ECONOMIC DEVELOPMENT AND INFRASTRUCTURE COMMITTEE

Inquiry into Mandatory Ethanol and Biofuels Targets

Melbourne—6 August 2007

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Witnesses

Dr T. Beer, Leader, Alternative Transport Fuels Stream, Energy Transformed Flagship, CSIRO; and Mr P. Campbell, Team Member, CSIRO.

The CHAIR—I welcome Dr Tom Beer and Mr Peter Campbell to the public hearings of the Economic Development and Infrastructure Committee's Inquiry into Mandatory Ethanol and Biofuels Targets in Victoria. All evidence taken at this hearing is protected by parliamentary privilege. Comments you make outside the hearing are not afforded such privilege. Could I ask each of you please to state your name, business address, the organisation you are representing and your position within that organisation. Thank you.

Dr BEER—Thank you. My name is Dr Tom Beer. I work for CSIRO. I am situated at their Aspendale laboratories, which are at 111 Station Street, Aspendale. You should all come and visit sometime. Within CSIRO I am the Stream Leader of the Biofuels Stream of the Low Energy Transport Theme of the Energy Transformed Flagship.

The CHAIR—You win the prize. Mr Campbell.

Mr CAMPBELL—I am Peter Campbell. I work in the same institution at the same place. I am assistant to Dr Tom Beer as a research scientist.

The CHAIR—Thank you. As I explained, Mr Crisp has to leave. As you have given us permission to ask questions first, I will ask Mr Crisp to put those to you and then he has to leave.

Mr CRISP—Thank you, gentlemen. I read the submission you supplied to Tasmania and then followed on and then today I notice you have an abbreviated submission. There are a couple of things I would be interested to talk to you about, and that is the hydrogen fuel model. I accept in the short term we are considering biofuels; in the longer term we may have to consider other fuels. Within that hydrogen model there what interested me were your comments that at reasonably low cost the introduction of hydrogen to the fuel mix in the conventional car improved environmental outcomes within the combustion process. I would like to hear some expansion on that because it was indicated that it was relatively low cost.

Dr BEER—I would have to deal with that off the top of my head. Basically the reason it is environmentally friendly is that in urban areas the exhaust from the hydrogen vehicle in theory should only be water vapour so there is no air pollution associated with it. We have spent a long time looking at the greenhouse gas and climate change implications associated with hydrogen. There is ongoing work on some of the more abstruse aspects of that, but the quick conclusion there is the hydrogen needs to have been made from some form of renewable rather than the obvious source of hydrogen in Australia, which would be steam reforming from natural gas. For instance, in Perth at the moment where they are running hydrogen buses as a trial, the hydrogen made by steam reforming is neither particularly cheap nor is it particularly a valid way to reduce greenhouse gases because in fact it is neutral. You do no better in terms of greenhouse gas emissions with that than you would if you were running a diesel bus. On the other hand if you could make the hydrogen from solar collectors, from wind, tidal power, nuclear or any form of renewable that does not have carbon emissions associated with it, then hydrogen can look very good. I have not done the detailed costings on hydrogen to be able to say that is going to be a cheaper way or not.

Mr CRISP—Or whether it was economic to do some injection into fossil fuel based fuels. Thank you.

The CHAIR—Do you want to make a comment on that, Mr Campbell?

Mr CAMPBELL—My comment would be we need to follow that up to get you better figures.

Mr CRISP—The second question is whether you had a view, with a mind to

hydrogen as a fuel, as to whether the efficiencies—and I am sure this will have to be on notice, by the way—that brown coal to oil is something that we see discussed versus burning the brown coal to produce electricity, to produce hydrogen, have there been any thoughts on the economics of those two paths?

Dr BEER—We have started work on that. In fact we received money from Federal Cabinet this financial year to start work on alternative fuels and that is going to be a research group that is working on coal to liquids, a research group that is working on gas to liquid fuels, and then the biofuels group that I am leading. Hopefully, if you can wait another three years or so, we might have better answers for you.

Mr CRISP—Thank you. I will stay a little longer and listen to your presentation but do not take me leaving as being a sign of anything other than I have to be somewhere else at five.

Dr BEER—I am sorry, if you had given us a bit more notice that hydrogen was specifically to be addressed here we might have come better prepared for that.

The CHAIR—You can take it on notice. That is fine. Over to you for your presentation.

Dr BEER—We sent a presentation—it looks like you have copies of—and what I really had intended to do was to briefly run through the main points in that and possibly spend a bit of time with the advantages and disadvantages of a mandated target for alternative fuels, including biofuels and ethanol, which was the terms of reference for the Committee. Putting it in a wider context that Mr Crisp was alluding to before, within CSIRO we do see the role of biofuels and alternative fuels in general as being that of a transitional fuel. In the long term we see the vehicle technologies moving towards more and more electrification. We have a lot of debates internally about, 'Are we talking about 30 years? Are we talking about 70 years', but over a period measured in numbers of decades we expect that the vehicle fleet will be very strongly electrified but we do not have a clear vision of whether that is going to be a plug-in vehicle where you plug it in at night and charge it up; whether it will be a fuel cell that runs on hydrogen; whether it will be some form of battery and supercapacitor technology that is going to give you the 'voom' for an electric vehicle that is required.

We do have research work on batteries and supercapacitors that CSIRO is very excited about and we hope it may lead to breakthroughs but we do not know. In the long term, the electric car, but at the moment our calculations indicate that is likely to be far enough away that in the interim we are going to have problems with oil. Again we do not have a crystal ball but there could well be supply problems, they could be pricing problems, and that depends on whether you believe that peak oil has occurred where demand outstrips supply or whether it is still possible to pump out more oil from the ground to meet the ever-growing supply. There is no sign that supply or demand are slackening off. If I may draw personally here, one of the most insightful calculations I did was to look at what Australia's petroleum demand was during the last recession, the one we had to have, where there is no dip at all, no decline in oil usage, it tapers off a little bit and then it goes up again. There is some economic term for it—

Mr THORNLEY—Inelastic.

Dr BEER—Inelastic, thank you. Probably we are going to have a problem and we need other sources of fuel. The obvious one within Australia as a country is natural gas. Something is going to have to be done to get the natural gas supply, but to do that things have to change. It is not a fuel that you can immediately use. You have to either convert the vehicle stock to natural gas vehicles or you have to build gas to liquid plants to convert the natural gas into a liquid fuel that can be used in the current generation of vehicles. The advantage of

biofuels is that they offer almost a 'business as usual' option that you can take this fuel and in the case of ethanol use it at about 10 per cent in petrol and then most of the vehicle fleet, as Orbital recently showed, not all of the vehicle fleet but most of the vehicle fleet can then use it without major modification. Similarly with biodiesel, the problems do not tend to be technical in the use of biodiesel but tend to be more social, that is the warranty; most truck manufacturers are pretty dubious about anything other than what they know and what they know is diesel. We have tried to summarise that in the submission in the merits or otherwise of mandated targets for alternative fuels including biofuels and ethanol. If I quickly run through them, as I have already summarised a number of these points.

The fuel security point, I have already said that it is either going to get expensive or there could be supply disruptions, but some time within the next 30 to 70 years there is probably an oil crunch coming. The balance of payments issue is an interesting one, which at the moment we are still—no, this might have been the first year where we have gone backwards in balance of payments on oil. We are importing more than we are exporting. In the past it has been the other way around. That is probably going to—

Mr THORNLEY—We are at peak oil even if the rest of the world is not.

Dr BEER—Yes. Australia definitely is, and America was a long time ago. Well put. Rural development:

> Virtually all first generation biofuels and most second generation biofuels require crops of some description. The biofuels mandate could lead to an increased demand for certain crops and hence investment in rural areas to produce these crops.

Now, as with much in life what can be seen as an advantage can also turn into a disadvantage, depending on who that favours and who that does not favour. Energy efficiency:

> A sizeable amount of energy is used to transport fuel from production platforms to refineries and from oil refineries to distribution centres. If there are locations around Australia producing fuel then the energy used in transporting fuel to where it is needed will be reduced.

That is because biofuel operations can be made more localised and positioned where the crops are rather than otherwise. I recently pointed that out to somebody that back in the old days in the 19th century when fuel was more expensive or moving things around was more expensive, the idea of transporting all of your wheat to a central location was less in people's mind. Instead you had threshing machines that used to go around from farm to farm, do the on farm threshing and then the local mills would do the milling and things would be produced on site. The cheap price of oil over now a century or more has meant that we have grown very used to centralised production facilities and most have come to believe this is the way it has to be. Now, there is a good chance that that may change in the future, depending on the price relativities.

Health issues: numerous studies show that the emissions, especially of particle matter, can have a substantial impact on health. This was a key point in the Prime Minister's Biofuels Taskforce that not enough is known as to whether putting 10 per cent ethanol into petrol will reduce particulate matter emissions or not. The Federal Government has funded a $4½ million study that CSIRO is undertaking with Orbital Engine Corporation specifically to examine that issue and take it from the emissions of vehicles through to the modelling of that so we get the spatial distribution worked out with where the population lives. Then we have some medical experts working with us on putting them into health effects and then trying to come up with a cost-benefit analysis at the end of that. We are hoping those results will be available around May next year.

Greenhouse emissions:

> Use of 'waste' products such as used cooking oil for biodiesel, methane from landfill for electrical generation and the like can lead to substantial reductions in greenhouse gases when measured over the entire life-cycle.

Then we have sets of numbers for what those emissions can be. I should digress here and point out that life-cycle calculations are important in these greenhouse gas emission calculations because in the early days a lot of people came to the Australian Greenhouse Office saying, 'I have this fuel that emits no greenhouse gases, it's ethanol', and according to the formal international rules of greenhouse gas accounting, they were telling the truth. Think of a burning match. There is CO2 emitted but you do not have to count that CO2 as a greenhouse gas because the carbon dioxide was taken up in growing the tree in the first place or growing the plant in the first place. The question then is not one of what is coming out of the tailpipe, but the question is how much energy do you need to use in making that fuel, in harvesting it, putting fertiliser on it, getting tractors around the place, moving it from where you have grown it to the centralised production facility. Now for at least six or seven years CSIRO has undertaken a process of doing those life-cycle calculations that we hope have a certain amount of credibility associated with them. They are probably the advantages. Those points were what we could see as definite advantages of having a mandate for biofuels.

The disadvantages that we could see were, there is a definite lack of supply. You only need to look at the share price of the biodiesel producers to see evidence of that. They are having real trouble getting hold of sufficient feed stock for biodiesel. We have recently done a study looking at imported palm oil and have serious concerns about the greenhouse gas emissions associated with imported palm oil, not to mention other sustainability issues associated with that.

> Second generation biofuels, which are biofuels made from cellulosic waste, do not have such an effect on food crops, but the economic production of second generation biofuels is an area of active research and development and is not expected to contribute to biofuel production for a number of years.

There is one theory though that does say that you can not get to second generation biofuels unless you have a first generation industry in place. Therefore it can be seen as a temporary, even if it is an inefficient measure, in order to get to the efficiencies involved in second generation biofuels.

The increased food prices are already an international concern. There have been tortilla riots in Mexico. I was recently talking to an Indonesian colleague who was very concerned at the price of palm oil because palm oil is widely used as a cooking oil in Indonesia and the increase in palm oil prices means that it is getting out of the affordable range for ordinary Indonesians. Similarly I have heard that the chairman of the company I have forgotten the name of that produces a lot of Australian soap products is greatly concerned that if tallow is diverted in a big way to biodiesel, we will all have to be paying a lot more for our detergents, soaps and so on that use tallow as a feedstock. Cost:

> A high proportion of the cost of producing ethanol and other biofuels is the cost of the feedstock. This price is very volatile.

You are really up to the difficulties of drought in that case, that if you have a drought then the price will shoot up. That does not happen with oil, but it could happen with biofuels. Lack of appropriate vehicles: we mentioned before that only 60 per cent of vehicles at the moment are capable of using 10 per cent ethanol. It is not too expensive to retro-fit and make the vehicles ethanol capable, but be aware because the proponents of many of these fuels will claim that all vehicles can use them and that may not be the case. Warranty issues: I also alluded to, that heavy vehicle manufacturers in particular will not warrant their vehicles for the use of biodiesel and will only provide a warranty to five per cent. Again there are claims that engines should be able to use 100 per cent blends of ethanol without problems but they have

not been investigated to the detail that the vehicle manufacturers would like.

Then the increased greenhouse gas emissions as a result of deforestation that I mentioned in terms of the palm oil and the greenhouse gas. Then the question of health issues; we do not know enough about them. I mentioned the study we are undertaking. They are probably the main things we had to say. We also mentioned the mandatory target; we really do not have much to say about whether the mandatory target should be 5 per cent or 10 per cent except to recommend that really if a mandate is introduced the wording of it should be quite carefully examined to make sure it does not have unintended consequences, which is if it specifically restricts other competitive fuels that could work just as well, and we were thinking of methanol versus ethanol, and butanol versus ethanol and so on, then that could be an unintended consequence of a particular mandate.

Measures required by the Government to facilitate an alternative fuels industry in Victoria: I do not really feel we are competent to comment on measures as such, but bring to your attention something I am sure you probably already know that you have two very small producers in existence in Victoria at the moment and there are plans that have been on the drawing board now for a long time to produce big facilities that do not seem to be getting under way. There is obviously a very strong interplay of market forces and government assistance that is involved where the current situation has come about.

How to maximise regional economic development benefits of a mandatory biofuels target, including jobs growth and investment potential: we really do feel that probably the situation should encourage Australian produced fuels rather than imported fuels. Again it will be a question of how a mandate is worded. I can remind you of the story—again I am sure you know—of the situation when Trafigura tried to import the shipload of ethanol from Brazil because it was far cheaper and still is far cheaper to import ethanol from Brazil than to buy it on the Australian market, but the Federal Government fixed that with a 38c per litre excise. The name had to be very carefully chosen so it would not violate the [WTO] regulations. I think it is a domestic excise there. Again, if there is a mandate in place, the options for import will be very strong because they are most likely to be the cheapest way to meet the requirements of a mandate.

We have already discussed this whole question of electricity as an alternative fuel and the fact that again if you do have sizeable numbers of electric vehicles, especially plug-in electric vehicles, then making electricity by burning firewood would be a biofuel. Whether that is your intention or not, that is not for us to determine but we want you to be aware that your remit could be very wide if you want to make it very wide.

The CHAIR—Thank you, Dr Beer. Mr Campbell, have you any comments you want to make now or would you like to leave that for questions?

Mr CAMPBELL—No, I am happy to go for questions.

The CHAIR—Thank you. Dr Beer, if you were writing our report with information you have at this point—it is the question I ask most of our witnesses—what would be your three recommendations? One witness wanted four, with a few parts; you are able three, plus more if you require.

Dr BEER—No, I do not think it is our role to make recommendations for you.

The CHAIR—If you wished to make any comment in relation to key items we need to very carefully consider, what would be your two or three?

Dr BEER—Except for the obvious one that we feel that CSIRO should be given

buckets of money to undertake research on biofuels—

The CHAIR—Fair enough, thank you. Mr Thornley.

Mr THORNLEY—You may be able to help me with the economics of ethanol production. From my limited understanding, sugar cane as a feed stock is much more efficient. Is that true and, if so, what are the barriers to Australia developing a sugarcane ethanol industry that might be in some way competitive with the Brazilians? What have the Brazilians done that has put them so far ahead on the cost curve? Somebody told me there is some sort of Cogen plant running off the thing as well. If you could illuminate on that a little for us. I realise that Victoria is not a big source of sugar cane but I am trying to understand—

Dr BEER—Yes. The Brazilian history is instructive and it helps to be in the middle of a foreign currency crisis that prompted them into certain action because they could not buy the oil. I forget what the Brazilian currency is—a Cruzeiro, I think. Back in the first oil shock of the 70s the Brazilians needed to find an alternative. They realised they had lots of sugar cane, and the government swung into action with that program. The disadvantage with the Brazilian situation is that given you are dealing with an internationally traded agricultural commodity, eventually it is going to happen that the price of sugar cane goes up, the price of oil was going down, and they overtook each other in what was an unintended direction and people were then abandoning their ethanol vehicles at which stage the Brazilians provided yet more government support and managed to turn the industry around. We have written that up in a document recently, which I could send to you if you are interested.

The CHAIR—Thank you.

Dr BEER—There is also a much reproduced diagram that people called 'the learning curve' that tends to show that on a dollar per gigajoule basis, the cost of ethanol from Brazil has been going down, the cost of petrol has slowly been going up and the two have finally intersected. It is one of these things where a combination of luck, necessity, and in hindsight what was foresight, has paid off for Brazil.

Mr THORNLEY—What is to stop Australia being a fast follower and utilising similar scale refineries and therefore producing ethanol at similar costs?

Dr BEER—Possibly nothing. In fact I have read papers from various academics who feel that Australia could be a biofuels superpower. I must admit I have a certain degree of scepticism, essentially because of those price fluctuations. If somebody cannot find a way to iron them out, at some stage in the future you get into the same situation where the biofuel is too expensive relative to your other competing sources. If you are in an open market without government stepping in and saying, 'No, you must buy this stuff', then you have gone the wrong way and people switch fuels. It is not totally economically driven though because otherwise we would all be driving LPG vehicles around. There is a combination of familiarity—people like the vehicles they have always liked—it is a combination of economics and it is a combination of availability and other things, as well as the one about prejudice and marketing. Ethanol does not have a good name with most Australian consumers because of some of the past excesses in the industry.

We have the other geographic problem that you alluded to yourself that sugar cane is a tropical crop. It does have excellent yields. You can get a lot out of it. You can do even better when you get very clever with the production process. For instance, there is a lot of debate—and there is a lot of debate in the scientific literature—about, 'Are you spending more energy to make ethanol or less energy to make ethanol than you get out?' We are pretty convinced that it has swung to a positive. We believe that the big change was between when the mills used molecular sieves for distillation rather than boiling up the mixture to get rid of that

excess water, and then a lot of the energy and efficiencies in the process went. Improved technology can make a lot of difference as well but obviously the proponents of ethanol mills feel that they can do it with sorghum or wheat or other crops as well. The plans are there.

Mr THORNLEY—But I am not hearing the fundamental reason. I am hearing path dependence argument, which is that until you have enough ethanol vehicles you do not have a market, and I understand that. There is a financial engineering argument, which is what do you do when the curves go out of sync, but you can hedge that. If you think over the long term that your ethanol production cost is likely to be lower than your oil cost, which is probably not an insane proposition going forward, then you can hedge your position for the volatile periods when it is not. I am trying to understand if there is a fundamental, technical or economic reason why we would not have this industry, or whether it is largely driven by the path dependency quality.

Dr BEER—On a state basis, for 5 or 10 per cent you could probably manage it. But on a national basis to meet 100 per cent of Australia's liquid fuel needs, it is impossible.

Mr CAMPBELL—There are another couple of issues as well. In Brazil they have a lot more manual labour than we do in Australia. When we do crops we tend to mechanise a lot more. That means we use a lot more fuel in order to produce the fuel. We do not tend to get the efficiencies that they would in Brazil, for example, because of this. Like you said, in the long run that probably does not matter, but it does for people trying to make a living out of it in the short term. The other thing is that the sugar crop already consumes quite a bit of area in Queensland. If we really wanted to expand that to be able to produce a sizeable amount of fuel, that would require seeking out new land in order to grow sugar cane on. Most of the land that is up in Queensland that could be done on this is already covered by forest. If we start cutting down the forest, then we have the problem with, we might not be producing enough reductions in CO2 to offset it.

Ms THOMSON—I wanted to ask what work CSIRO has done in relation to algae.

Dr BEER—Yes. Probably the answer to that is not enough. CSIRO is the custodian of the national algae collection. In that we have done a lot of work on algae as algae but not—the intent of your question was in terms of algae as a feedstock for biofuel, and particularly as a feedstock for biodiesel.

Ms THOMSON—Yes.

Dr BEER—There are two methods being proposed: one is the use of photobioreactors, and we have a very small laboratory operation on that, which really shows it is feasible and you can do it, you can grow them; no idea whether you can grow them commercially or—and commercially means both economically viably and in sufficient amounts to do it. We know that you can grow them and there are photobioreactors now. But the other way is really in open ponds. A third way is in my bathroom, they all seem to grow there. But there are many difficulties along the whole path. The US Department of Energy spent outrageous amounts of money in researching oil from algae. One of the many problems is that algae do not seem to want to give up their oil, so that getting the oil out of the algae is not as easy as getting it out of cashew nuts, for instance. Pressing them is not enough. You have to find a way to get them to release their inner molecular structure. We believe that algal speciation, getting the right algae is going to be difficult. If you have open ponds, your problem will be how do you stop colonisation by other algae.

Ms THOMSON—I do not see it working as an open pond—

Dr BEER—Open ponds are cheap, they use a bit more land area but if you have a

good supply of water they are a good way to go. The West Australians are into open pond algae, mainly for pharmaceuticals. The other big issue is who on earth would want to grow algae to burn it, when you can grow it for feed stock, oils or pharmaceuticals? It is far more lucrative if you are into growing algae. They are a few top of the head considerations. We do not have a research program on algae, but maybe coming back to your question about recommendations maybe you should recommend that CSIRO should have a research program on algae and the Victorian Government should fund it.

The CHAIR—A couple of us have been out to Smorgons to have a look at the biofuels out there. We are very interested in that.

Mr THORNLEY—I am also keen to understand if you have a perspective on compressed natural gas as a fuel. We obviously understand some of the basic issues.

Dr BEER—Let me put it this way: earlier I mentioned that natural gas seemed to be the obvious transition fuel—Australia has a lot of it—and if oil becomes scarce that is the thing we have to do something with. We then see three possible pathways—and again I did allude to them before—one is you convert your vehicles and then we all drive around in natural gas vehicles; not popular, and the LPG story tends to indicate that it is not popular because people do not like to use up their boot space with a tank. A CNG tank is much bigger than an LPG tank. It would really take the space away there.

The CHAIR—You might like to follow up that very point in your research because we have been told otherwise by the CNG manufacturers. That might be useful for you to read our evidence.

Dr BEER—They might be running it at higher pressures than we have seen in the past. The second one is the gas to liquids. It is, if you like, unproven technology. They are building a plant in Qatar at the moment to convert natural gas to liquids. Apparently it has cost triple what it was supposed to cost. The countries that have done it have generally had to do it—Nazi Germany or South Africa, because they have been embargoed and they had no other means of getting oil in. Nevertheless, plans surface frequently and maybe we will reach the stage where that becomes a viable way to go. As I mentioned earlier it is one of our three major research areas, that is gas to liquids—how you take the natural gas and make a liquid fuel out of it. The third possibility is methanol, which has its own possibilities. Our assessment is whether methanol is a successful, long-term fuel will depend on developments in the direct methanol fuel cell. We mentioned that we see the electric car as being the end point. One way to drive an electric car is with a fuel cell. The normal way to drive fuel cells at the moment is with hydrogen but there is a thing called the direct methanol fuel cell that you drive the fuel cell with methanol. At the moment it is a toy. You would not drive more than a mobile phone with it but again with sufficient ingenuity and funding that may well in the future become something that you could drive cars on.

Mr THORNLEY—Thank you.

The CHAIR—Before the final question—I will flag that in terms of research for CSIRO, could you give us some indication of whether you agree with the assessment of the Prime Minister's Biofuels Taskforce in its conclusion that biofuels would have a negligible role in providing the fuel security for Australia?

Dr BEER—I do not think I am in a position to agree or disagree with the Prime Minister's Biofuels Taskforce.

The CHAIR—Do you have any comments on the costs for conversion of E10 incompatible vehicles?

Dr BEER—No, we are not into costs. We have not looked at that.

The CHAIR—Are you into information in relation to CSIRO being satisfied with fuel life cycle emissions calculations currently being made public?

Dr BEER—I do not understand the question, I would have to say.

The CHAIR—Is CSIRO satisfied with the fuel life cycle emissions calculations being made public?

Dr BEER—By us or by others because—

The CHAIR—By you or by others.

Dr KOOPS—The CSIRO reports showing life cycle emissions for various fuels. Are you satisfied that those figures are robust at the moment, or are there specific areas that perhaps need more work?

Dr BEER—I see. Let's put it this way: most people are still relying on the work we did in 2001. Even at the time we said that would have about a five-year lifetime because everything changes. The technologies change, the fuel mixes change, the prices change. The methods of allocation that you need change and the whole work should be redone again. That was a heavy vehicles report, we did the light vehicles report in 2004 and we did receive financial support from the Victorian [EPA] to help us do that, which was much appreciated, but that is coming up to probably its five-year lifespan as well. It should all be redone.

Dr KOOPS—It might be a good idea to revisit all that research eventually.

Dr BEER—It probably would be.

The CHAIR—If this Committee were to make a recommendation—and I know you said you are not into making recommendations for the Committee, but if it were to make a recommendation in relation to increased research on a topic, what would you recommend should be researched more?

Dr BEER—You beautifully laid the path for me. We really should redo those earlier life cycle calculations on heavy vehicles. They are overdue for repetition by now. The light vehicle ones could probably wait another year or two. Then the work on algae is probably something that we have not, as an organisation, done enough of but the part of the reason for that is we think it will be really quite expensive to undertake sensible research on algae. I really have mentally forgotten how much the US Department of Energy spent on it, but it was many millions of dollars.

The CHAIR—Thank you very much. We will be forwarding you copies of *Hansard* in the next couple of weeks and you will be free to make any typographical error corrections. We again thank you very much for your attendance today and your submission.

Dr BEER—Thank you, our pleasure. I hope you found it helpful.

Witnesses withdrew.

Committee adjourned.