community and energy advocates are very disappointed in the Partnership for a New Generation of Vehicles (PNGV) because they feel it was a way for the administration to stall on automotive environmental issues. He then asked, if nothing does come of PNGV, will there be any adverse consequences? Kelly Brown responded to this by saying that PNGV has been very effective at encouraging efficient diesel technologies. But, he added that no matter how clean and efficient such technologies become, he didn't think that diesel would ever be given a chance since diesel is being ruled out by the regulators. David Hawkins said the reality was that diesel technology has been very dirty in the past and the public is aware of this.

Kelly Brown suggested that a cooperative effort needs to be made to better understand the total “footprint” that a vehicle leaves throughout its lifetime including the recycling of materials, waste, etc, and not only emissions and fuel economy.

Linda Lance commented that under PNGV, non-diesel technologies have also seen progress so it has not been a waste of time. One important establishment of PNGV has been the cooperative effort that it has created between government, industry and others.

The question was then posed from the audience as to whether CAFÉ could be more effective if its standards were well thought out and better designed. Greg Dana replied that such an idea sounds good but that it is extremely difficult to develop a strategy that is supported by all of the major forces involved.

The audience then asked why PNGV has not brought new technologies to the market and Kelly Brown responded that fuel cells and advanced diesel technologies have resulted from the Partnership.

A member of the audience then stated that the public perception of a gas tax without any improvement in fuel economy results in consumers getting less for their money. It was asked if this perception could be changed if a combination of taxes and increased fuel economy are delivered together. Greg Dana replied that it would depend on what part of the public we are talking about. For example, he thought that rural residents, such as farmers, would not really benefit from an increase in fuel economy so changing their perception in this regard might be very difficult. Linda Lance added that it greatly depends on where the gas tax revenue goes. To gain support for such a tax, we need to make it very clear where the revenue will be allocated because people don’t feel the direct benefits of such a tax.

In closing, Dan Sperling said that it appears that we need a different approach from a flat gas tax; perhaps we need to consider more innovative transportation strategies like car sharing.

Session II Technology Choices for the Next Century

Chair: Dan Sperling, ITS-Davis

Speakers:

Alan Lloyd, CARB
Transportation Energy and Environmental Policy for the 21st Century

Ferdinand Panik, DaimlerChrysler
The Fuel Cell – A Powertrain Stretched between the IC-Engine and Alternative Forms of Energy

Jim Patten, Cummins Diesel
Prospects and Fuel Requirements for Diesel Exhaust

Andrew Burke, ITS – UC Davis
Ultra-Clean Vehicles: Technology Options and Policy Considerations

Chair: Dr. Dan Sperling

Dr. Sperling noted that in the morning round table Session, the participants had discussed the lessons that could be learned from the past with regard to the problems and issues that we will be facing the transportation field in the future. With those insights from the past in mind, Session II will focus not only on the transportation technologies that lie ahead in the next decades, but also, on the very complex choices that will have to be addressed to bring those new technologies to fruition. These complex choices will involve a multitude of inter-related factors and facets, which include matters such as cost, preferred attributes, what people desire and how they value their desires, as well as the applicable rules and laws.

Speakers:

Dr. Alan Lloyd, California Air Resources Board (CARB)
Transportation Energy and Environmental Policy for the 21st Century

Dr. Lloyd began his talk like many others during the Asilomar conference by noting that he was speaking as an individual and not on behalf of CARB. After explaining that it was CARB's role to protect public health, he observed that there had been talk in the morning round table Session about how the price of gasoline can effect VMT. Since California had recently experienced some gasoline price increases, he thought it would be interesting to see if there had been any corresponding impact on VMT, although he predicted that any such impact would be small.

One of CARB's main goals has been, and continues to be, encouraging advanced vehicle technology and clean fuels. Statistically, the bad news is that vehicle miles traveled (VMT) in California have been increasing since 1980 at almost twice the rate of population growth; but the good news is that peak ozone levels have decreased in that same period by 49%. While the success of the latter was largely the result of regulations which were needed to push the auto manufacturers, California still has the highest ozone and particulate levels in the U.S. In fact, 90% of Californians currently breath polluted air and the Los Angeles area will not be able to attain federal air quality standards until 2010 or later.

> *Editor's Note: Since the conference, California lost this distinction to Texas when Houston became the worst location in the U.S. for ozone levels.*

There have been some recent changes in California's emissions model which now take into account some additional factors such as speed corrections, idle rates, off cycle NOx, and evaporative emissions. By taking all of these new aspects into account, the new model reports that emissions are much higher than was measured by the prior model. However, part of this apparent change for the worse can be explained by the fact that the new model is measuring sources of emissions which were present but not measured in the earlier model.

One of the main sources of California's particulate matter emissions is diesel engines – primarily those in heavy duty applications. In addition, CARB has formally identified diesel particulate exhaust as a toxic air contaminant. To protect public health, these emissions need to be reduced as much as possible. For a host of reasons, diesel will remain a mainstream fuel in California. Ultra low sulfur diesel would improve these problems and should be required in the future, along with diesel aftertreatment technology.

The changes that are needed to help improve California's air quality are several, and they include: a) trucks, mini-vans and SUVs will have to meet the same regulations as cars; b) near zero evaporative emissions standards; c) the ZEV mandate for 2003; d) cleaner exhaust-emission standards from 1994-2010; and, e) cleaner burning gasoline.

With regard to ZEVs, battery powered electric vehicles remain an important and viable technology~~,~~ in the near term. Direct hydrogen fuel cell vehicles (FCVs) are also an important new technology for the CARB ZEV mandate and should help auto manufacturers comply in future years. Research is currently being conducted as well in zero emission technologies for stationary applications, such as fuel cells, that could tie-in to the hydrogen generation for ZEVs. In conjunction with these zero emission technology goals, work is also currently underway for near-zero emission vehicles which include hybrid electric vehicles; direct methanol, ethanol and gasoline fuel cell vehicles;~~,~~ as well as advanced internal combustion engines. One of the keys to these technological innovations for lower emitting vehicles is cleaner fuels and to develop and investigate a wide variety of technologies.

One of the most exciting developments in California's drive toward ZEVs is the recent announcement of the California Fuel Cell Partnership between CARB, CEC, Ballard Power Systems, Ford, DaimlerChrysler, ARCO, Shell and Texaco.* The purpose of the Partnership is to operate bus and passenger car fleets to demonstrate the viability of this form of transportation technology and the new fuel infrastructure it will require. It will also serve to identify and remove any barriers to the commercialization of this promising new technology. Most of all, Dr. Lloyd recognized the value and the need of these private sector and government entities to work together on this project to ensure its success, including building personal relationships between these diverse partners.

**Subsequent to Dr. Lloyd's address, VW and Honda also joined the California Fuel Cell Partnership.*

After discussing the Partnership, Dr. Lloyd turned his discussion toward the emissions problems of heavy duty gasoline and diesel trucks. Specifically, heavy duty diesel trucks have shown a decrease in their levels of HC and CO, while NOx and PM levels have been increasing. Part of the problem of effectively regulating heavy duty emissions in the past has been standards and test procedures developed from unrealistic driving cycle assumptions. That causes emission control systems to be designed inappropriately. In addition, some trucks have been found to violate test procedures on the road, leading to even greater NOx emissions. In the future, these regulations can be improved by taking a more realistic account of actual heavy duty driving behaviors and other factors such as degradation and increased vehicle longevity. There is a need in the future to reduce our risk exposure to diesel particulates while retaining diesel as a continuing fuel option for commercial applications. The best way to address both of these concerns will be to require the lowest possible levels of sulfur in diesel. That will accomplish immediate emission reductions from the existing fleets and enable advanced aftertreatment technologies for new vehicles. Other technological solutions on the horizon for commercial applications include natural gas, hybrid trucks, and even fuel cell buses. In that regard, CARB is currently working on a possible ZEV mandate for buses.

In summary, while there have been some significant improvement in emissions to date, more improvements are needed from vehicles since the health risks to the public continue to be significant in both urban and rural settings. In this regard, we must address the health risks that are currently posed by the use of diesel fuel. Lloyd asserted that we *can* solve that problem. He is particularly excited about fuel cell technology because of its flexibility in fuels and its potential for ZEVs or near ZEVs. He is eagerly awaiting the fuel cell technological developments of the future, but stressed that the main challenges will likely be cost reduction and other needed changes to assist consumer purchases of this technology. Lastly, in the new millennium, we will also have to address the issue of how to accommodate the growth of the expanding air transport industry in a way that controls the emissions of this burgeoning form of transportation.

Ferdinand Panik, DaimlerChrysler
The Fuel Cell – A Powertrain Stretched between the IC-Engine and Alternative Forms of Energy

Dr. Panik centered his presentation around a catchy and astute aphorism to explain how the fuel cell could replace the current, conventional technology of the ICE: "The Stone Age didn't end because they ran out of stones; they found a superior technology". Perhaps a pun laden corollary to this could be, "The ICE age will not end when we run out of ICEs". Dr. Panik's discussion elaborated on this theme by drawing an analogy between other forms of technological advancement and revolutions which have transpired to date and the technological revolution that could be projected for fuel cells. By way of specific example, he showed that computer power technology evolved from room size, main frame computers to hand held laptops, and in so doing completely changed the role of computers in peoples lives and in business. In an equally profound way, he asserted that fuel cells have the same potential to revolutionize our living and working conditions.

The challenge for this revolution now lies in replacing the old technology of ICEs with the new technology of fuel cells. In fuel cells' favor, fuel cells are a superior form of technology in that they can be more efficient than ICEs. Specifically, he indicated that fuel cells can operate at efficiencies as high as 48% for direct hydrogen and 37% for methanol. The problem, however, is that the old technology of ICEs is very stable, and it is very difficult to produce change out of such a stable situation.

Dr. Panik pointed out that in addition to the fact the fuel cells are more efficient and are technologically superior to ICEs, they offer other advantages as well over conventional technology. For one, fuel cells encourage the use of renewable energy sources which coincides with the de-carbonization of the world's fuel base and thereby helps to avoid the approaching gap between fossil energy supply and total energy demand. Second, fuel cells offer drivers the superior comforts of electric drive vehicles such as reduced noise levels.

The main obstacles to making the jump from the ICE age to the fuel cell age are technical and economic feasibility. However, the concept cars and test vehicles that are currently in operation are successfully demonstrating that this new technology is indeed feasible. Ballard currently has three 250 kW buses in operation in both Chicago and Vancouver. Not only were no technical problems encountered with the operation of the buses, but equally important, there was no subjective "Hindenburg syndrome", or hydrogen phobia, by any of the passengers or the public.

The successful development of fuel cell technology will have to address several key aspects. First of all, further cost, volume and weight reductions will have to be realized. Also, important advances will have to be made on the issues of reliability, longevity, cold starts, and cooling. The needed reductions on cost and weight will not be easy, but it must be kept in perspective that ICE technology has already benefited from billions of hours of development on these issues. He stressed that these reductions for fuel cells will occur, but that they will take time, and they may not be able to surpass the ICE in terms of those characteristics. One of the keys to this technological development is to stimulate research by companies striving and competing to be the first to reach each hurdle and capture the financial rewards of patents.

In the past few years, there have been dramatic advances in fuel cell technology. While he asserted that hydrogen is the best fuel source for fuel cell vehicles, he acknowledged that hydrogen also poses certain re-fueling problems since the needed infrastructure is expensive and on-board storage of the fuel poses volume challenges. For these reasons, methanol may prove to be the superior fuel choice for individual, public use FCV's since its transport and handling is easier, while hydrogen may develop as the fuel choice for fleet applications. If methanol did become the mass application fuel of choice, there is also the potential for direct methanol fuel cells, which would eliminate some of the disadvantages of the current, indirect methanol technology that relies on the use of on-board reformers.

It is DaimlerChrysler's prediction that there is a high probability that FCV's will gain a significant market share in the next 20 years. During that time, it is predicted that the use of FCV's will expand beyond their initial niche applications and actually become a serious contender to ICEs. Dr. Panik noted that all of the major automobile manufacturers are currently working intensely to bring FCV's to the market around 2004. Toward that end, the alliance formed by Ford, DaimlerChrysler, Ballard Power Systems, DDB and Ecostar has built most of the demonstration test and concept FCV's worldwide to date. DaimlerChrysler expects to be the first company to commercially market the FCV in 2004.

Not only must DaimlerChrysler and the auto industry successfully develop and produce this new technology, but also, effective efforts must be made to develop the market for this new product in order to create a demand for it. Efforts such as the California Fuel Cell Partnership are a key to such market development since it will be necessary for the private and public sector to work jointly toward this mutually desired goal. It is also important to educate and expose people to FCV technology by such means as the Partnership. The goals of the Partnership are thus not only to test and demonstrate this technology, but also to expand public outreach and explore infrastructure requirements. Initially, both hydrogen and methanol fuels will be used in the Partnership, as will other fuels if the technology is mature enough.

When announcing the Partnership, Governor Davis said that "zero is zero".

In the end, he concluded that fuel cells are a tremendous business opportunity with the qualification that this business must be able to offer the transportation consumer something that it perceives as a better product in order for this business venture to succeed. In closing, he remarked that progress in the emerging transportation mega-markets of the developing nations will only be possible if it is based on technologies that offer clear improvements in air quality in reliance on renewable energy sources. As result, these developing markets offer better mid-term business opportunities for the automotive and fuel industries than do the existing markets.

Editor's Note: Hydrogen and/or methanol are most likely to be produced from natural gas.

Jim Patten, Cummins Diesel

Prospects and Fuel Requirements for Diesel Exhaust

Mr. Patten wants to try to provoke some discussion about where science and technology *can* take us rather than focussing on where we want it to go. Cummins Diesel is in the business of making diesel engines only, which they sell to a large market share of the heavier duty diesel truck applications. They do not make any vehicles, and the life-line of their business is customer preference, with no legislation involved. The customer base that they do service is a very small fraction of consumers, which is mainly farmers and truckers. As a result of their small consumer base, Cummins has no lobbyists, no office in Washington D.C., and they consider themselves to be a very ethical company.

He commented that as a safety matter, women who drive SUVs and pick-up's don't want to have to fill up at night or during the middle of the week. As a result, with these market drivers for size and fuel economy, diesels fit their demands for big, heavy, long range vehicles. Another driver for diesel is the demand for low-end torque and high performance at any altitude. Both of these performance interests can be well achieved with the turbo-charging that is an inherent part of Cummin's diesel engines. He also stated that when a customer pays almost $50,000 for their luxury SUV, they want it to last much longer than 100k, so reliability and mechanical longevity is an important driver for diesels as well. On that note, Cummins Diesel engine equipped Dodge pick-up's can last over 500,000 miles before they need their first overhaul, and this is true even when they are regularly used to tow significant loads. This longevity is one of the superior aspects of their engines which creates consumer demand for them.

Turning to the subject of government funding for diesel engines, he commented that such funding by the DOE has helped a great deal to speed up the technological progress that has been made with diesel emissions technology. The technical challenges which diesel engine manufacturers currently face involve reducing NOx and PM, and due to the toxicity of these pollutants, this is a very important challenge. He commented that the odor from diesel vehicles comes entirely from partially oxidized HC's, and most of the health effects are caused by them as well. As a result, Cummins is interested in completely converting these HC's. He also thinks, however, that many of the diesel emissions issues are associated with low temperatures. One of the problems with emissions controls is that since they are temperature driven, emissions will increase at lower operating temperatures. As a positive point on diesel emissions, he noted that in Southern California, emissions levels tend to rise on the weekends, rather than during the week, which indicates that the source of this increase is passenger cars and not diesels. He also thought that more studies need to be done on this matter in order to better understand it.

Sulfur diesel content is another important emissions issues. To explain, efforts have been made to reduce the amount of NOx produced by lowering the engine's temperature with the use of EGRs or water injection. However, if there is sulfur in the diesel at these lower temperatures, it will form sulfuric acid which ruins both the engine and the catalysts. Further, when sulfur containing diesel is run through a catalysts, that can have the effect of also producing particulates with a further negative impact on emissions. Even so, he is not sure whether particulates have health effects or not.

Technologically, its looks like the diesel industry will be able to achieve a mere 1g/hp-hr of NOx and an after-treatment will then be required to reduce NOx, PM, sulfur and unburned HC. Cummins would like to reduce NOx to one fifth of that, however, to .2g/hp-hr. In each case, Cummins has the technology to reduce such emissions by 99%, but all of these technologies have problems with sulfur. With direct injection diesels, you can get very low emissions and avoid the hot spots of conventional diesels, thus making CARB ULEV certification easier to attain. Another promising aspect of diesel emissions is that they tend to better maintain their designed emissions levels over the life of a vehicle, rather than deteriorating to the degree that gasoline engines do.

Editor's note: F-T diesel fuels produced from natural gas contain no sulfur.

As to after-treatments, NOx can be reduced by only 8% with conventional diesel, but a 40% reduction can be achieved with lower sulfur content diesel fuel. Other after-treatment catalysts pose both similar problems and possible emissions reductions in connection with low sulfur fuels. Cummins has tried to install sulfur absorbers upstream of the catalysts to prevent these reduction losses. They are also looking into several other types of catalysts to reduce emissions: a) One is a plasma assisted catalyst reduction which can achieve 90% emissions reductions and is very resistant to sulfur; b) Another technology is selective catalytic reduction (SCR) which injects urea into the exhaust emissions, thus converting them to ammonia, and a catalyst is then used to convert the ammonia to nitrogen; c) They also have a soot filter which oxidizes the soot during high operating temperatures and uses a catalyst to reduce the temperature needed for this process. The problem with this technology, however, is the issue of what to do in very cold temperatures - you can either let the trap get plugged up, or, you can add energy to continue the oxidation process. One possible solution is to provide such energy/heat with microwaves.

In closing, he believes that it will be possible to lower NOx emissions to the levels that will be required in Southern California and that it would be very good to remove all HC and PM from diesel emissions. However, to do this, the sulfur level in the diesel needs to be reduced. Once that is accomplished, however, there are many more options for diesel emissions reductions. He commented that fuel cells are a very attractive option from a long term perspective and he likes the complete elimination of NOx emissions with that technology. However, even with fuel cells, there is still the problem of converting hydro-carbons to hydrogen so he still thinks that reciprocating engines, which turn chemical energy directly into mechanical energy, are better, with the acknowledgement that NOx reductions remains a big issue with such engines.

Andrew Burke, ITS – UC Davis
Ultra-Clean Vehicles: Technology Options and Policy Considerations

While the LEV and ZEV CARB standards have been the largest driver to date for ultra-clean vehicle technology, other drivers have included the PNGV program and general concerns about GHGs. Perhaps ironically, however, these same increasingly tougher standards have resulted in decreased emissions from ICEs as well, such as SULEV's, with the affect that ICEs are becoming more difficult for AFVs to compete with. Even so, there has been a great deal of technology progress in AFVs over the last several years such as advanced battery developments, pulse battery technology, hybrid vehicles, and fuel cell development and demonstrations.

One of the limitations of the current discussions about AFVs is that much of the data in this field is based on simulations. While there is much that can be learned from such simulations, we need more data. The current technology involves many variations of vehicle types, drive-line components and operating strategies but the emissions calculations from these various combinations are still questionable.

One AFV of key interest has been the Ford P2000 direct hydrogen fuel cell vehicle. It has a 75 kW Ballard fuel cell, a 90 kW A.C. induction electric motor, is load following by design (and thus has no battery or regenerative brakes), and it has a curb weight of 3,3339 lbs. The simulated tests for the P2000 had predicted that it would produce FUDS 56 mpg and 85 mpg on the highway, and the actual runs produced 60/79mpg. What this shows is that simulated data for these advanced technology vehicles can be quite useful and pretty accurate. He thought that 50% improvements could also be made to the city cycle mpg with the use of hybridization and the Honda and Toyota hybrids have shown that this is true.

Some of the cost issues currently facing AFVs include matters relating to vehicle structure, drive-line components, and energy storage. Lighter cars, better performing cars, and more efficient driveline components and energy storage technologies will generally be more expensive to produce. While simulations have shown that impacts on fuel economy were not very significant for different hybrid configurations, the costs of different designs can be very different. For example, a charge depleting hybrid vehicle design is much more expensive since the larger you make the battery the more the vehicle tends to cost.

Marketing advanced technology vehicles involves a number of issues as well: range, fuel economy, drivability, customer adaptability, cost, refueling infrastructure, consumer education, government incentives/disincentives, and, fuel economy and emissions regulations. For one, consumers will need to be educated to market these vehicles so that they have a much better understanding of the differences between the various competing technologies. We can rank the competing technologies by different criteria as well to determine which are the more marketable: In terms of a cost ranking, he proposed the following order of increasing costs: hybrid ICE, EV, FCV (H2), and FCV (with reformer); as to drivability, from best to worst: EV, FVC (H2), Hybrid ICE, and FCV (reformer); and, lastly, these technologies can be ranked in order of increasing difficulty with refueling infrastructure: Hybrid ICE, Fuel cell (reformer), EV, and FCV (H2). With all these rankings in mind, he predicts that over the next 5-10 years, the marketability of these technologies ranks as follows, in order of decreasing marketability: Hybrid ICE, EV, FCV (reformer), and lastly, the FCV (H2).

With regard to the policy considerations that should be made for AFVs, we need to consider all of the following: full fuel cycle emissions vs. vehicle emissions; the average annual emissions vs. operating emissions in HEV mode; total EV emissions vs. total SULEV hybrid ICE emissions; and, total EV emissions vs. total fuel cell vehicle emissions. What is more, we need to consider total CO2 emissions and focus on mpg equivalents for vehicles that don't operate on liquid fuels. Some of the policy alternatives that we need to consider are whether it would be better to keep the 2003 CARB ZEV mandate or just require that all vehicles meet the SULEV standard. Also, we should consider higher CAFÉ standards as a means of promoting hybrid and FCV technology.

In summary, there are many technology options currently being developed for ultra-clean vehicles, and several of them offer “equivalent” fuel economy improvements as high as 50%. Which technology will ultimately be selected and succeed will largely depend more on efficiency that it will on total emissions, and, it will also depend largely on the cost of the refueling infrastructure that will be required for a given type of technology.

Session III Policy Implications of Transportation Pathways

Chair: Dan Santini, Argonne National Laboratory

Speakers:

Steve Gougen, DOE
Transportation Fuel Pathways: A Potential Future Scenario

Jason Mark, Union of Concerned Scientists
Environmental and Economic Analysis of Transportation Fuel Pathways: Overview of Issues and Results, and Discussion of Policy Implications

Lew Fulton, Energy and Environmental Analysis, Inc.
Lifecycle Analysis Versus the Kyoto//IPCC Accounting Framework: Overview of Issues and Results, and Discussion of Policy Implications

Chair: Dan Santini, Argonne National Laboratory

Chair Santini introduced the Session by stating that while the previous Session had assessed where we are now and where we can go in the next ten years in terms of vehicles and technology, Session III would delve into how we can achieve our goals to get from the present point A to the planned point B. In that regard, this Session will discuss the different pathways that we might take to get there. He then introduced the first speaker, Steve Gougen, as being from the Office of Heavy Duty Vehicle Technologies at the Department of Energy, who is the Team Leader of the Alternative Technologies Program.

Steve Gougen, DOE

Transportation Fuel Pathways: A Potential Future Scenario

Mr. Gougen began his discussion by presenting a historical perspective of alternative technologies over the last 13 years. Starting in 1973, the U.S. experienced the OPEC oil embargo, which the government reacted to in 1974 by developing "Project Independence" and the Federal Non-Nuclear Energy Research and Development Act. In 1975, the question was essentially posed, "Should We Have a New Engine?" Two years later, President Carter declared that combating the energy problem is the "moral equivalent of war". Then in 1979, we experienced long lines at gas stations with such adaptive measures as odd and even license plate fuel purchase dates.

Over the same time period, Mr. Gougen then reviewed the different alternative fuels that had been considered. Prior to the 1970's, the steam engine had been considered a possible alternative to the ICE. By the 1970's, the DOE began to look at the alternative technologies of the turbine and the Stirling engine. In the '80's, adiabatic engines and alternative fuels were considered, and now, in the '90's, we have been looking at hybrids, electric vehicles and fuel cells. Over the years, millions of dollars of R & D have been spent on each of these potential technologies, with current and further R & D still progressing only on the latter three technologies.

Three federal laws have played a key part in enabling R & D on alternative fuels: The Methane Transportation Research, Development, and Demonstration Act of 1978 (P.L. 96-512); The Alternative Motor Fuels Act of 1988 (P.L. 100-494); and, the Energy Policy Act of 1992 (P.L. 102-486). Under these laws, the government tested and collected data on heavy-duty compression ignition engines fueled by: ethanol, methanol, propane, CNG, LNG, bio-diesel, and dimethyl ether (DME). The lessons that were learned from this R & D are several: A) Modifications were needed to enable heavy duty diesel engines to use alternative fuels. This meant that ignition systems had to be added for liquid fuels such an methanol and ethanol since they are not compression ignitable like diesel. Also, spark, glow plug or pilot injection systems have to be used for gaseous fuels such as CNG and LPG. B) The complexity of these modifications not only reduced reliability, but also accounted for additional costs. C) Lower efficiencies resulted than those achieved with unmodified diesel engines. D) Alternative fuel engines have not made significant penetration into the commercial truck market for reasons which include limited fuel production capability, lack of distribution infrastructure, higher fuel and operating cost, higher vehicle costs, and unproven reliability and durability. E) Commercial transport operators depend on, and need to be assured of, the availability of cost-competitive fuels with an uninterrupted supply in order for them to commit to such fuels for continued operation and profitability.

In addition to the above, several lessons which have been learned, several other lessons *should* have been learned as well: A) Don't contract out your thinking; B) Do not "over impose" or raise unrealistic expectations about new, unproven technologies; C) Be sure to include all aspects of the entire system when projecting costs; and D) Don't try to solve a scientific problem using political science.

He then presented a chart which compared the energy conversion efficiencies of several fuels and technologies. Direct hydrogen fuel cells were listed as having both the highest current and projected efficiency capacities. After that, current heavy duty diesel engines were shown to be just as efficient as projected methanol fuel cells and projected compression-ignition direct injection ICEs for light duty applications. The projected efficiency of gas turbines and gasoline direct injection ICEs were shown to exceed the current level of methanol fuel cells. Lastly, conventional technology spark ignition ICEs were projected to only catch up to the current efficiency level of methanol fuel cells.

Another chart compared the energy density of various fuels in the following order of descending densities: diesel (1058), gasoline (922), LNG (635), methanol (488), liquid hydrogen (270), CNG @ 3,626 psi (266), and lastly, compressed hydrogen gas @ 3,626 psi (68) (units listed are thousand BTU's per cubic foot.)

He added that even though much effort has been made into looking into alternative fuels and technologies, petroleum fuels still account for 97% of transportation energy consumption in the U.S.; natural gas makes up 2.8% and electricity the other .2%. The consumption of renewable energy is projected to increase only slightly in the next fifteen years, while increases in oil, natural gas and coal use will, by comparison, continue to increase at a higher rate. Only nuclear energy use is projected to be in decline during this period. Further, transportation petroleum fuel consumption is growing, as is the world population, which will in turn increase urban pollution and greenhouse gases.

The projections for world oil production indicate that the level of peak productivity is actually not very far off. At the current annual increase levels in world oil use of about 2%, the world will probably consume about 99 million barrels a day by the year 2015, and, the depletion trend of world oil resources shows that half of the world's oil reserves will have been used by 2020. With the assumption that petroleum fuels will continue to be used during the next 20 years, the prediction is that the focus during that time will be on cleaning up fossil fuels, reducing sulfur levels therein, and developing additive packages such as oxygenates, lubricity enhancements, and optimum blended fuels.

Turning to the Kyoto Protocol of 1997, the agreement called for a reduction in greenhouse gas emissions to 7% below 1990 levels by the year 2008-2012. In the U.S., the transportation sector alone accounts for 1/3 of carbon dioxide emissions and is the fastest growing emissions sector. Since the 1973 oil embargo, essentially all of the increase in U.S. highway fuel consumption can be attributed to heavy trucks, SUVs, vans, and light trucks. By contrast, the total amount of highway fuel consumption for automobiles in the U.S. has generally stayed at or below 1973 levels.

A possible scenario for future liquid transportation fuels designed for sustainable transportation could likely involve high-efficiency, clean diesel-cycle engines which utilize compression ignition and clean liquid fuels/blends derived from diverse feedstocks. This use of clean, quality fuel combined with exhaust treatment could well result in more efficient light, medium, and heavy trucks, and could use the existing re-fueling infrastructure. The diverse feedstocks for this purpose could include coal, biomass, natural gas and petroleum. Natural gas could be used as such a feedstock by converting it into a liquid fuel by the combined processes of syngas generation, F-T conversion, and hydroisomerization. Another way to produce clean, liquid fuels involves Fischer-Tropsch production with partial oxidation and Cobalt-based catalysts to reduce carbon dioxide formation. Fischer-Tropsch produced diesel is a particularly good fuel for several reasons: a) It has a higher Cetane number than conventional diesel (76 compared to 48-50); b) It contains no sulfur or aromatics; c) It has a low cloud point (10 degrees C); d) Compared to conventional diesel, it produces 8% less NOx, 30% less PM, 38% less HC, and 46% less CO. What is more, even lower emissions can be produced from engines that are optimized for Fischer-Tropsch diesel.

There are various sources of feedstocks for Fischer-Tropsch fuels. In the near term, we can use 37 tcf re-injected natural gas in the North Slope of Alaska, which would produce about 3.7 billion barrels of F-T diesel. In the mid term, 246 tcf of sub-quality gas in the lower 48 states could produce about 24 billion barrels of F-T diesel which is more than twice the original Prudhoe Bay discovery. Also, a combination of coal or biomass gasification plus the use of the lower 48 states' sub-quality gas to furnish supplemental hydrogen could lead to very large quantities of FT products. Lastly, in the long term, there is a virtually inexhaustible supply (1000's of Quads) of methane tied up in the form of methane hydrate off the U.S. coastline

In closing, perhaps the future will bring sustainable transportation via ethanol or fuel cell vehicles, and, he offered the following didactic quote: "Don't bet the farm on unproven technology" – by Dr. James J. Eberhardt.

Jason Mark, Union of Concerned Scientists
Environmental and Economic Analysis of Transportation Fuel Pathways: Overview of Issues and Results, and Discussion of Policy Implications

Mr. Mark explained that there is a need for a comprehensive form of environmental accounting which takes into account all the various aspects of vehicle emissions: greenhouse gases, criteria pollutants, toxics, upstream emissions, and others. Based on this, he made the case that transportation environmental policy and technology need to take a more integrated approach which moves forward on all these aspects of vehicle emissions. By contrast, policies and technologies of the past have often made progress on some of these emissions, such as greenhouse gases, while ignoring or even encouraging others, like criteria pollutants. An example of a policy and technology combination that fails to take such an integrated approach is the situation with diesel passenger vehicles. While diesels have been touted as offering environmental improvements based on their better fuel economy and lower greenhouse gases, unfortunately, they also result in a 186% increase in NOx and a 300% increase in PM. Tier II also perpetuates this same environmental backtracking by setting lower standards for diesels than for gasoline cars. People ask if diesel can close the gap with gasoline on these emissions, but since no one really knows the answer to that at this point, perhaps it is better to ask if it is reasonably worth the effort to pursue such technological improvements with diesel.

As upstream emissions or full fuel cycle accounting are growing in importance, more focus is given to alternative fuels and technologies to help alleviate these integrated environmental concerns. It is not clear what role diesel can or will play in offering lower emissions for both air quality and climate change. The fuel pathways that are emerging to address these and other concerns can be grouped into essentially three clusters: 1) conventional vehicles; 2) hybrids; and, 3) fuel cell/battery electrics. In each of these clusters, a different comprehensive environmental impact can result depending on whether the fuel used is gasoline, diesel, methanol, ethanol, hydrogen, or electricity.

In the case of conventional vehicles, as compared to diesel, gasoline offers better air quality at the expense of climate change impact, and vice versa for diesel. As compared to conventional vehicles, hybrids offer greater possible gains in <u>both</u> categories of emissions. Lastly, fuel cells and battery electrics can offer anywhere from similar results for climate change as hybrids to extremely low emissions in either category with methanol; and, ideally, zero emissions of any kind with hydrogen.

The three fuel pathway conclusions that he offered for an environmental strategy were: 1) for the near term, we should focus on improved gasoline vehicles, higher fuel economy, lower vehicular emissions and hybrids; 2) in the mid-term, the most improvement can be made with intrinsically clean and efficient vehicles like battery electrics and fuel cells; and 3) in the long run, we need to look into renewable fuels with low carbon, low polluting pathways; for that, biomass feedstocks look promising.

The policy implications of all of the above are several, so we need an integrated environmental approach that makes use of all of the following: 1) a comprehensive environmental accounting so that we can address both air quality and climate change goals; 2) concern for upstream emissions and full fuel cycle accounting; and, 3) identify stepping stones rather than roadblocks for the best fuel pathways. Such an integrated approach can be implemented by a combination of regulations (LEV II/Tier II, CAFÉ, EPACT), incentives (vehicle credits, fuel credits), and R & D (PNGV, light truck R & D).

Lew Fulton, Energy and Environmental Analysis, Inc.
Lifecycle Analysis Versus the Kyoto/IPCC Accounting Framework: Overview of Issues and Results, and Discussion of Policy Implications by Mark Delucchi, Lew Fulton, and David Greene

Dr. Fulton explained that he has been involved in a project which, under the Kyoto Protocol context, examines upstream emissions, where they occur, and the policies that effect not only emissions outcomes but also how we can account for such emissions. In this context, the Kyoto Protocol has four strategies for reducing GHG emissions: 1) National policies and measures; 2) Annex 1 Joint Implementation Projects; 3) Clean Development Mechanism; and 4) International Carbon Permits and Trading.

The first three of these strategies are project level in nature. Thus, they pertain to specific initiatives whose impacts on GHGs are to be measured against a null alternative. The first, national policy strategy, will contribute generally to a nation's ability to meet its target, and the second and third projects will generate emissions credits for the donor country. As to the fourth, accounting rules will imply a boundary within which GHG emissions are counted and outside of which they are not. His study explores the importance of these boundary definitions to the impacts of transportation policies on global emissions.

One key problem in his study is the issue of what happens to upstream emissions in other sectors and countries when we implement GHG reduction policies in transportation. Further, how should we account for these changes and how could such "spillovers" affect accounting efforts in a Kyoto "cap and trade" context? For these purposes, his analysis estimates upstream GHG emissions on a per-vehicle mile basis, by economic sector and country for a variety of fuels and vehicle technologies between 2000 and 2020. By this means, he is able to estimate the actual vehicle and upstream emissions that could occur for several specific policies in the U.S. and Canada in order to assess the implications for GHG national accounting and Kyoto style trading agreements.

His co-author, Mark Delucchi, has derived a modified fuel cycle GHG model to incorporate more detailed tracking of certain upstream sectors and to introduce the tracking of international emissions to address the sub-issues of what percentage of upstream emissions occur outside the U.S.. By this means, their analysis takes new coefficients into account so that various scenarios can be run to determine whether there is a change in foreign emissions. By this means, questions can be addressed such as, "Are we seeing foreign emissions go up while domestic emissions are declining?"

As his part of this project, Dr. Fulton has looked at four policy scenarios:

Policy 1: Conventional Vehicle Economy Improvement. This involves new light-duty vehicle fuel economy standards (cars and light trucks, combined) set at 35 MPG for 2010 and 50 MPG for 2020.

Policy 2: Carbon Tax. This policy would require a uniform tax on the carbon content of fuels of approximately $100/ton-C (about $25/ton-CO2-equivalent GHG), and could involve two variations: It could be applied to either end use carbon and/or to FFC carbon emissions with such tax amounting to about twelve cents and seventeen cents a gallon, respectively.

Policy 3: PNGV Success. This policy focuses on the introduction of ICE hybrid vehicles that are two times more efficient by 2003, and fuel cell hybrid vehicles that are three times more efficient by 2010. These phase in schedules reflect lag times to production and market introduction in many market classes.

Policy 4: AFV Penetration. This involves the maximum, cost-effective use of cellusic ethanol as a blending stock for gasoline, together with greater use of natural gas and diesel vehicles.

In conclusion, he stated that the results they have produced are fairly intuitive and are thus not too surprising. For example, in a U.S. 2010 scenario looking at GHG g/mi for selected fuels, out of country emissions represent a low percentage (around 5%) of the total GHGs in both the U.S. and Canada, for all fuels except foreign-derived GTL's. What this implies for policies is that in terms of GHG emissions production, methanol looks like a good strategy. Further, since there is very little variation by fuel, most transportation policies that involve fuel switching will not cause a significant shift of upstream emissions from in-country to out-of-country. However, a small change in out-of-country emissions for the U.S. could lead to a significant change in certain other countries, due to expanded NG production in such nations as Azerbaijan. Lastly, equilibrium effects still lurk about, such that the effect of lowering oil consumption on WOP and on resulting shifts toward oil elsewhere could be a big problem and especially difficult to account for.

Discussants

Frank Stodolsky - Argonne National Laboratory

There are challenges ahead which depend on what the focus is of our questions and concerns, such as GHG, criteria pollutants, toxics, petroleum use, or energy security, and this in turn relies on a subjective weighting of criteria.

Commenting on Steve Gougen's presentation on petroleum use by year, he thought that there could be a three fold increase in fuel economy if there was an increased use of freight rail in place of heavy duty vehicles.

He thought that we need to consider a modal shift since even ultra clean FCV's can still get caught in traffic jams and thus suffer from other sorts of transportation problems like congestion. This in turn brought his focus back to the use of rail as a modal alternative to vehicle transport. He cited that rail transport, although certainly not a new idea, is three times more efficient than one person using a 50 mpg hybrid vehicle. He stressed that we thus need more discussion and focus on rail transport since it can help address both the efficiency and congestion problems of vehicle transport.

Mark Delucchi - ITS-Davis

He agrees that we need to establish our long term vision and ultimate social objective before we try to determine what options we should take to get there. He suggests that we should consider a hierarchy of long term goals of urban air quality, GHG, and then energy efficiency. Lastly, we should not get too hung up on technology; its just a means to an end.

Commenting on Jason Mark's presentation, he offered some caveats on fuel cycle analysis. He thought that we should take a rather jaundiced view on fuel cycle results since they are not policy specific and don't have economic content. This is an important omission and in some cases this is true to the point of invalidating some decisions or options. He added that we need to be skeptical especially when we are talking about small percentage differences. While a social cost analysis does, of course, have more problems, the roles of social cost and fuel cycle analysis are just points of information as opposed to tools that we can use to set prices.

As to his co-author Lew Fulton's presentation, he commented that there were some findings that they did not have time to present. Their study also looked at IPCC potentials versus comprehensive and better justified CO2 factors. They found that in a few cases, there were significant differences in using IPCC versus other factors when there are significant perturbations in the N2 cycle. There is no accounting for nitrogen effects on the climate in IPCC, and, there are interesting intra-country effects. If you map fuel cycle results in IPCC categories, you find more variations than with respect to geography. The analysis only looked partially at materials substitution in auto manufacturing, but interesting questions remain, such as full petrochemical use.

In closing, he commented that he thinks that it is important that we have a sense of where we want to go and that we need to have more debate on what our priorities are, but, it's a tough debate.

Lee Schipper - Lawrence Berkeley National Laboratory

He thought that we can not just insert a certain technology into a model and come out with accurate emissions predictions; rather, we also have to take behavior into account. For example, it is hard to know what the real world emissions results would be with diesel engines. While diesel vehicle sales are up in Europe, largely because of the price difference there between diesel and gasoline, the fact is that in real world driving, existing diesels get only marginally better fuel economy. In the end, much of the cost savings from diesel use in Europe thus comes form lower pump prices rather than better fuel economy. This in turn underscores what is really important to consumers – not improving fuel economy, but saving money.

There are currently big experiments taking place in Europe and this should give us important information that we need. If we can not get that information, we will have to try to build accurate models, but this is difficult and problematic. Good information is very important for these purposes since there are contentious issues involved.

The policy implications that we can learn from the European diesel experience are several: a) Fuel prices affect vehicle choice and use; b) Drivers will invest now to reduce future fuel costs; c) Big energy savings are difficult without pricing.

Michael Wang - Argonne National Laboratory

He commented that any studies or claims about reductions in emissions through the use of Fischer-Tropsch fuels must depend on what fuels are being replaced.

With regard to Jason Mark's presentation, he agrees with his analysis and result, and adds the additional issue of the cost of the various technologies in attempting to reach zero emissions for both air quality and GHG. With that in mind, he asked, which technology will be relatively cheap in attaining that goal?

Lew Fulton's presentation indicated that methanol production in other countries is small. However, he noted that if we move to FT diesel, then outside country emissions of GHG would double so it is not a forgone conclusion that foreign emissions are small. Nonetheless, he agrees with the allocation of emissions to appropriate countries.

He believes it is particularly useful and necessary to look at full fuel cycle emissions when we set out to compare different fuels since these emissions can vary greatly among different types of fuels. Further, as tailpipe emissions become reduced over time, he predicts that upstream emissions will become a major issue. Four issues that he thinks warrant consideration on this subject of upstream emissions are:1) The fuel cycle model, the focus of which is "garbage in – garbage out"; 2) The various types of boundaries that are involved: technology, system, national, and global boundaries; 3) Technology progress over time will bring focus to upstream fuel production in addition to down stream vehicle operation; and 4) The location of emission criteria pollutants can be an issue, and in some cases even important amounts of upstream emissions occur inside an urban area.

Session IV Environmental Policy and Technology Change

Introductory Speaker: **Mike Walsh, Editor of Car Lines and Consultant**
Global Trends in Motor Vehicle Pollution Control – Into the New Millennium

Chair: **David Greene, Oak Ridge National Laboratory**

Speakers:

Steve Plotkin, Argonne National Laboratory
Policy and Technology Change, Lessons from the Clean Energy Future

Craig Marks, University of Michigan
PNGV – A Government-Industry Partnership Experiment

Tom Wenzel, Lawrence Berkeley National Lab
The (Unexpected) Success of Emissions Regulations in Advancing Vehicle Technology

Paul Leiby, Oak Ridge National Laboratory
Policy and Technology Transitions

Alex Farrell, Carnegie Mellon
Historical Patterns in the Science, Engineering and Policy of Vehicle Emissions

Introductory Speaker: Mike Walsh
Editor of Car Lines and Consultant
Global Trends in Motor Vehicle Pollution Control – Into the New Millennium

There are now reported to be a total of 800 million vehicles in the world. Of that total, China and India, with at least one billion people each, have only 10 vehicles for every 1,000 people. The potential for increases in vehicle ownership in these large developing countries is therefore enormous.

Over the last three decades in the United States, while VMT, GDP, population and NOx emissions have all increased, the emissions of CO, lead, VOC, PM10 and SOx have all decreased – 98% in the case of lead. Most of this increase in VMT has been from the light truck category. The U.S. has also seen air quality improvements in the last decade such that the percentage of air quality concentrations of CO, lead, nitrogen dioxide, ozone, PM 10, and sulfur dioxide have all decreased during this time period. By comparison, car emissions in Germany in 1995 had declined to the same levels that they were in 1980. And, by 2005, it is projected that 80% of all gasoline sold in the world will be unleaded. Even with these improvements, however, transportation still stands out as a major source, even a dominant source, of the pollution problems that we deal with, and, this is especially true in major urban areas around the world. A special case in that regard is Bangkok where a major source of their urban air pollution is from motorcycles.

Some other significant vehicle trends are that since 1970, the average fuel economy of light duty passenger cars has increased from just under 15 mpg to just under 25, while light duty trucks have only increased from about 10 mpg to 15. The global production of vehicles has increased from 10 million/year in 1950 to over 50 million/year at the end of the 1990's. Likewise, motorcycle production increased significantly around the world from 1990 to 1994 in both developed and developing nations alike. The total number of cars, commercial vehicles and motorcycles increased to just under 800 million in 1995 from less than 50 million in 1930.

If we look at the proportion of where the world's vehicles were located in 1996, the US and Canada had 751 vehicles for every 1,000 people; Japan – 547; Oceania – 471; Europe – 283. At the other end of the spectrum, Asia had the least vehicle/population density at 19, Africa had a bit more at 22, and the world had an average of 117. These numbers tend to correlate fairly closely with GDP such that nations with higher GDP/person tend to own more vehicles per person. However, there is some variation in this theme such that countries like Switzerland, Japan, Norway and Denmark all have higher GDP per person than the US, but the US owns more cars per person.

Some consequences of all these millions of vehicles are the serious pollution problems that we presently face. In the urban setting, this comes in the form of CO, lead, particulate matter, and nitrogen dioxide. Regionally, emissions can result in photochemical smog, or ozone, and acid rain. At the global and long term level, we end up with greenhouse gases and global warming. In the U.S., some serious air pollution problems certainly remain. In 1997, 110 million Americans lived in non-attainment areas. The EPA's forecast for 2007 is that 129 million people will be living in one of either 28 ozone non-attainment areas or 80 marginal areas. Serious problems projected include crop losses, impaired vision, eutrophication, and impacts on public health.

With regard to the latter, the World Health Organization has concluded that 460,000 premature deaths result each year globally from PM and 370,000 from sulfur dioxide. In California, the Air Resources Board has determined that the toxicity of diesel PM can cause high concentrations of cancer in rats while 30 human epidemiological studies have found a link between diesel PM and lung cancer.

California was recently the first jurisdiction in the world to unify light truck and passenger vehicle emissions standards. The EPA has proposed to do the same, but true standards unification will not be fully phased-in until 2009. By contrast, Japan recently tightened its vehicle emissions standards for the first time since 1978, with such changes to take effect in 2000. Japan plans to take another look at heavy duty vehicle standards in 2002, while those standards are currently rather lenient compared to other parts of the world. Taiwan is doing its part to clean up vehicle emissions by recently adopting a ZEV mandate for motorcycles. China in turn has adopted Euro 1 standards to be in effect for the entire country in 2001, while Shanghai has already adopted such standards.

In India, the story of vehicle emissions control progress has not been as promising as in China. India now has catalytic converter requirements in the cities, but since there is no unleaded fuel available outside those areas, many of these devices have likely been poisoned. Pollution control measures have largely been spearheaded by the Supreme Court in India, rather than through the legislative or executive branches of government.

While significant improvements have been made with regard to cleaning up local emissions from vehicles, the developments with regard to greenhouse gas emissions have not been as successful. For example, Europe has created a CO2 emissions standard, but it is only voluntary in nature and is therefore not mandated by the government. Europe's main, and disappointing strategy for decreasing GHG has been to increase the use of diesel. Yet, CARB recently announced that diesel particulates are a human carcinogen and Mr. Walsh thinks there is strong evidence to support this. Hopes for GHG reductions have also been placed on programs such as PNGV. In that regard, in the U.S., we are developing several promising technologies but so far, we have not been able to proliferate them into the marketplace, nor have policymakers been convinced yet to take these new technologies seriously.

If we break down where the global sources of carbon dioxide are coming from, it becomes evident that 77% originates from energy consumption, but of that figure, only about 15% originates from transportation energy sources. By comparison, in the U.S., the percentage of total CO2 produced which originates from the transportation sector is 31% while in Europe it is 26% and in Latin America 32%. The U.S., in turn, produces the greatest amount of CO2 from the transportation sector per capita.

There are various strategies for progress in vehicle emissions currently afloat. In Europe, some such approaches include gasoline direct injection, lean NOx catalysts and low sulfur fuels, turbo direct injection diesel, and fuel cell vehicles. In the U.S., President Clinton proposed the following tax credits for the 2000

Budget: 1) A 10% tax credit (up to $4,000) for the purchase of electric and fuel cell vehicles through 2006; 2) Tax credits for hybrid vehicles of $1,000 for those one third more fuel efficient, and up to $4,000 for those 3 times as efficient. Overseas, India has begun to phase out leaded fuel, China has adopted unleaded, Euro 1 standards, and Japan has tightened gas and diesel standards and agreed to CO2 reductions.

As to the challenges that lie ahead for us, progress needs to be made on the following six items: 1) the rapid spread of Tier 2/Lev II emissions standards; 2) comparable standards for heavy duty and off-road vehicles and engines; 3) very low sulfur gasoline and diesel fuels; 4) eliminate two stroke engines, or make them much cleaner; 5) develop very high efficiency vehicles/engines; and, 6) use of low carbon/renewable fuels.

Speakers:

Steve Plotkin, Argonne National Laboratory
Policy and Technology Change, Lessons from the Clean Energy Future

Mr. Plotkin explained that over the past few months he and his co-author, David Green, have worked on "The National Laboratories' Clean Energy Futures Study" to recap the transportation sector analysis of the "5-Lab Study" and to add three aspects thereto: a) cross-sectoral integration, such as electricity and electric vehicles, with the admission that integration is not complete; b) analysis through the year 2020; and c) analysis of explicit policies so that the model can reflect different policy scenarios – e.g. putting money into R & D in order to accelerate technology development. The analytical basis for the model is the Energy Information Administration's National Energy Modeling System (NEMS). The key difference between this model and the standard modeling approach is that in this study, policies can change the technology set and characteristics.

The model contains three scenarios: Business-as-usual, Moderate, and Advanced. The policies considered are: a) major R & D spending increases, between 50 and 200%; b) tax credits for high efficiency LDV's; c) acceleration of air traffic management improvements; c) increased telecommuting; d) moderate fleet programs and collulosic ethanol programs; and, for the Advanced Case scenario only the additional three policies: e) cap and trade @ $50/ton of carbon; f) voluntary agreement on fuel economy for LDV's, CAFE Standard sensitivity case; and g) pay at the pump insurance.

He then posed the question of whether we have a sound basis for projecting the impact of new transportation policies. In line with that concern, he presented some examples of the analytic dilemmas they face when trying to forecast and model the impact of certain policies and issues. First, he discussed the challenges and shortfalls of trying to forecast the impact of increased R & D funding. He acknowledged that there is no established methodology for this task and as a result, the element of luck looms large. Such a forecast can, however, examine the current R & D, the technologies that are in the pipeline, potential roadblocks thereto, reports on R & D shortfalls, and DOE program goals. They also make educated guesses on earlier market entry dates, improved fuel economy performance, and reduced costs. In general, he acknowledged that they need help on the methodology of their study and toward that end, they can use more theory and empirical evidence.

As a second example, he discussed voluntary standards for light-duty vehicles and their dilemma of defining manufacturer strategies and projecting vehicle purchaser behavior. Their approach starts with NEMS technology choice methodology. Further, in their approach they use a reduced discount rate to simulate higher value for fuel economy, and they include a slow down of the "horsepower race", earlier market entry for technologies, and extensive changes in alternative fuel vehicle choice codes. In sum, he stated that they need a sounder basis for projecting consumer behavior.

With regard to the difficulty of predicting technology costs and performance, he presented a graph which showed that there is currently a wide discrepancy among various studies about what the cost will be to increase fuel economy technology from the current 27.5 mpg CAFE standard to 47.5 mpg and more. To illustrate the range of these varied projections, one source indicates that a CAFE increase to just 32.5 mpg could cost as much as $2,000 in technology per vehicle, while another study claims that mileage over 47.5 mpg could be achieved for less than $1,000. Six such studies in all have been done to date, all by what he acknowledged to be talented people. The question is, therefore, which study do they rely upon for their model and their projections?

Projecting consumer purchasing behavior for the next two decades also poises a number of challenges and uncertainties. In this field, there is actually the potential for changes of great magnitude as has been illustrated by the recent consumer preference for vehicle safety features. He cautioned that a stumble in implementation of a particular technology by one automaker could “poison the well” for the technology. He then asked how much we can rely on stated preference surveys and he pointed out that some technologies will also change performance aspects and can thus be market risks. For example, it is uncertain whether the consumer will accept the performance trade-off’s of diesels.

In the end, the stakes and the uncertainties in their projections are both high. The policies aimed at combating greenhouse gasses and reducing oil use can cost billions of dollars, but we still need better analysis methods. However, to end on a hopeful note, it isn’t necessary, or even possible for that matter, for policy impact projections to be exactly right. Second, an extensive technology portfolio yields some redundancy and there are some historical analogs to draw from, which include: PNGV, the California ZEV mandate, and the first CAFE standards. Even so, they are still left with major analytic concerns.

Craig Marks, University of Michigan
PNGV – A Government-Industry Partnership Experiment

By way of background, PNGV is a cooperative R & D program between the U.S. Federal Government and USCAR which was originally organized in 1993 by President Clinton and the Chairmen of Ford, GM, and then Chrysler. Its purpose was to provide a mechanism capable of helping to meet government defined societal goals with regard to fuel economy and environmental quality while, at the same time, enhancing industry productivity and competitiveness. A further goal was to demonstrate that economic security and environmental quality can, in fact, be mutually supportive and achievable. Lastly, the partnership was formed on the belief that R & D collaboration is the most effective way to develop the technology that is needed for the above purposes. Because the Partnership consists of three companies that have been in fierce competition for the last 75 years, the cooperation that this Partnership has created among them has been dubbed “coopetition”. In addition to the original government and private founding members, the partnership also includes suppliers and universities.

The research goals of the Partnership are not just a technical demonstration of an 80 mpg car. The production prototype vehicles must maintain current performance, size, utility and cost of ownership, as well as meeting safety and emission standards. These criteria must be met in order to have the large impact that is achievable only through market-driven, widespread adoption. The project’s goals are three-fold: a) manufacturing goals – to improve U.S. auto manufacturing competitiveness by reducing production costs and product development times for the production of all cars and trucks; b) near-term: conventional vehicles goals – to pursue technological advances that increase fuel efficiency and reduce emissions of standard vehicles in today’s fleet; c) long term: new generation vehicle goals – to develop a new class of vehicles with up to three times the fuel efficiency of today’s comparable vehicles (80 mpg in a mid-sized car).

With these goals in mind, a time schedule has been developed for the progress of technology within the Partnership. Under this schedule, between 1995 and 1997, the various technological options were analyzed, developed and narrowed until a technology selection was made. Then, from 1997 to approximately 2002, concept vehicles will be developed, with production prototypes being completed by 2004.

Several tradeoffs have been made more evident by this program, including fuel efficiency vs. emissions, affordability vs. adoption, and customer preference vs. environmental concerns. For example:

- New, extremely stringent emission standards may rule out the potential use of compression ignition direct injection engines, the most viable short-term, high-efficiency power plant.
- New technology that increases cost will limit vehicle sales and reduce societal benefits.
- Customers' choice of large, massive vehicles may be inconsistent with their politically expressed desire for increased fuel economy and lower emissions.

The partnership has worked on several technologies. Lightweight materials, for example, have been used to reduce vehicle mass with consequent improvements in both fuel economy and emissions, regardless of the propulsion system. Direct injection engines show the promise of 15-35% improvements in efficiency, while hybrid designs and PEM fuel cells have shown a potential for both low emissions and high efficiency. Significant technological progress has been made by the Partnership with regard to all of the following: four stroke direct injection engines, fuel cells, batteries, power electronics and electrical systems, materials, and manufacturing processes. The major technical challenges that the Partnership has faced and continues to face are: cost, emissions capability, fuel cell maturity/performance, fuel strategy, and battery performance.

With regard to emission standards, it is unclear whether direct injection engine technology will be able to meet the strict emissions standards that have been proposed since the Partnership was formed. Meeting such standards may require a re-evaluation of the technology selection process already completed by the Partnership.

The positive results of the Partnership include:

- Establishing a successful mechanism to achieve nontraditional cooperation among government, competitive companies and suppliers, aimed at achieving both societal and business goals
- Performing a comprehensive review of technology and the selection of the most promising technologies within a scheduled time frame
- The production of competitive concept vehicles

From a pragmatic standpoint, the Partnership has achieved: common state of the art knowledge, commitment of significant technical and business resources, substantial supplier involvement, and earlier introduction of technology. The unresolved organizational challenges that remain are two-fold: achieving full participation of all stakeholders and inventing a mechanism that produces policy consistent with accepted science, available technology and marketplace realities.

Tom Wenzel, Lawrence Berkeley National Lab
The (Unexpected) Success of Emissions Regulations in Advancing Vehicle Technology

Mr. Wenzel explained that his presentation would cover three topics: 1) The differences in CO2 and criteria pollutants such as HC, CO, and NOx; 2) The history of emissions regulations and their effect on technology advancement; and 3) Alternative policies to advance technology.

1. The differences in CO2 and criteria pollutants such as HC, CO, and NOx.

He explained that the emission levels of criteria pollutants are much more variable than CO2; this applies both across different vehicles and within an individual vehicle. CO2, by further contrast, has a global impact while the relative damage that is caused by criteria pollutants depends on the location and time of said emissions. Lastly, while on the one hand he thought that there are economic incentives that can be used to reduce CO2 emissions since fuel costs money, on the other hand, he stated that there is no economic value assigned to criteria pollutants since they are considered more of a public "bad".

2. The history of emissions regulations and their effect on technology advancement.

The history of emissions regulations can be divided into essentially four rounds of criteria emissions standards. The first round began with the Clean Air Amendments (CAA) of 1977 and Tier 0 standards for new vehicles. These regulations reduced new car CO and HC 95% from the pre-control levels and reduced new car NOx by 75%. The levels were set to require the installation of specific new technologies: 3-way catalysts, oxygen sensors and closed loop control. Even with all these improvements, however, the in-use emissions of Tier 0 vehicles are several times higher than when the vehicles were new.

The second round of regulation arose with the 1990 CAA which addressed loopholes in the 1977 amendments and established the Tier 1 standards. These regulations addressed two separate loopholes: vehicle enrichment from normally functioning vehicles, and very high emissions from malfunctioning vehicles. As to the first, some Tier 0 vehicles produce extremely high emissions for several seconds when a high load is placed on the engine, such as during acceleration at high speeds or during AC operation. This problem was addressed in the 1990 amendments with the use of a supplemental test procedure. Second, the malfunction and failure of vehicle emission controls can lead to extremely high, in-use emissions. This loophole was partially addressed by CAP2000, the new car certification procedures that consider emissions of vehicles driven under actual usage conditions as well as under laboratory aging. OBD (on board diagnostics) regulations and enhanced inspection and maintenance (I/M) programs also partially address emissions from malfunctioning vehicles. Tier 1 also reduced new car HC standards by another 24% and NOx by another 40%; at the same time California adopted the lower federal Tier 0 standards for CO. While the Tier 1 standard levels were based on the assumption that new technology, such as electrically heated catalysts, would be required, manufacturers were able to meet the standards by using different, less expensive technologies. For example, tighter fuel control was established with the use of port injection as opposed to throttle body injection or carburetors. Also, incremental improvements were made to allow the placement of catalysts close to the engine to hasten warm-up. In contrast to Tier 0, Tier 1 emissions control equipment was also more durable, so that low emissions levels could be sustained over longer periods of vehicle use. A limitation of the Tier 1 standards is that the standards for light trucks and SUVs are not as strict as those for cars, even though the sales of these larger vehicles exploded during Tier 1's reign.

In round three, the California LEV standards were established by the California Air Resources Board in 1990. The LEV standards allow manufacturers the flexibility to certify the emissions levels of their vehicles to one of four categories: TLEV, LEV, ULEV and ZEV, as long as the weighted average emissions of each manufacturer's fleet meets the fleet average HC standard. The fleet average HC standard decreases over time. The ultimate, conventional vehicle technology category, ULEV, was designed to reduce new car HC by another 80% from Tier 1 levels, and NOx and CO by another 50%. Regulators anticipated that electrically heated catalysts and/or the use of alternative fuels would be needed to meet the ULEV standards. However, manufacturers have again shown that they have been able to meet the ULEV standards using different technologies: better air/fuel measurement, using more sophisticated universal exhaust gas oxygen sensors, in-cylinder fuel control, and further improvements to catalysts, such as using palladium and increasing surface area.

Round four was established in 1998-1999 when CA LEV II and Federal Tier 2 standards were developed. These new regulations brought light trucks and SUVs under the same standards as cars for the first time, to be phased in over a period of several years. Second, under LEV II, California enacted a new, even cleaner category known as SULEV, with 80% less HC and 70% less NOx than the ULEV standards, in order to encourage the production of hybrid electric vehicles. Even so, Nissan has announced that it will be able to meet the SULEV standard without using hybrid technology, with the use of a new conventional gasoline engine that will be debuted in 2001. The Federal Tier 2 standards are similar to the CA LEV II standards, except that for Tier 2 the fleet average is based on NOx rather than HC. Further, under LEV II, the average car will be a ULEV, while under Tier 2, the average car will only be a LEV.

Mr. Wenzel then contrasted the intent and the reality of on-board diagnostic systems. Such systems were originally designed by CARB with the intent to reduce vehicles' in-use emissions and by 1996, all vehicles were required to have such systems. From the consumer's perspective, the only visibility of these systems was a light on the dashboard which came on when the OBD system determined that the in-use emissions had reached a level that was 1.5 times higher than the car's original level of certification. The intent was to quickly identify emissions equipment malfunctions to a vehicle operator so that the needed repairs could be made in a timely fashion. Ideally, OBD systems were also intended to replace the conventional means of monitoring in-use emissions via I/M programs such as California's biennial smog check program.

The actual success that OBD systems have brought is that they now help manufacturers to identify design and manufacturing emissions equipment flaws and errors as vehicles are being assembled. This screening method helps to minimize the use and importance of emissions equipment recall testing. Manufacturers have also increased the durability of their emissions equipment in order to minimize the illumination of dash board OBD indicator lights so as to avoid the dismay of their consumers.

Along with these successes, however, there are also some questions about OBD systems that remain to be answered. For example, are the systems too sensitive such that consumers are given false failure warnings? Also, will non-dealer, independent mechanics have access to all the OBD information that they will need to provide complete and effective emissions equipment servicing? Lastly, since there is no flexibility in the sensitivity of most OBD systems as vehicles age, can they really replace I/M programs for vehicles that are 10 years old and are out of warranty?

3. Policy Approaches to Advance Technology

There are three general policy approaches to advance vehicle emission control technology: 1) standards, which can be either performance-based or prescriptive; 2) market incentives, which include information, taxes, feebates, and marketable credits; and 3) public R & D funding.

1) Standards

Emissions and fuel economy standards tend to be performance based, even if the standard level is selected based on preferred technologies. Two exceptions to this are OBD regulations and the CA ZEV mandate:

A) OBD: OBD makes use of a prescriptive standard via a regulation that specifies technology in detail. OBD systems, however, only anticipate when emissions standards will be exceeded; the sensors do not directly measure actual emissions performance. The question should also be asked whether the same results as those obtained with OBD could have been reached at lower cost using extended emissions warranties and stronger recall testing programs.

B) ZEV: The CA ZEV mandate was originally a prescriptive standard, requiring that a percentage of each manufacturer's California fleet be electric vehicles. Now, however, the use of partial ZEV credits for non-electric vehicles provides manufacturers with more flexibility than was permitted under the original mandate. For example, Honda has withdrawn EVs from the US and will now meet CA regulations using a hybrid design instead. In conclusion, vehicle performance standards set a firm emissions level and permit manufacturers flexibility in developing cost-effective technology to meet that level. Fleet averaging standards, such as CAFE, LEV HC, and Tier 2 NOx standards, permit even greater flexibility and also encourage technological innovation.

2) Market Incentives

Market incentives have come in many different forms. In theory, providing consumers information on the emissions of their vehicles may affect their vehicle purchase decisions, and may indirectly affect manufacturers' production decisions. The federal experience with new car fuel economy labels, however, has not had a large impact on customer purchase decisions. California has recently used a CA smog index label to show consumers the comparative emissions levels of new cars, and Colorado has provided the public with a ranking of car models by their I/M failure rate.

Taxes and fees are touted as the most efficient policy to encourage better fuel economy and lower emissions. However, they have proven difficult to implement since there are extreme political challenges involved with a gas tax and the large variability in vehicle emissions make it technically difficult to accurately measure vehicle emissions for the purpose of assigning an emissions fee. Feebates, which involve fees on low fuel economy/high emission vehicle purchases and rebates on high fuel economy/low emission vehicle purchases, may be attractive politically, in that the policy is revenue neutral (the total fees collected equal the total rebates awarded). Lastly, marketable credits may make sense for global pollutants and greenhouse gases, but they make less sense for regional pollutants such as ozone precursors.

In conclusion market incentives will only work if performance can be measured by the use of agreed upon methods. CO_2 emissions are less variable and thus easier to measure as compared to criteria pollutants; similarly, new car performance and emissions have proven easier to measure than in-use emissions. And incentives that rely on consumer response, such as information and taxes/fees, run the risk of not achieving their objective in reducing emissions.

3) Public R & D Funding
The third policy approach to advance technology is public R & D funding, such as PNGV. While the intent of the Partnership was to encourage the development of long-term, advanced vehicle technologies, any such technologies that are in fact developed by the Partnership will likely require some incentives for market acceptance. These incentives can include tax credits/feebates, fuel subsidies, preferential parking, or special lane access. However it is not clear that public funding was necessary to develop these technologies. Could the same goals have been achieved via higher CAFE standards and the use of feebates to spur efficiency innovation?

In closing, he thought it was important to note that since CO_2 is different from criteria pollutants, the polices that are needed to advance efficient technology may very well differ from those that can be used to encourage clean technology. For example, marketable credits may be more effective for CO_2 than they would be for criteria pollutants. By way of regulatory success, emissions standards have indeed advanced vehicle technology in several ways. Even so, regulators have both underestimated the potential of incremental improvements and the cost of technological improvements. And, while performance standards have provided manufacturers with design and technology flexibility, regulators still need to be vigilant to close the existing loopholes in the regulatory schemes.

Alex Farrell, Carnegie Mellon University
Historical Patterns in the Science, Engineering and Policy of Vehicle Emissions

Mr. Farrell presented several timelines of events to show how the science, engineering, and policies of different vehicle emissions issues have evolved over the last several decades. “Science” in this case refers to what is understood about air pollution in terms of chemistry, toxicology and epidemiology; “Engineering” refers to the knowledge of how vehicle emissions are formed and how they can be controlled in terms of fields such as mechanical, electrical and chemical engineering; and, “Policy” refers to government actions (such as studies, laws, or regulations) relating to air pollution. These timelines were compared with a very brief timeline of the auto industry innovation.

<u>Lead</u>

Pre-1900: toxicity known
1922: The anti-knock properties of tetraethyl lead (TEL) are discovered and leaded gasoline is introduced
1925: Public controversy over acute health affects of TEL and the start of “scientific hegemony” by the lead industry disputing the existence of any health effects from lead
1965: *Contaminated and Natural Lead Environments of Man*
1972: *Airborne Lead in Perspective.* 90% of all gasoline is leaded.
1974: *Sub-clinical lead exposure in Philadelphia schoolchildren*
1974: EPA announces phase-out of lead in gasoline.
1981: Failed attempt to reverse lead phase-out
1990: Clean Air Act: leaded gasoline banned.
1999: U.S. Army replaces lead bullets

<u>MTBE</u>

Late 1960s: ARCO invents MTBE
1979: MTBE approved as a substitute for TEL
1988: MTBE used in Denver to address wintertime CO problem, initial reports of reactions to MTBE fumes.
1990 Clean Air Act: oxygenated gasoline, MTBE is hazardous air pollutant
1991: ARCO introduces EC-1 as an affordable "clean gasoline"
1993: Widespread reactions to fumes, Oxybusters, first studies
1995: Widespread use begins, Santa Monica contamination
1996: USGS report
1998: UC study
1999: MTBE banned

<u>Smog – HC and NOx (early)</u>

1940: Mysterious new air pollution problem in L.A., role of auto exhaust identified first in 1951
1943-50: Mischaracterization of smog
1954: Auto industry sends first team to L.A. to investigate smog and forms cooperative agreement to "share" research and technology.
1957: Near unanimity on central role of auto emissions in forming smog.
1959: CA legislation to establish air quality and auto emission standards, 80% reduction in HC and 60% reduction in CO to go into effect in 1966.
1960-67: Increasing Congressional interest and federal legislation
1961: *Photochemistry of Air Pollution*
1962-70: Rise of environmentalism and decline of auto industry reputation - *Silent Spring, Unsafe at Any Speed, Vanishing Air*, Earth Day

<u>Smog – HC and NOx (middle)</u>

1970: EPA established, Clean Air Act Amendments - 90% cuts
1973: First oil price shock, CAFE standards later implemented
1974: Big steps in ozone science
Role of NO and NO_2 in the chemistry of the troposphere and stratosphere
Mathematical modeling of photochemical air pollution
Rural and urban air pollution in New York State
1974 and 1977: Emissions standards delayed and relaxed by Congress
1975-77: Japanese and European automakers introduce cars with advanced emissions controls
1979: Second oil price shock
1981: U.S. autos meet (relaxed) emissions standards for the first time
later 1980s: Emergence of "in-use" and "gross emitter" concepts

<u>Smog – HC and NOx (late)</u>

1989: *Catching Our Breath*
1990: Clean Air Act Amendments and California Low Emissions Vehicle (LEV) program
1991: *Rethinking the Ozone Problem*
1993: Many U.S. autos meet original 1975 standards for the first time
1995: *On-Road Vehicle Emissions: Regulations, Costs, and Benefits*
1996: Honda introduces first ULEV, requirements for EVs delayed.
1999 LEVs and ULEVs available in many vehicle categories; alternative fuels are little used; 1998 ZEV requirement rolled back in 1996; Foreign manufacturers (e.g. Honda) somewhat greener emissions standards set by rollback approach

<u>European Sketch</u>

1970: First European-wide standard for fuel, "Optional Harmonization"
1970s: Auto exporters develop technologies for compliance with U.S. and California requirements.

1978: First European limit on lead in gasoline
1980: First European air quality standards
1982: Waldsterben in Germany accelerates Green movement
1984: Systematic air quality monitoring (EMEP), start of lead phase-out
1985-89: European auto industry struggles, different markets result in different preferences for emissions standards (i.e. UK domestics for lean-burn, German exporters for catalyst), end of optional harmonization
1992: European Union formed by Maastrict Treaty
1996: First European air quality management framework (96/62EU)

Auto Industry Innovation & Competitiveness

1900-45: Technological convergence. Ford and Sloan business models.
1945-73: Emphasis on style plus incremental technological changes and new luxury items such as air conditioning and automatic transmissions.
1974-1983: U.S. auto industry in crisis due to oil price shocks and import competition.
1984 - present:

> Technological changes are used to increase vehicle performance and size.
> Emissions much lower, but no fundamental changes in powertrain or fuel.
> Innovation occurred even during periods of constant emissions requirements.

Overall, emissions regulations appear to be a minor issue for innovation in the auto industries; the difficulties in the mid/late '70's were largely symptoms of bigger problems related to oil price shock effects and the expansion of Japanese competition.

After presenting the above timelines, he discussed what economic and engineering research on innovation says about the interaction between regulation and innovation. First, innovation depends most on related infrastructure so the most important government policy is to promote infrastructure. Second, environmental regulations can have a significant impact on R&D expenditures, but not necessarily on inventive activity. Third, mature industries prefer incrementalism while radical innovations require long-term goals for continual improvement. Fourth, regulation has improved oil refinery productivity, but it has had little to do with innovation, productivity, or profitability since innovation is driven mostly by markets. Lastly, regulations can either inhibit or encourage innovation depending on how they are designed.

Mr. Farrell pointed out that several patterns observable in the vehicle emissions history are quite consistent with these general findings:

- Historically, air pollution policies have often been enacted prior to there being definitive scientific evidence and prior to there being well-understood technological responses.
- Emissions standards have generally been set by "roll-back".
- Progress is most difficult when core products are threatened.
- Air pollution policy has had virtually no effect on the overall long-term fate of the automobile, oil industries, or of specific firms, but, it has had a large impact on the shape of some technologies, such as catalysts.
- Research is often narrowly framed, leading to costly errors.
- In the past, U.S. auto standards have often been met best by imports, largely due to the better management/production practices of foreign auto firms, and because those firms tend to have less political leverage and so tend to accept regulation more and fight it less.
- There has been repeated consideration of alternative fuels and powertrains, but incremental changes to conventional technologies have always won.

With these historical perspectives in mind, Mr. Farrell then offered some closing thoughts on looking ahead. For one, our present scientific understanding of climate change is as good as, or better than, the understanding we had of some air pollution problems when they were first regulated. Similarly, the technological options for mitigation and control of GHGs are, by comparison, better understood, although there is surely a long way still to go, especially on reducing costs. Second, the international harmonization of emissions standards is likely to increase and it is likely to be upwards, towards more stringent standards. However, trying to draw parallels between developed nations and the less industrialized countries is not very useful due to the scale of the problem, the endemic poverty, and in these nations' political economies. Lastly, drawing parallels between the challenges of the auto and the oil industries on air pollution and climate change are also not very useful because climate change does in fact challenge core products, fossil fuels and the internal-combustion engine. However, current research may address this problem.

Paul Leiby, Oak Ridge National Laboratory
Policy and Technology Transitions

The general purpose of Mr. Leiby's presentation was to discuss the factors which influence technology adoption and diffusion and some of the modeling "technology barriers" in the context of an alternative fuel vehicles (AFVs) and alternative fuels (AFs) adoption model which he and his co-author, Jonathan Rubin, developed.

The two main aspects of technological change are 1) innovation and 2) adoption and diffusion. As to the first, the rate of innovation is both difficult to predict or to guide via policy. However, his model focuses on the latter two aspects which require a great deal of prior, qualitative discussion. Many projections for the adoption and diffusion of technological change reflect idealized long-run potentials, and they may also rely on smooth penetration curves, fixed introduction or availability rates, and fixed cost estimates. Actual adoption strongly interacts with other market outcomes and policies, and involves dynamic barriers and feedback. Several adoption problems that often exist in the context of large, self-reinforcing, technology based systems are: a) technology adoption often requires an elaborate infrastructure network; b) long term horizons and "technology lock-in" can challenge policy objectives; and c) positive feedback and complex dynamics can challenge policy analyses.

With regard to the latter, there are several sources of "positive feedback". For example, there is learning by doing via the manufacturing process, and, social learning by consumers. Other sources include production economics of scale with very large firms, network benefits, and infrastructure requirements which make introduction costly.

With specific regard to AFVs, hybrids, and FCV's, they all face transition barriers that are common to other technologies. Leiby and Rubin's model is used to evaluate the effectiveness of alternative policies for these technologies and is used to illustrate the limits of long-run equilibrium analysis or technology penetration scenarios. The technique that is used in their model can also be transferred to evaluate other technologies and industries.

He went on to discuss several of the standard connections between policy and technology adoption. To begin with, there are market-policy interactions which include resource supply and demand curves as well as the fact that prices balance connected markets endogenously. Other connections include the effects of multi-technology consumer choices which are dependent on the endogenous price and non-price attributes of a technology, as well as the application of tax and other policy levers at multiple points such as retail fuel, fuel production, vehicle sales, etc. He presented a chart to examine the aspect of consumer choice over multiple technology options in more detail in order to distinguish the endogenous and exogenous factors that affect these choices. For example, he listed the following as the endogenous factors that influence consumers' fuel and vehicle choices: fuel price, fuel availability or the fraction of stations offering a given fuel, vehicle price, and vehicle diversity. By contrast, the exogenous factors are: refueling frequency based on vehicle range, refueling time and cost, performance effects on fuel consumption, performance changes in horse power to weight ratios, and cargo space as it relates to the space that is required or lost for fuel storage.

Changing his discussion to the transitional adoption barriers for advanced technology vehicles, he showed that with economies of scale, several of these technologies would become closer to being cost competitive with the production costs of conventional vehicles. This could occur as production numbers exceeded 20,000 units, or in the case of electric vehicles, perhaps closer to 100,000 units. This transitional adoption barrier/factor and others are considered in their TAFV model, as are other factors such as network externalities and infrastructure barriers.

He went on to explain that policy intervention is possible at many points, and discussed several examples thereof. For example, current policies include: EPACT which will involve 2% of new vehicles by 2005 with regard to private and local fleets and require 50% alternative fuel use for these fleets; the continued ethanol tax credit; and, a low-GHG fuel subsidy. Other polices that could be considered include: a broad-band alternative fuel (AF) credit, such as a fifty-cent AF credit from 2004-2009; new technology and fuel credits; the increase of CAFÉ standards by 1 mpg; and, a retail AF sales mandate of 30% by 2010. He also showed that a range of different scenarios can be considered with their model depending on the price and cost of different fuels and what tax credits existed for them.

To summarize the results and insights gained from their model, he stated that the market barriers to significant new vehicle/fuel systems are substantial due largely to limited retail fuel infrastructure availability and the economies of scale for vehicle production. Because of these barriers, without some new policy initiatives such as sustained large subsidies or, significant increases in oil prices, the EPACT 2010 AF goals will not be achieved. One such new policy could be a Fuel Sales Mandate which would achieve the EPACT goals. However, it would be expensive and such a policy would probably involve the least cost if it were based on a single vehicle/fuel technology, such as imported methanol and dedicated alcohol vehicles. In order to accomplish a reduction in GHGs, a low-GHG tax credit or ethanol tax credit could be employed that could result in the displacement of 12-22% of the gasoline market depending on the price of oil.

He felt that a limited vehicle sales mandate used as a transitional policy would not be effective in inducing extensive advanced technology vehicle purchases or AF use. Further, he thought that mandating 50% fuel use by fleet AFVs would not be adequate either given the low price of oil. In all, their model quantifies the magnitude of the transitional barriers for AFVs and AF use at $1.00 per gallon at present, and declining to $0.50 by 2010, and this is based on the cost of the fleet mandate and the inability of a large oil price rise to induce change. This reinforces their conclusion that low oil prices will be a long term barrier for the adoption of these technologies, and, without eliminating this long term barrier, transitional policies can be ineffective and costly. Their model can explore combinations of conditions where transitional policies can effectively overcome short term barriers as would be the case with higher oil prices, sustained AF subsidies, and cost reductions from R & D.

Another aspect of their model is that it can be used to consider the interactive effects of different policies such as CAFÉ, AMFA, and EPACT. To explain, under AMFA, AFVs are considered very high MPG vehicles for the purposes of CAFÉ standards and the model estimates the value of these credits to be $550-$1,100 per FFV or dedicated vehicle, respectively, and up to 0.1%-0.5% of sales, respectively. The model results further show that these credits would be used and that they would influence vehicle manufacturer behavior.

Session V How to Market Clean and Efficient Vehicles

Chair: Tom Turrentine, ITS-Davis

Speakers:
Ben Knight, Honda Motor Company
Short and Long Term Approaches: Striking a Balance

Kenneth Kurani, ITS-Davis
Social Marketing of Clean, Safe and Efficient Vehicles in America Thus Far

Ben Knight, Honda R&D Americas
Short and Long Term Approaches: Striking a Balance

Mr. Knight explained that Honda's strategy to advance on common environmental goals is by pursuing a balanced, dual approach. First, continue to improve on practical current and near term technologies that can have the greatest immediate impact on the environment, and second, invest in advanced research and technology that has the possibility to deliver major benefits long term.

In a review of key energy and emission issues, Honda notes that the current high public concern for air pollution is being followed by an increasing concern for climate change and in the not so distant future, energy sustainability. (He noted that regional socio-economic factors and differences worldwide influence these priority concerns and timeframes.) Honda's technology strategy and R&D direction is aimed at these three energy and emission issues. Honda recognizes that extraordinary improvements will be needed not only to achieve these environmental goals for society at large, but also, that there currently exists no single technical solution for their simultaneous achievement. As a result, the industry's continued progress toward cleaner and energy efficient transportation will require continued R & D on alternative technologies and fuels. Further, these environmental goals can only be achieved by the coordinated efforts of the public, industry and government. Honda has made an effort to actively and creatively promote clean and efficient technology to the public, and continues to learn from these efforts and the introduction of cleaner cars nationwide.

Honda's long term goals concerning climate change and sustainable energy will likely be addressed by long term technological solutions like fuel cells, hybrid electrics, weight reduction, and alternative fuel vehicles. Honda will also continue to improve the environmental performance of gasoline fueled transportation since it will play a major role for at least the next two decades. However, since there is presently a limited consumer interest or demand in fuel efficient technologies, the goal for increased vehicle fuel economy can only be achieved if there is a public consensus on the issues and, consumer demand and interest in such products is increased through the coordinated efforts of government, auto makers, and fuel providers. Such a concerted effort would need to orient the consumer toward more fuel efficient vehicle purchases in the near term, and alternative technology and fuels in the long term.

An added challenge in achieving mid-long term energy goals is the chicken and egg problem that exists between advanced alternative vehicle technologies and the provision of new infrastructure which they will require. Thus, at the same time that consumers need to be re-oriented to encourage market demands for fuel efficient products and technologies, consumers can not be expected to accept or demand new technologies unless and until the necessary infrastructure for them is made available. As a result, the attainment of our transportation environmental goals must jointly address these two critical aspects of consumer orientation and infrastructure development. One of Honda's approaches is to offer advanced AFV technology to the market in order to encourage a market and infrastructure development. The Civic GX alternative fuel vehicle is such an example.

Mr. Knight then discussed Honda's dedicated compressed natural gas (CNG) Civic GX as an example of a mid-term technology that has been developed toward the achievement of Honda's environmental transportation goals. He asserted that this vehicle is considered by many as the benchmark in the industry for a dedicated CNG vehicle due to its performance, range, low operating cost, safety, reliability, and its outstanding emissions and energy benefits. Specifically, the GX offers similar drivability, performance, and fuel economy as a gasoline powered Civic. In independent testing, it provided a 26% reduction in CO_2 compared to the gasoline Civic, and its total vehicle emissions were at or below 10% of ULEV standards. Even so, to improve the marketability of this technological success, the existing infrastructure would have to be upgraded to provide: a) effective temperature compensation for full fuel fills and therefore maximum range, b) a common credit card payment system, c) re-fueling stations up-rated to 3600psi where feasible, d) and the promotion of leading specifications and features for new installations.

Other technologies that Honda is developing to increase fuel efficiency and/or decrease emissions include weight reduction, continuously variable transmissions, lean burn engine operation, and VTEC variable valve timing engine technology. One of the stars of its conventional ICE developments is what Honda refers to as its gasoline ZLEV engine. The research prototype ZLEV vehicle, when run on standard California grade gasoline, is said to have tailpipe emissions that are 1/10 of ULEV, and zero evaporative emissions obtained by the use of a sealed fuel system technology. In fact, the car is said to burn so cleanly that in some circumstances, it can produce tailpipe exhaust that is even cleaner than its ambient air supply.

In his discussions of the EV Plus, Mr. Knight commented that Honda's approach is to advance the vehicle technology as far as possible in order to give government, fuel providers, and the public the best understanding possible of the capabilities and potential of this new technology. Honda is currently evaluating advanced battery EV technology, market acceptance factors, and infrastructure issues. Honda's large scale demonstration program includes consumer use of EVs. Preliminary findings suggest very exceptional values and considerations from these users. For example, their highest priorities for vehicle choice are environmental performance and technology appeal, which is a marked contrast from other vehicle consumers. Many EV Plus consumers report they are able to make 90% of their trips with this vehicle, and have some means of accommodating the trips beyond the range of the EV.

In the near future, Honda will be introducing its new hybrid vehicle in December, 1999 – the Insight. The Insight is a super-fuel efficient, electric-motor assisted ICE vehicle. Specifically, it will offer the following technological innovations: a) a 1.0 liter lean burn ICE with electric motor assist and regeneration; b) lightweight aluminum body parts; c) a lean-burn compatible NO_x catalyst; d) good aerodynamics; e) reduced engine internal friction; f) idle stop; and g) instantaneous fuel efficiency instrumentation for educating the driver. In terms of marketing the Insight toward the consumer, it will offer aerodynamic styling, good performance, quiet operation, convenience features, ultra high fuel efficiency, and ultra low emissions.

Honda is also currently involved with other transportation innovation projects including the 12 vehicle smart car sharing project called 'CarLink', operated in the San Francisco bay area~~,~~ and organized by UC Davis to examine station car and business center coordinated vehicle use. Also the UCR CE-CERT 'Intellishare' Project, utilizing 15 EV PLUS vehicles, which is examining Intelligent Community Vehicle System (ICVS) architecture in a multi-port experiment.

In closing, Mr. Knight stated that "as a responsible member of society…Honda will make efforts to contribute to human health and the preservation of the global environment~~al~~". In order to progress toward this goal for the common good, Honda is willing to develop and market clean and highly efficient products, provided there is a fair and feasible public policy framework to facilitate such business ventures. However, given the current, low level of consumer interest in such products, a fundamental change in the consumer's sense of value and responsibility for the use of cleaner and more efficient technologies is necessary.

Kenneth Kurani, ITS-Davis
Social Marketing of Clean, Safe and Efficient Vehicles in America Thus Far

Dr. Kurani began his presentation by explaining that the purpose of his presentation of "social marketing" is threefold: a) to address "vehicle" attributes which have systemic and social dimensions, such as safety, efficiency, and emissions; b) to discover and facilitate the expression of values related to systemic/social attributes such as views of personal health, fairness, and stewardship; and, c) to facilitate citizen/consumer participation in policy formation and market processes.

In the course of conducting social marketing for transportation, there are essentially three ways in which consumer responses are conceptualized: “status quo,” “historical dislocations,” and “continuous change and adaptation.” The status quo contains all the existing services and products from which consumers will evaluate any novel alternatives, and at the same time, any such alternatives must be sufficiently like those in the present to be accepted by the consumers. Historical dislocations, on the other hand, involve consumer adaptation in the face of large dislocations of historical conditions e.g., fuel prices. Lastly, continuous change and adaptation involves the detection of consumer response changes via the use of guided, reflexive observation. Such observation he argues is “therapy.”

This concept of “transportation therapy” is based in part on Anthony Gidden’s structuration approach which states that the transformation of time and space in modernity and the impact of that transformation on culture includes the two key concepts of: a) reflexivity and b) lifestyle.

Further, with the above background concepts explained, Dr. Kurani went on to explain that social marketing is the application of commercial marketing technologies to the analysis, planning, execution, and evaluation of programs designed to influence the voluntary behavior of target audiences in order to improve their personal welfare and that of their society. Social marketing focuses on the welfare of the target audience as opposed to that of the marketers, and as a result, it not only emphasizes the subject-object relationship between policy and consumers, but it also stresses the need to treat “the market” not as a single entity, but to address the people who make up the market.

When we try to determine what the people that comprise the market want or demand, we are actually trying to determine the mental models that are shared by a social group, which together comprise a cultural model. When Kempton, Boster, and Hartley undertook a study of American environmentalism (with specific emphasis on global warming) they discovered more than one cultural model with regard to matters of energy, efficiency, global warming and environmentalism. Their research on this area has disclosed at least two, distinct cultural models about solutions to global warming. On the one hand, specialists tend to espouse solutions based on efficiency within the existing fuel pathways. Laypersons, by contrast, do not seem to draw the connection between global warming and efficiency based on their cultural model. In turn, laypersons find it easier to conceptualize a solution to global warming that is based on a transformation to alternative, non-carbon based fuels rather than a solution based on the efficient use of conventional fuels since they incorrectly connect global warming with pollution in their cultural model.

What this tells us is that if we want to encourage the marketing of fuel efficient technology as a first step solution to the problem of global warming, the specialists still need to explain to and convince the larger public about the connection between conventional fuel efficiency and environmental problems. At a practical, day-to-day marketing level, what this also tells us is that any fuel efficiency information that is attached to a new vehicle on the show room floor is presented too late to have any impact on the public’s purchase behavior.

To conduct effective social marketing of more fuel efficient vehicles, then, we need to first decide what values and attributes we want or need to market such as safety, personal health, environmental stewardship, thrift, and/or fairness. Some current educational examples of the marketing of such values and attributes include the DOE sponsored Clean Cities program and the Livable Communities initiatives. The effective marketing of these ideas needs to come not only from a credible, educational source, but there also needs to be continuity and agreement among the educators about what is being marketed. To date, such marketing efforts lack such a concerted characteristic and tend instead to offer only bits and pieces.

To summarize, since laypersons do not presently connect the efficient use of conventional fuels with the alleviation of global warming, they do not, as consumers and citizens, support efficiency gains in the market. To effectively correct this lack of understanding, social marketing can be used to educate the public about the connection between efficiency and global warming as a first step solution to facilitating consumer demand for more efficient products.

Session VI Idea Development for Programs, Research, and Policy Break Out Sessions

Moderator: Barry McNutt

The conference participants separated into five sub-groups of their own choosing, after which the following summaries of these break-out discussions were presented to the conference at-large:

Break-Out Groups and Summaries:

Group 1: Theme: Modeling Gaps in the Transportation Community and the Need for More Data Types

The group reported that there are currently modeling gaps in four areas:

1. Full fuel cycle and environmental aspects
2. Income and fuel price feedback effects
3. Consumer preference changes over time (20-30 year period)
4. The lack of a world model (carbon trading, world oil price estimates)

In response to these gaps, the types of data that were deemed needed are:

1. VMT for various types of models - more detail, not just speculation
2. Seasonal effects related to VMT
3. Updates to outdated assumptions concerning in-use driving characteristics
4. Fleet data and used car data

Group 2: New Fuel Economy Standards (revisions to CAFE)

The following suggestions were made for the kinds of revisions that could be made to the current CAFÉ standards:

1. Carbon based full fuel cycle emissions standard gradual increases
2. Vehicle volume based standard by vehicle class
3. Combine domestic and import fleets for regulation averages
4. Raise the weight limits to include larger trucks
5. Make the test procedures more accurate for actual, in-use (on-road) fuel economy
6. Fines: replace the civil penalty with a more simple economic one
7. Make the regulation voluntary with market incentives
8. Timing for CAFE regulation updates: wait until after the 2000 year federal elections

Group 3: Public Education

This group summarized their discussions as follows:

1. First, fundamental education is needed at the "K-12 grade" level to teach "what is green". Consumers not only need to learn to demand "green" products, but they need to understand the fundamentals first.
2. For the immediate car buyer, labels on cars and marketing information are needed to emphasize how “green” a car is.
3. Following both of these, the vehicle manufacturers will compete to make the best green car.
4. Who should do the education? Vehicle manufacturers need to focus on educating the immediate car buyer, while the scientific, government and environmental groups need to focus on the longer term solutions and messages.
5. There is also a possible need for a public icon that is associated with the environmental movement similar to "Smokey the Bear".

Group 4: Political Atmosphere and How it Affects the Regional Environmental Movement

1. National sovereignty affects decisions
2. Political decisions can have a very large affect on environmental policy

Group 5: Hybrids, from 2000-2020

1. Fuel economy gains/improvement for hybrids depend largely on the particular driving cycle, with gains much greater as congestion increases and average speed slows.
2. ANL projections from an industry Delphi study:
   a. 2005: Spark ignition gasoline engine will be the focus.
   b. 2010: Diesel hybrids and fuels will peak in demand, then drop off, as other fuels for fuel cell vehicles expand thereafter.
   c. By 2020, hybrid fuel economy will improve by a factor of 2.5; the cost of hybrids will be 1.15 times that of conventional vehicles; NOx emissions of hybrids will be 1/3 that of conventional vehicles; fuel cell hybrid vehicles begin to replace ICE hybrids along with methanol and hydrogen fuels.

Session VII Toward a Sustainable Transportation Future

Chair: John DeCicco, Environmental Protection Agency

Speakers:

Chris Grundler, Environmental Protection Agency
Michael Love, Toyota Motor Sales, USA, Inc.
David Hawkins, Natural Resources Defense Council
David Rodgers, Department of Energy

The theme of this section was for the speakers to discuss the results of the conference and make their case for the next century, with specific regard to two matters: a) What are the policy steps that will guide us to a sustainable future?; and, b) How do we foster the progress we have seen in the last decade and keep pace with the growth of transportation demands?

Chris Grundler, EPA

Mr. Grundler began by stating that in a post Tier II world, issues of climate change will become the main challenge for both the light duty vehicle (LDV) and the heavy duty vehicle (HDV) sectors. He thought that while climate change concerns will thus eventually be the main driver for changes in the transportation industry, given that global warming is the ultimate externality, the industry can not be relied upon to address this problem without the driving force of government regulation. He also noted that since global warming is a big problem without any obvious solutions, he agreed with Linda Lance's comment that this problem will only be solved if there is a strong push for change by either the industry or the public. Since there is no such push from either source at present, he asserted that a crisis would probably also be an effective means to mobilize corrective action, but at the same time, he acknowledged that a crisis of the global warming magnitude would come too late.

Under these circumstances, in which the problem is complex and the solutions are uncertain, cynicism abounds and this, in turn, can have a corrosive, counterproductive effect. In response, he stated that without at least hoping for progress under these conditions, no progress will ever occur. We must keep in mind that our goal is sustainable living for the future and we must continue to work toward that end not only with hope but also with an ability to deal with the obstacles and pessimism along the way.

With the above said, he posed the rhetorical question, "So, where are we going?" In response, he explained that there will not likely be one, silver bullet solution technology, nor one silver bullet policy. He expressed a fear that the issue of climate change might be "hijacked" by economists and policy "wonks" who would make the same kinds of mistakes that they have made in the healthcare industry by trying to come up with a neat, complex and perfect solution. Instead, we should not try to focus on such a complex solution of perfection; rather, the better strategy will be based on practical policies which make sense and are based on common sense. Such practical solutions should be based not on a single policy, but rather, upon a framework of complementary policies. And as for our own domestic policies, he stated that they must serve as an example to the rest the world so that we, as the leading energy consumers, can show that we are doing something effective ourselves.

The four keys to effective global warming policies are: 1) technology R & D; 2) market incentives for technology adoption; 3) standards; and 4) increasing social marketing/public education. The question is, however, how can we best bring these four elements together to show people that we not only have an issue that needs addressing but that we can also move forward on its solution. For starters, we have to broaden the constituency of support so that the public becomes more aware of what the stakes are and why they should care. To date, we have made so little effort in this regard that it should come as no surprise that there is very little public or political support. This, in turn, gives the misleading impression that these environmental problems are intractable. The outreach to the public thus needs to be more consistent and sustained than it has been to date since significant policy change will only occur in this area if we can effectively inform and educate the public.

With specific regard to CAFE, Mr. Grundler mentioned that some people think that it should be abolished entirely, while others feel it should be made more stringent. He asked that we consider the issues of whether there is a third and better solution, and he encouraged government and industry to begin a discussion on what better regulatory options might be available to the current CAFÉ regulatory scheme.

As for the next Asilomar conference, he stressed that we must bridge the gap between the analytic and policy communities and he would like the next conference to serve as more of a problem solving mechanism toward that end. Two areas in which it would be particularly useful to bridge this gap are social marketing and the relationship between incentives and standards.

Michael Love, Toyota Motor Sales, USA, Inc.

Mr. Love presented "things which he thought he heard" during the course of the conference from other speakers, as summarized below:

a) Alternative fuel vehicles will not proliferate on their own, but will require government incentives – Phil Patterson. Mr. Love agreed with that since such proliferation is not an easy task, but he did not think that such incentives have been sufficient to date.
b) Just when we think that we are running out of oil, new technology is found which expands the supply – Barry McNutt. In response, Mr. Love felt that this continued reliance on the established oil production industry puts us in a tricky place.
c) The reactions of the public in the United States are profoundly different from those in other parts of the world with the effect that policy and other solutions that might work elsewhere will not necessarily be effective here - Lee Schipper.
d) Regulation is needed to level the playing field among the private sector participants, otherwise, they won't pursue any changes on their own. As a corollary, even if a manufacturer wants to do the right thing, they will not be able to without the playing field being leveled by government regulation - Linda Lance.
e) Ford is still trying to determine if consumers are willing to pay for environmental improvements and if so, how much. Further, it is discouraging how little people are actually willing to pay for such things, but Ford is still trying to see what it can do - Kelly Brown.
f) Auto manufacturers must join in the drive for increased gas taxes, otherwise, they will be the target of opportunity for CAFE increases - David Hawkins.
g) If the fossil fuel economy is going to improve, all parties, including the public, must be involved - Greg Dana.
h) New emissions inventory models are showing that things are actually worse than we thought - Alan Lloyd.
i) We should move toward fuel cell vehicles because they are a superior product to ICEs, not because of any shortage of oil - Ferdinand Panik.
j) Efficiency, and not emissions, will determine technology selection - Andrew Burke.
k) A comprehensive accounting of both conventional and greenhouse gas emissions is needed to identify technological stepping stones - Jason Mark.
l) We need to agree on a long term vision of what our social objectives are before we engage in discussions for how to get there - Mark Delucchi.
m) Environmental problems are about technology - David Greene.
n) A technology miss-step by a manufacturer has the potential of "poisoning the well" for all who come later - Steve Plotkin.
o) Low oil prices are a long term barrier to alternative fuels - Paul Leiby.
p) Public policy must get consumers to value better fuel economy and emissions - Ben Knight.
q) Lifestyle changes imposed by environmental and efficient vehicles are still a big issue for the lay public - Ken Kurani.

In light of the above comments, Mr. Love had a few comments of his own. First of all, he stated that the auto manufacturing industry is not a homogenous one - each manufacturer can have different ways of doing things. Second, he strongly agrees that the public must demand environmental vehicles, or their cause is lost. As to whether greater public demand for environmental vehicles can be created by the auto industry, he cautioned that auto advertising has proven effective at telling the public how certain products can satisfy their needs, but, it is not a very effective means of telling the public what their needs or wants *should* be.

He agreed with the earlier comments that there is no one, technological silver bullet solution to our environmental problems. Rather, he suggests that we can only attain our goals with incremental steps keeping in mind that no one technology will solve all our problems. This incremental and diversified strategy is reflected in the process oriented technologies and marketing of both Honda and Toyota.
As a cultural business matter, this gradual kind of process tends to be a more Japanese based strategy as opposed to the usual American business strategy of trying to solve problems in one big, “home-run” shot.

He believes that there are significant barriers to the introduction and adoption of new technologies, such as the continual supply of cheap oil and the existing infrastructure of conventional fuels. Since this kind of established technology and infrastructure will be difficult to push aside, he suggests that the gradual, Japanese approach will be an easier route.

In closing, from a manufacturer’s perspective, we have to create a business environment in which making and selling environmental vehicles will be profitable and cost effective. When that is the case, if businesses can make money producing such products, we can rest assured that they will engage in such production.

David Hawkins, NRDC

His overall impression of the conference was that there was a plentitude of information and discussion presented about “how” and “what” we can do to achieve certain environmental goals. However, he is concerned at the lack of emphasis given to “why” we are heading for these objectives, both in this conference and in the last conference in 1997.

He also noted that there appears to be some confusion about what the goals are for the policy process and this is epitomized by the public’s apparent disconnect between energy conservation and pollution reduction. The truth is that these two aspects are really one and the same. He also noted that since the current pollution of carbon into the atmosphere is an a unprecedented perturbation in the context of the world’s geologic cycles, he finds it ironic that the public is shocked that such a massive disturbance would cause a problem, let alone a major one. To repeat, he stressed that this is an air pollution problem that we are facing.

The programs that have been used to push for environmental changes so far have not been effective because they have not had the staying power to keep the support of the politicians. The only way that we can get the continued commitment and support of the politicians is if the public starts demanding these changes from them. This demand can best be facilitated, in turn, by educating the public about environmentally inappropriate behavior in a manner that is sufficient to instill angry demands for change. It is our job to educate and instill such anger in the public for this purpose. Part of the message that we need to impress upon the public is not only that we have a huge air pollution problem, but that in order to solve this problem, we need to internalize the cost of using resources which are the cause of this problem.

There also needs to be a more effective connection between the social marketing and technological aspects of our environmental goals. On the one hand, the analytical and technical people have determined that there are certain technologies which are the problem and that they need to be replaced by other technologies which are the solution. However, we will never see the proliferation of those solution technologies unless we not only determine what public attitudes will be needed to demand those technologies, but we must also find a way to encourage those attitudes in the public – both via effective social marketing. In other words, it is not enough to develop solution technology at a technical level; rather, we need to incorporate that technology with the effective, social marketing of the public attitudes needed to demand that technology.

We can learn this kind of social marketing from political campaigns since they are a proven and effective form of this kind of marketing. We should study and learn from the advertisements in these campaigns so that we will have a better idea of how to tap into and shape the public's perspectives for environmental purposes.

In closing, he re-emphasized his perceived need for us to have more discussion about "why" these objectives should be pursued and not simply focus our efforts on "how" we are going to get there.

David Rodgers, DOE

Mr. Rodgers offered what he called a ten word synopsis of the conference: "Old technology is the problem and new technology is the solution." Explaining further, Mr. Rodgers stressed that its often easy to believe in new technological solutions even though some of the current problems were created by the old technology solution to the previous problem. Thus, we should use technology wisely, but guard against technology optimism or faith in the "next big thing." He also stressed that there are multiple paths to unsustainable transportation currently in existence around the world and, that we know much more about the problems than we do about the solutions. Tongue in cheek, Mr. Rodgers suggested that the best remaining options are those that we have not yet studied since the ones we have looked at so far aren't very good. He said that a common problem with advanced and alternative fuel technologies is that the more they are studied, the more reasons are found not to implement them.

Reflecting on his old/new technology paradox, he points out that it is *people* who will always be both the problem and the solution. For example, as *technology* begins to eliminate the local pollution impacts of vehicle use, this will in turn encourage *people* to use their vehicles more since they will create less environmental impact. When this happens, sustainable goals for transportation will be disconnected from their local environmental impacts, and the continued drive toward sustainable transportation will have to shift to other matters such as congestion or global warming. In the end, technology can not only solve certain problems, but it can also enable behaviors that contribute to the problem.

Technology alone cannot address public policy concerns, because technology will be used to meet individual consumer choices, not necessarily to benefit the public at large. For instance, manufacturers might use more efficient diesel engines to make larger trucks more attractive to consumers rather than introducing the technology to improve fleet fuel efficiency beyond the current regulations. To complicate matters further, technology advocates tend to minimize the disadvantages of future technologies while simultaneously minimizing the benefits of current technologies.

As we move forward, there will be significant debate over the paths of technology progress. For example:

- Competition from clean alternative fuels has played an important role in encouraging manufacturers to produce cleaner gasoline and diesel vehicles. Are alternative fuels important merely as a "foil," or are they important because of their direct benefits as well?
- Integrated approaches to cleaner air and energy independence that purport to require no sacrifice are intellectually pleasing, but they usually conflict with direct/indirect political and consumer priorities.
- Gasoline taxes would be politically difficult to enact unless combined with programs and/or regulations that deliver a specific result.

He offered his predictions and thoughts: First, we are jumping ahead too fast to the extent that people are waiting for fuel cell buses instead of buying the current conventional technology of CNG buses today. What this means is that people are postponing the adoption of cleaner, conventional technologies in the hopes of better, yet uncertain technologies of the future. Second, it is likely that all light-duty vehicles sold in the U.S. will become ultra-clean, to the point that other point sources of urban air pollution will become much more important. Heavy-duty vehicle emissions will probably remain a problem for at least the next 20 years in the U.S. In other parts of the world, however, developing countries will spend many more years with high levels of urban air pollution. Third, current trends are leading to concentration of energy sources, which conflicts with the likely need to use a variety of energy sources and forms to meet future energy needs. The desire for a single replacement for petroleum will continue to distract the world from the net benefits that are available through existing technology. This desire for a single replacement runs counter to the American desire for more choices in selections of consumer goods. Why not have fuel choices, such as gasoline, diesel, propane, electricity, biomass fuels (probably ethanol), natural gas, and hydrogen. Finally, regarding gas-to-liquid fuels (like Fischer-Tropsch diesel), the question is not *if* they will become viable, but *when* they will become viable, and they will produce net increases in greenhouse gas emissions unless mitigation measures are taken.

In closing, we have to stop searching for the right vehicles that consumers *should* want and need, and instead, supply what people *do* want and need for mobility while keeping them clean and green. To do this, we may need new policies and perspectives that will require a better understanding of cultural models. In the end, people and technology have brought us the current situation, and only people working together using technology appropriately will lead us to solutions to the transportation problems facing us.

Discussion among panelists:

Chair DeCicco began the panel discussion by posing the following issue: Conventional cars are generally marketed on issues of the quality and the ability of the product to meet the needs of the consumer. On the other hand, the forces that drive environmental and fuel economy regulations tend to be based more on the solutions that are needed to overcome fears. He wonders if we can flip these usual approaches to encourage environmental and anti-global warming products by making environmental qualities of cars meet the perceived positive desires of consumers.

In response to the above issue, David Rogers thought there is an increasing responsibility among educators and youth to accomplish this task. By way of example, he thought it was useful to contrast the aerosol can with the automobile. In the case of the aerosol can, an effective transition was made to get people to buy a more environmentally friendly product even when the risk involved, ozone depletion, was out of sight or touch to the common person. However, it is much more difficult to get people to buy environmentally friendly cars. The reason for this is that the market does not currently offer a readily available, equal quality alternative to conventional, polluting vehicles because policy has not sufficiently encouraged the availability of greener product substitution. We need to explore policies other than those like a gasoline tax which penalize people for doing the things they need and like to do. Instead, policies need to be implemented which give people viable alternatives and choices to the current, polluting options that are on the market. The problem is, such a change involves a money intensive transition from a status quo where all of the current capital is tied up in the conventional vehicles and infrastructure. We don't know how to get the money that is needed to make this change. He also added that the efforts that we have made so far to implement changes toward greener transportation only go half way. When we ask consumers to pay extra money for greener cars but we don't link the impacts of such decisions back to them, we can not really expect the public to take much action in this direction.

Chair DeCicco didn't think that we had really tried to do what Rogers suggested. Instead, DeCicco thought that most of our experience to date has been more like telling the public that even though a new technocratic solution costs more, they should need it. The problem with this approach is that such forced "needs" are not sustainable since they are not linked to peoples' real wants in a fundamental way.

Chris Grundler responded that part of the problem is a result of our short term views and concerns and is also related to how the media fails to provide information on long term concerns. For example, the public does seem to understand and receive plenty of media coverage about local air pollution, but longer and more tenuous concerns like conservation, national energy security, and global warming have not really been driven home to the public. At the same time that we need to better determine a way to get the message across on these issues to the public, we have to take caution to not become too elitist and engage in telling and dictating to the public what they should and should not need or want. To do this, we need to inform the public about choices, rather than force choices upon them via a sustained public education effort.

David Hawkins commented that the goal of convincing people through the use of education to make more environmentally friendly decisions needs to keep in mind that the educational message needs to make sense to the public within the context of what is important in their lives. For example, people don't connect issues of efficiency with concerns about local air pollution, and they don't relate to talk about grams per mile. Rather, we have to fashion a message that makes sense to the public in terms of things like the number of deaths or cases of lung cancer that result from something like air pollution. Carbon thus needs to be better articulated to the public in this way as a health harmful pollutant.

Michael Love made the point that people want to do "the right thing" and that they really don't want to do "the wrong thing". But at the same time, they are very sensitive about how "the right thing" will affect their pocket book and their time. We therefore need to give reinforcement to the public to convince them that both of these aspects can be compatible. He was also concerned that it is easier to address local pollution and smog problems with vehicles, as opposed to GHGs, because the former involves tangible, negative consequences that the public can be concerned about. Further, the technological solutions offered by the auto manufacturers to address these local problems do not force consumers to make any tough choices. The question is, can we do the same with carbon as a pollutant? We would likely have a better chance of succeeding in that regard if we can make consumers feel good about a greener choice that they can make, rather than taking a scolding approach which tries to make them avoid behavior which we try to tell them is bad.

Chris Grundler essentially agreed with the above point by stressing that effective public outreach should not tell people what they are doing wrong or how they are being bad. Rather, we need to instill in people a value that is associated with our conservation goals. People will not give up what they want, so we can not tell them to change their lifestyle, but, we can create a demand for cleaner products.