T R A N S C R I P T

LEGISLATIVE ASSEMBLY ENVIRONMENT AND PLANNING COMMITTEE

Inquiry into Tackling Climate Change in Victorian Communities

Melbourne—Wednesday, 26 February 2020

MEMBERS

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Mr David Morris—Deputy Chair
Mr Will Fowles
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WITNESS

Professor David Karoly, Leader, Earth Systems and Climate Change Hub, CSIRO.

The CHAIR: Thank you for joining us today for the public hearing for the Inquiry into Tackling Climate Change in Victorian Communities.

On behalf of the Committee I acknowledge the traditional Aboriginal owners of the land upon which we are meeting. We pay our respects to them; their culture; their elders past, present and future; and elders from other communities who may be here today. I also extend a welcome to any members of the public and the media present today. This is one of a number of public hearings that the Environment and Planning Committee is conducting in Melbourne and around Victoria to inform itself about the issues relevant to the Inquiry.

Before we begin, there are some important formalities that I must outline. All evidence taken today will be recorded by Hansard and is protected by parliamentary privilege. This means that you can speak freely without fear of legal action in relation to the evidence that you give. However, it is important to remember that parliamentary privilege does not apply to comments made outside the hearing, even if you are restating what you have said during the hearing.

You will receive a draft transcript of the evidence in the next week or so for you to check and approve. Corrected transcripts are published on the Committee's website and many quoted in our final report. I understand that you have been informed that today's proceedings are being broadcast live on Parliament's website. Please be aware that footage from the website can only be rebroadcast in accordance with the following conditions: the material must only be used for the purposes of fair and accurate reports of the proceedings and must not in any circumstances be used for satire or ridicule or commercial sponsorship or commercial advertising. Broadcast material must not be digitally manipulated. Any excerpts from the proceedings must be placed in context to avoid any misrepresentation, and any remarks that are withdrawn are not to be rebroadcast unless the withdrawal is also rebroadcast.

Thank you for making the time to meet the Committee today. Could you please state your name and your title before beginning your presentation? Gee, that was very long, wasn't it?

Prof. KAROLY: It was indeed, but thank you very much for having me here today. My name is David Karoly. I am an honorary professor at the University of Melbourne and also Leader of the Earth Systems and Climate Change Hub within the National Environmental Science Program, which is funded by the Australian Government and is one of six National Environmental Science Program hubs. I am currently employed in CSIRO. There will be separate submissions by CSIRO in later hearings, I understand. And I understand that I have got about 40 minutes in total, less the time for the introduction there. That is okay. My plan is to spend about 15 to 20 minutes on a presentation and give about half the time for questions and answers afterwards. If anyone wants to interrupt for points of clarity and things like that, please do so as I go through as well.

Visual presentation.

Prof. KAROLY: I could spend a very long time talking about the background to climate change science. What I have decided to do is to give more of an update, an overview of the science, particularly material that is specifically relevant to Victoria. There is in my presentation right at the end a list of references, and the key references are the joint report from the Bureau of Meteorology and CSIRO called the *State of the Climate* report, which comes out every two years—and I am referring to the 2018 one. And then most recently, in late 2019, the Victorian Department of Environment, Land, Water and Planning put together its *Victoria's Climate Science* report, and I use a large amount of that material. It is an excellent report—and I have not been paid to say that.

[Slide 1]

What I am going to do is give an overview, and I am going to start with the image in the top right-hand side. It is the global average temperature relative to the pre-industrial period—relative to 1850 to 1900, essentially—from five different datasets. And what you can see is there have been pronounced increases in global average temperatures since around the early 1900s, with now the global average temperatures being more than 1 degree

above pre-industrial levels and the last five years are the hottest five years in the observational record that we have got. There are many periods in the geological past when temperatures were hotter than that. I am not going to concentrate on the, if you like, million-year timescale at all.

[Slide 2]

So what I am going to try to do is spend some time talking about climate change in terms of the physical risks, the extreme events that are associated with that and the importance for communities to respond to these changing risk environments, changes in temperatures, changes in water resources. But I am also going to talk briefly about the need to transition to a zero-carbon economy in terms of addressing or minimising the physical climate risks. If we are going to minimise the physical climate risks, we have to address the ongoing climate change, and I am going to talk about that as well. I am going to cover this sort of brief introduction, some global climate updates, climate change in Victoria, what is happening in terms of both global and Australian emissions and emission projections, and then a one-picture summary of how difficult this problem is.

[Slide 3]

So, first thing: global overview. This shows the greenhouse gas variations in the left-hand panel, in the circles, over the last thousand years and carbon dioxide concentrations over the last thousand years. And you will see an almost what is called exponential increase, rapid increase, since 1800 relative to a base concentration of carbon dioxide of 280 parts per million. That carbon dioxide concentration was the highest level until 1800 at any time over the last million years. Something different happened. That 'different' is human activity.

Burning fossil fuels and land clearing are the major causes of that increase. How do we know that? Because some commentators will say, 'Oh, no, that's due to increases in underwater volcanoes', or they will say it is due to the warmer temperatures leading to release of carbon dioxide from the oceans. We know that from the other graph it is the carbon dioxide component associated with photosynthetically processed carbon dioxide, and that has more carbon-12 carbon dioxide than carbon-13 carbon dioxide. Carbon has two isotopes, carbon-12 and carbon-13. If carbon dioxide is photosynthetically processed through fossil plants, which are a composition of oil, natural gas and coal, then carbon-12 is enhanced, and that is what has happened—the carbon-13 ratio has declined exactly in parallel. That is the best evidence of human activity and its impact—not the only evidence but the best evidence—in one graphic.

Carbon is critically important. Carbon dioxide was critically important in the industrial revolution, but we now know it has major adverse impacts. What I am going to try and do is to point out to you some of those adverse impacts, but I am also going to point out that it is not just carbon dioxide. The bottom right-hand graph shows the carbon dioxide concentrations were 405 parts per million. They are now 410 parts per million at the end of 2019. Yes, that is critically important, but the warming influence on the climate is not just due to carbon dioxide. There are other long-lived greenhouse gases, and if you combine the warming influence of the other long-lived greenhouse gases and come up with something called the equivalent carbon dioxide, we are now at 500 parts per million of equivalent CO_2, taking into account the warming influence of the other long-lived gases.

[Slide 4]

We hear of—and I should have already talked about—the 1 degree Celsius threshold. The target from the Paris agreement is to limit global warming to 2 degrees. That is all in terms of global average temperatures. People do not live in the ocean; people live on land. We know that land warms up.

Mr FOWLES: That is a startling piece of science, David—thank you!

Prof. KAROLY: Well, I sometimes say that people are not fish—but that may not be appropriate. What we do know is that land heats up faster from winter to summer, heats up faster from night to day, but equally associated with climate change, and therefore this most recent IPCC special report on *Climate Change and Land* points out that land surface has warmed up at nearly double. Now, they exaggerate—it is only one and two-thirds times or 1.7 times. This is the graphic to 2019 of the global temperature increases on land. You see it goes from minus 0.5 to plus 1 and in fact, above that, touching on plus 1.5 now.

The CHAIR: Can I just ask on a point of clarification? In terms of continental Australia, we are surrounded by ocean of course, so the average temperature across the globe might go up by 1 degree but inland Australia might go up through the day—

Prof. KAROLY: One and a half times. I will show that in just a little bit.

Mr FOWLES: Can I ask just in terms of how the average is calculated? It is presumably dependent on the number of measuring points, but then—

Prof. KAROLY: No, it is independent, nearly, of the number of measuring points, because what we do is we do not calculate the average temperature based on the absolute average temperatures; we calculate it as the average of the departures at each location from the average at that location to remove the geographical influences.

Mr FOWLES: Okay, so it is the average of the averages.

Prof. KAROLY: No, it is the average of the departures from the long-term average, and the coherence of these variations of the long-term averages is typically 1000 kilometres, spatial scale. You can see that when you look at maps of, say, the temperature departures from one year to the next, and when we go to 10 years it is even larger spatial scales. So what we are doing is estimating the change from normal at each site.

Mr FOWLES: I am going to hazard a guess: there are more measure points in Western Europe and North America than there are in Australia per square kilometre or per 100 square kilometres.

Prof. KAROLY: Yes, but we can estimate quite accurately to within a tenth of a degree the average departure from normal in Australia using only 10 locations well distributed in Australia and probably even less than that.

Mr FOWLES: Right. We only have 10—

Prof. KAROLY: No, no, we have hundreds of sites, but that means that we can provide even more accurate variations. Does that help?

Mr FOWLES: It does, thank you.

[Slide 5]

Prof. KAROLY: These are the Australian temperatures on the left-hand panel and the Australian rainfall in 2019 and in the observational records since 1900. You will notice that this is showing—the black line is—the 15 year running averages. 2019 was the record hottest year in Australia both in terms of the daytime maximum temperatures and the annual average. We set a new record high—both annual temperature of the averages and the annual maximum. And because of work we had done in 2013 and 2014 after the previous record—if you look at that graph you can see that the previous record was in 2013—we did an analysis of what the chances were of the new record being set just due to natural climate variability alone, and the answer is virtually zero.

The CHAIR: Can I just ask, what is more significant: is it the fact that in the last five years there has been record after record after record, or is it more profound that since I think 1980 or thereabouts that graph is pretty much consistently almost in the red? What is more profound?

Prof. KAROLY: Well, they are both the same thing, and in practice what is more profound is that from 1910 to about 1950 there was year-to-year and decade-to-decade variability but no long-term trend, and then since 1950 the trend has been—

The CHAIR: It has emerged.

Prof. KAROLY: It has emerged, but not just emerged, it has continued and if anything accelerated in the last five to 10 years. This is temperatures, remember. It is a different story on rainfall.

Mr FOWLES: I appreciate that. In terms of the impact that is the outcomes of climate change—and I am aware that I am cutting into your time—how important is the variation in maximum temperatures, like how hot the blisteringly hot days are, as opposed to the average temperature?

Prof. KAROLY: Or even the night-time minimum.

Mr FOWLES: Yes, so like how mild a winter's morning is as opposed to how hot a summer's afternoon is.

Prof. KAROLY: So that depends on the sector in which you are looking at the impact. For agriculture, particularly stone fruit, night-time minimum temperatures are critically important for stone fruit and things like that. Night-time temperatures are critically important for human health because they provide the, if you like, time to recover from the high daytime temperatures. They are all important but in different ways.

Mr FOWLES: Right; okay. Thank you.

Prof. KAROLY: So, if we look at this right-hand panel here—annual rainfall over the last 120 years, including 2019—most people would say there is a lot of variability. Yes, there is. It is mainly decadal as well as year-to-year. Spot 2019: it was the driest year on record and significantly lower than any other year through primarily a combination of natural factors.

[Slide 6]

Climate change is expected to lead to increases in average rainfall across the whole of Australia, primarily in the north, with reductions in rainfall in the south. I will talk about that a little bit more. This is what has happened to rainfall in Victoria. It shows maps from this Victorian climate science report released in 2019 of the cool season or wintertime rainfall here as maps of how extreme those last 30 years are relative to all the other 30 years in the last 120 years. What we see is that the lowest on record or in the lowest 10 per cent of years is essentially the whole of Victoria in the winter—the cool season. Rainfall in Victoria has plummeted in the last 30 years. Whereas in summer there are actually increases north of the Divide in rainfall, partly because we are getting more days like we have had in the last two weeks. We are getting more tropical, humid days with heavy downpours in summer. Both of those changes have been projected for a long period and have been seen.

Mr FOWLES: In some respects it is actually more extreme than that shows, because if you have got four deciles in the average colour block and if you had a colour for each of the deciles it would actually look more extreme because you have only got like one decile—

Prof. KAROLY: Yes. This is the sort of standard way—the top and the lowest. A decile is the 10th percentile, so we have effectively got the whole of Victoria except really parts of the south-western region in this lowest 10 per cent of periods, and in practice it is the lowest 10 per cent of the last 20 years as well.

Mr FOWLES: But the whole of the cool season is, with a couple of small exceptions, in the bottom 30 per cent. It is either below average, very much below average or the lowest on record.

Prof. KAROLY: Yes, absolutely.

Mr HAMER: Just on that top graph, even in summer that would be coming off a very low base, so the long-term trend in northern Victoria would have been generally the dry season and have—

Prof. KAROLY: It is drier, but it depends exactly on where you are. But in much of certainly the eastern and north-eastern parts of Victoria you get substantial rainfall, and particularly south of the Divide, even most of Victoria, there is a pretty even balance. There is not a strong seasonality in rainfall. It is just that in summer it dries out really quickly, so if you are looking at water resources it is the cool season rainfall that is critically important in filling reservoirs, in providing background water for agriculture and in filling the groundwater. I can provide you with distributions of the seasonal variations of rainfall between the northern part of Victoria and the southern part of Victoria if you would like.

Mr HAMER: But in the north-east it would be different, but generally north of the Divide it would be fairly arid. They would not be getting much more than 400 or 500 millimetres of rain, and even less in the north-west annually.

Prof. KAROLY: That is correct. Completely agree. Mildura is quite dry and that far north-west is very dry in summer.

Mr HAMER: Anyway, yes.

[Slide 7]

Prof. KAROLY: I am going to try to zoom through, but please interrupt because the reason I am here is to answer your questions. The top left-hand panel is unusually hot individual days across the whole of Victoria. This is the top 1 per cent of days in terms of count of days, and given you are really good at arithmetic, 1 per cent of days is about 3.6 in a year. Notice that it starts in the 1900s at about 3.6 between one and three, and then, all of a sudden since the 1980s, we are getting five and 10 days—double the expected amount.

Mr FOWLES: Five or 10 days would fall in the 1 per cent of all days recorded?

Prof. KAROLY: That is correct. All days recorded in a year are happening in the top, so it is really double to treble the normal amount of days in a year in this really unusually hot day top 1 per cent.

The CHAIR: Can I just ask, I know you are not a biologist but I would imagine having a substantial number of more hot days means a great deal of stress for our bush, for our Indigenous plants that have—

Prof. KAROLY: Yes, and particularly animals and birds.

The CHAIR: Yes.

Prof. KAROLY: And so it kills flying foxes—

The CHAIR: Including us.

Prof. KAROLY: Yes. People are somewhat more protected because they can move into air-conditioned areas or use active processes. Possums, grey headed flying foxes, koalas, you name it, they are all seriously adversely affected.

Mr FOWLES: To what extent are birds able to get out of the way?

Prof. KAROLY: They do, and the problem is that they tend to fly. By flying, they increase the energy output in their bodies, they cannot lose the heat rapidly enough and there is evidence of budgerigars, parrots, whatever taking off, flying and—

Mr HAMER: Dropping dead.

Prof. KAROLY: dying. No, dying in flight. The same with flying foxes. That is why 10 000 flying foxes died in 2009 in the heatwave then. Bushfires: again this is now springtime frequency of days of very high fire danger, dramatic increases in the springtime as well as in the summer, number of extreme fire danger days like 2019. Okay. I have used up most of my time.

The CHAIR: You can keep going. We are fascinated.

[Slide 8]

Prof. KAROLY: Okay. I am now going to start to touch on projected changes versus what we have seen. This is again from the climate science report. What it shows in the top left is how Victorian temperatures have tracked, and what I will call the triangle or funnel is what were the future projections for the period up to 2030 relative to the 2000 levels. And what you see is that in the period from 2000 to 2019, or 2018—the projected changes, that funnel, is the full range of projections across the climate models—we are tracking at the worst case, the hottest, in year-by-year temperatures across Victoria. And not only is it getting hotter—if you look at the right-hand panel, which is wintertime rainfall, showing this pronounced decline in wintertime rainfall over Victoria with lots of year-to-year variability; we know that some winters are wet, some are dry—but we are tracking at the worst case of drying in winter as well. And it is not just winter, it is most of the cool season.

So if you want to look at, well, which climate model simulation should you look at, you should be looking for projected changes, the hottest and driest. And the farmers and the water resource managers will tell you that is exactly what they have been experiencing across Victoria—and people are looking at their gardens as well.

[Slide 9]

Well, what do we expect to happen in the future? This is a graphic from the *State of the Climate* report showing climate model simulations with increases in greenhouse gases included. That is the grey and then red band. And just so that we can compare, 'Well what would have happened if we didn't have human activity, if we didn't have increases in greenhouse gases?', that is the blue band of climate model simulations. It is not one model. It is in fact more than 40 different climate models run globally—and just extracting the data for Australia, for Australian temperatures. You see first of all that the black line, the decadal average of these observational temperatures, lies well within the model-simulated range. It is way outside the model simulations with natural variability and it allows us to make a conclusion: I would say simply there is no way that you could explain the observed temperature is just due to natural variability alone—unless you are one of the media commentators who wants to hide the influence of human-caused climate change.

2019 I have added to this graphic. Not only is it way above that change but it is way above the range of—and the red band is the projections for 2020 to 2030 onwards—the decade-to-decade variations. Again the black line is tracking at the upper range.

The CHAIR: Can I just ask: there have been a number of points over the last hundred years where there has been a shift—the consequence of emissions, you see an acceleration and that—so do you think it is now a smooth projection upwards or are we likely to see continuing big shifts?

Prof. KAROLY: That is a tricky question to answer, because if you look at year-to-year variations there appear to be shifts, and for instance globally there was a discussion about the period from, say, 1997 to 2015—global warming stopped according to some commentators. That is primarily due to the starting date which is in what is called a La Niña event, when sea surface temperatures led to a cooling of global temperatures, and ending in an El Niño event—sorry, starting in an El Niño event where the warming was faster and finishing in a La Niña event in 2010–2011. If you start at a hot period and end up in in cooler period, it is not surprising the trend is lower. It is selective misuse of the data, or cherry picking, to promote an agenda.

So the bottom line question is: if we average climate over 10- to 15-year or 20- to 30-year periods there are no apparent shifts. And you can see that—

The CHAIR: Okay, maybe I used the wrong word, 'shifts'. If you accept the science of climate change, which I do, and the permafrost—

Prof. KAROLY: Melts.

The CHAIR: melts and we have an explosion of greenhouse gases that are 1000 times more potent—

Prof. KAROLY: No, only 100 times.

The CHAIR: A hundred times, is it?

Prof. KAROLY: Yes, on a 10-year timescale.

The CHAIR: Then you would expect a—

Prof. KAROLY: Acceleration of warming. So, yes, there are a number of factors not taken into account in the climate model simulations that make it even more scary. But I should not use that word, perhaps, in this. But, yes, for many other people the changes we are seeing are scary. But if you just look at that graphic for Australian temperatures, the only change that you can see is relatively stable temperatures from 1900 to 1950 and then a rapid warming since then, perhaps with an acceleration over the past five years, but even that is hard to determine when you look at 10-year variations.

The CHAIR: We might know that more keenly in 10 years time when we can look at it to see whether it was just a wobble.

Prof. KAROLY: Yes, that is correct. But many people would argue the acceleration is in fact what the climate models suggest as well.

[Slide 10]

This is a summary of all of the impacts not only that we have seen but what is projected to happen in the future. Yes, Victorian temperatures have increased only about 1 degree, not the 1.5 degrees over the whole of Australia, because Victoria is essentially highly moderated by the ocean temperatures whereas inland Australia is increasing much hotter than 1 degree over the last 100 years. The Australian average is 1.5.

I mean, I can run through the cycle. Yes, increases in temperature. This is for the 2050s under a relatively high emission scenario, but it is almost independent of which emission scenario we use. Almost all of these changes are locked in. It is only beyond 2050 that rapid emission reductions will make a difference, and I will show that globally in a second. Yes, temperatures will rise. Yes, we will get even worse fire seasons than 2019, substantially worse. Melbourne's climate will be more like a city in northern Victoria.

The CHAIR: Bendigo or something like that?

Prof. KAROLY: Wangaratta. There is not going to be enough snow for skiing in most of the Victorian alpine areas. There is continued decline in cool season rainfall and more intense downpours, and if I was to describe 2019 and this summer, it would be more intense downpours and very low rainfall in the winter time.

Mr FOWLES: And all of these changes are baked in, you say.

Prof. KAROLY: Not the absolute magnitude, but pretty well all of those changes. It is under high emissions. I will quickly show you in a graphic in 3 minutes what happens versus high and low for the global average, but pretty well all of these are locked in. We can make differences if we act now beyond 2050, and if we do not, it gets even worse.

Now I am going to talk about some of the most recent stuff, which is not in the Victorian climate science report, and what I am going to do is focus on a new set of global climate models. All of the data that is being used in the projections for the Victorian climate projections was based on the previous generation of climate models, what was called the fifth phase of the Coupled Model Intercomparison Project, CMIP. Scientists like acronyms.

The CHAIR: So do politicians.

[Slide 11]

Prof. KAROLY: Anyhow, we are now up to the next generation, called the sixth phase of coupled model simulations. What this shows—let us start with the Australian temperatures because it is easier. This is sort of sideways—it is what is called a histogram, a probable distribution of the temperatures, with the temperatures on this scale and now the new generation. It shows more models showing more warming. If we look at the Australian temperatures, this light grey and this darker colour are the range of temperatures in 2100 with the older simulations, what is called CMIP5, and that is the light colour. And the new ones here: it is only 16 models so far, but this could be updated. It is now up to 30 that are available, even 40 models now available.

Mr FOWLES: And these are models being produced by agencies like yours all around the world?

Prof. KAROLY: That is correct, yes, and university groups all around the world—60 different modelling groups all around the world. But unfortunately the key point—these are all global models, not focusing on Australia—there is a significant number that show essentially 1 degree higher warming in Australia in 2100 for a high-emission scenario.

Mr FOWLES: But the point of those histograms is that even the outliers are saying nearly 2 degrees.

Prof. KAROLY: That is correct.

Mr FOWLES: But the outliers at the other extreme admittedly are saying 7 degrees or 8 degrees.

Prof. KAROLY: That is correct.

Mr HAMER: And that is 2 degrees from 2000, is it?

Prof. KAROLY: That is correct. All of these are temperature changes relative to the 1995 to 2014 levels. So we can look at the global averages as well, which is here, and that is the same story, but I wanted to focus on the Australian. Notice that the lower band has not shifted up as much. A number of the same models used in the previous iteration are still being used, but there are new ones.

[Slide 12]

Let me emphasise that this is the Australian community climate model simulation run at CSIRO with dates released. This shows the observed global average temperatures in black and then temperatures for one high-emission and one low-emission scenario. Remember that I said it does make much difference by 2040 or 2050. Notice that in practice in 2050 the average is about half a degree different. So yes you can make a difference because you reset the track.

This is future temperatures for a low-emission scenario. This is the scenario which the world is aiming at to limit global warming to below 2 degrees.

Mr FOWLES: Aiming but not necessarily taking concrete action towards.

Prof. KAROLY: You can comment on that. I would like to just comment that current global projections are if all countries meet their agreed Paris commitments, the warming level would be about 3 degrees—3.2 degrees under the older generation of models. This uses the low-emission scenario that would meet the Paris commitment under the older generation of models and it now shows 2.5 degrees of warming—meeting the Paris commitment with not only zero but negative net emissions from 2080 onwards. This is bad—

Mr FOWLES: Sorry, this is 2.5 degrees even if we hit the Paris target?

Prof. KAROLY: Even if we hit the Paris target and we have negative emissions relative to 2080. Yes. That is why this is so important. Yes, it shows much higher warming, but that much higher warming also applies even for these low—

It requires us to reset the ability of the Paris commitments to achieve warming less than 2 degrees.

Mr FOWLES: So Paris is seen by some as being ambitious politically, but from a thwarting of climate change perspective it is not ambitious enough.

Prof. KAROLY: Yes.

Mr FOWLES: I am just taking notes and just wrote down, 'We are all going to die'.

Prof. KAROLY: I should add that that is also a very accurate statement. The only permanent death sentence is being born. Everyone who is alive now will die

Mr FOWLES: Speak for yourself.

[Slide 13]

Prof. KAROLY: not necessarily this week or today. Let us come back to lighter matters like the Paris commitment. This is global CO_2 emissions from burning fossil fuels globally up to 2018 only. Here is 2015, and prior to 2015 there had been a reduction in the rate of increase of emissions. After 2015 unfortunately the world accelerated its emissions of greenhouse gases, which is not consistent with the Paris agreement. It set a new record in 2018 and will set an even higher record in 2019 for emissions of greenhouse gases—carbon dioxide from burning fossil fuels. That is not heading in the right direction to meet the Paris commitments.

Mr FOWLES: So from a scientific perspective—there is a social view on this question as well—this phrase 'uninhabitability' gets tossed around a bit, but at what point practically does the globe become uninhabitable for a decent chunk of humanity?

Prof. KAROLY: Look, I can only comment on what other people have said, which is John Schellnhuber, head of the climate impact centre in Germany, Max Planck Institute. His assessment was that the sustainable population of the world in 2100 for a high-emission scenario—

Remember I should have said and did not that this high-emission scenario leads to 6 degrees of global average warming and remember I said that land warms up at 1⅔ times? That is 10 degrees for the land average. He says that the global sustainable population for that scenario is about a billion. In other words—

Mr FOWLES: Seven-eighths go?

Prof. KAROLY: Well, nine-tenths.

Mr FOWLES: Oh yes, because the population grows in that time.

Prof. KAROLY: Actually, many of the people in here are likely to be dead by 2100.

Mr FOWLES: I would have thought so.

Mr HAMER: Sorry, just on that 'high emissions', is high emissions business as usual? What does high emissions actually mean?

Prof. KAROLY: Well, it depends what you mean. It means the high-emissions scenario used in the—it is essentially business-as-usual emissions. I was going to make a comment; I realise I am being recorded.

Mr FOWLES: Is that with any intervention?

Prof. KAROLY: No, that is with no intervention to adjust for climate policy. It was a 'business as usual' for the sort of 1990s business as usual.

Mr FOWLES: So it is a pre-Kyoto extrapolation of—

Prof. KAROLY: That is correct. It might be described as the Gina Rinehart scenario, but Gina Rinehart might not be happy me commenting on that. Maybe I should not have said that. And I have said it, so it cannot be deleted from Hansard.

Mr FOWLES: You are allowed to withdraw it and then the withdrawal goes on the record too. But I am glad that you said it.

The CHAIR: You are protected by privilege. Keep going.

Prof. KAROLY: Thank you. All of this information is in fact led out of a group based in CSIRO in Canberra that leads the Global Carbon Project.

[Slide 14]

What about Australian emissions? Well, they go up and down, and this is the latest information on Australian emission projections from 2019 through to 2030. Australian emissions—the Federal Government has a target to reduce emissions, and Australia's Paris commitment is 26 to 28 per cent emission reductions relative to 2005—2005 is up here at just over 600. I like to round numbers to make them a little easier. Twenty-six to 28 per cent is roughly a quarter, 25 per cent, and it is really easy to do a quarter of 600; it is 150. That means we should be down here, and you have to assess whether we are going to be down here based on this latest data, taking into account all of the Australian Federal Government. I am not allowed to comment on that.

Mr FOWLES: So what is LULUCF?

Prof. KAROLY: Land use, land use change and forestry associated with the clearing of forests and that is why there are emissions and why there are negative values recently associated with the increases in forestry. So it is not the name of a doll; LULU is not the name of a doll. It is land use, land use change and forestry.

Mr HAMER: So when there is more land clearing that graph trends up, and when there is, I suppose, net plantings and less land clearing that would be a trend down.

Prof. KAROLY: This is offsetting some of the other emissions. It is critically clear to see that the electricity sector has had major reductions in emissions since about 2010, primarily associated with the use of wind power and solar power, but in almost all the other sectors, particularly agriculture and direct combustion and transport, they sort of go in the order of the colours there.

The CHAIR: Can I just ask?

Prof. KAROLY: Go ahead.

The CHAIR: So there have obviously been additional plantations planted. I am curious to know what the impact of the 2010 bushfires and this last summer is. Presumably a lot of CO_2 was released into the atmosphere with bushfires, so they may have reversed that bit of red.

Prof. KAROLY: They are not counted in these budgets because bushfires are considered to be natural processes that affect the forests and other vegetation in Australia. So getting accurate emissions estimates for the carbon dioxide released from bushfires is quite difficult. They are not accounted for. These are associated with both land clearing losses when trees are cut down—and you can measure the areas that trees are cut down—or the additional forest area and the estimated uptake. But this does not count the emissions from the 2009 bushfires or the current 2019 bushfires.

However, there are initial estimates of that, and they are that the estimates of the carbon dioxide released in the most recent August, September, November, December, January bushfires is the same as approximately the total Australian emissions, 500 million tonnes additional going into the atmosphere. That does not get counted in this.

The CHAIR: So is it global climate emissions auditing standards where the problem is where these things do not get accounted for? Is it that no one has invested yet in an appropriate model to measure it? It just seems to me that these things should be measured.

Prof. KAROLY: They are measured and estimated, and we can estimate, for instance, from observations of greenhouse gas year to year variations, month-to-month variations and potentially even day-to-day variations. But the expectation is that the forest and the vegetation will regrow, and how you measure that regrowth, that is also not included in these budgets.

The CHAIR: Climate change can potentially change the nature of the forests, what can be carried on that land, so is this an area where thinking may change—

Prof. KAROLY: That is a question that is impossible for me to answer because it is scientifically very difficult and there is also in some sense a philosophical issue: is it appropriate to account for natural variations associated with climate factors? It is important to understand that some of the newer generation of climate models do take into account natural fires affecting forest cover and estimate the emissions in those going into what are called earth system global models that model the changes in forest growth, essentially with warmer temperatures or changes in rainfall patterns or changes in fire frequency in some regions. But most of the models do not take that into account.

Mr FOWLES: Is it something of a misnomer to characterise that as natural, given that the causes arguably or the scale of these fires might in fact be unnatural and they actually all probably derive from industrialisation?

Prof. KAROLY: That is correct, and that is why I said it was a philosophical discussion.

Mr FOWLES: Yes. So is your view that in an ideal world, notwithstanding the scientific difficulties that attach to it, we would be capturing those things, because there are things like gases being released from the melting of the polar ice caps as well.

Prof. KAROLY: Absolutely, and those are covered in the observed carbon dioxide, methane, nitrous oxide and other greenhouse gas variations.

Mr FOWLES: So why bushfires? Is it just because it is hard?

Prof. KAROLY: No. The concentration changes from the bushfires will be reflected in the Australian carbon dioxide variations and the global CO_2 variations. So they are covered. What we cannot do then is directly estimate how much of the change from one year to the next was due to the Australian bushfires versus all the factors—burning fossil fuels.

Mr FOWLES: All the other things going on. Sorry, just to clarify, the direct combustion, what is that if it is not transport and industrial processes; what does that cover?

Prof. KAROLY: Direct combustion will be probably steelmaking and—

Mr FOWLES: That is not an industrial process?

The CHAIR: Aluminium.

Prof. KAROLY: I would have to check.

Mr FOWLES: It is a pretty big chunk.

Prof. KAROLY: No, it is. It is a very big chunk, and it is probably direct combustion not for electricity but for heating in other systems. So it will be—

Mr FOWLES: So it might be household—

Prof. KAROLY: Some of it will be household, but of it will also be using oil or natural gas or coal not in industrial processes but in essentially heating.

[Slide 15]

Okay. I am almost done. We can skip my summary slide because I am going to use this to do the summary. There was in 2019 a United Nations climate action summit. All the scientific bodies decided they had better produce a one-wheel infographic that summarises. There is not a lot of good news in this. I have talked about a bunch of these things already. We are already at 1.1 degrees Celsius above pre-industrial levels, halfway to the Paris target—or a little more than halfway. From 2015 to 2019 was the warmest five years globally. Climate impacts are hitting harder and sooner, a worse case than predicted even a decade ago. Unfortunately there continues to be annual growth in carbon dioxide emissions, and we set in 2018 a new record. Emissions which had been hoped to peak in 2020 are now not expected to peak globally until 2030. That is not consistent with stopping CO_2 warming.

So what do we need to do in terms of current policies if we are going to realistically seek to limit emissions to only 2 degrees above preindustrial levels? We have to treble our current commitments, which would be consistent with if rather than a 26 to 28 per cent target for Australia in 2030 we had a 75 per cent emission reduction target in Australia by 2030. Admittedly this is for all countries, and I think Australia is part of 'all countries'. It does mean limiting global warming to below 2 degrees, and this is all based on pre the latest climate model simulations, and reductions in greenhouse gas emissions are required in all sectors. I have probably used up a lot more than my time and I have scared you enough.

The CHAIR: No, you actually have not. I have a couple of questions, if that is all right.

Prof. KAROLY: Sure. It is not up to me, it is up to you.

The CHAIR: Indeed. Thank you for your time. You have painted a pretty stark reality in terms of how the climate is changing and you have made some observations obviously about what the global community is attempting to achieve and whether that is realistic. From a Victorian perspective, there are obviously lots of different datasets that are around that have been developed by scientists like yourself—

Prof. KAROLY: And by DELWP.

The CHAIR: and by DELWP and others. Are there, from a Victorian perspective, datasets that have not been developed that should be invested in that might assist different industry groups in understanding the challenge in their sector and to inform them about the adaptation changes they might want to make to their

sector to reduce their emissions profile or to recognise the different mixture of horticulture or agriculture that can be grown in their particular local communities? What is missing?

Prof. KAROLY: DELWP, as I said, the Victorian Government, did a very good job of doing the latest set of Victorian regional climate projections, and separately there has been work done on water resources and the impacts of climate change on those. In addition, there has been substantial effort done in looking at mixing and matching the efforts in different sectors to meet the Victorian commitment of zero net emissions by 2050, because the zero net emissions by 2050 is consistent with this acceleration in the reduction in emissions that is needed to try to avoid 2 degrees of global warming. The part that may be missing is the fact that the latest generation of climate models that show accelerated warming have not been used in regional climate projections yet. There is a plan that is being prepared across the whole of the country for, if you like, what is called the next generation of national and regional climate model simulations not only for Victoria but for the whole of the country and for other states as well. That plan hopes to engage Victoria as well as the Federal Government and other groups as well in making use of the new generation of coupled ocean atmosphere climate models to prepare a new generation of regional information, updated to take into account the latest global climate model data. That cannot be started until the global climate models have been completed.

Mr FOWLES: Do those models get updated annually?

Prof. KAROLY: No, no. The climate models, this CMIP process, was last completed in 2013 and we are now updating it in 2020. It is timed to link in with the intergovernmental assessment process of the science of climate change through the Intergovernmental Panel on Climate Change. Their last assessment report was completed in 2013 and the next one will be completed in 2021. The last generation of national climate projections was completed in 2015, and there is a plan to seek funding from the Federal Government and to do activities starting in 2021, to be completed in 2023.

Mr FOWLES: So there has been around about an eight-year cycle for most of these.

Prof. KAROLY: That is correct. And—conflict of interest—I am leading the preparation of this plan for the next generation—or should I say the Earth Systems and Climate Change Hub was asked by the Federal Government to lead the preparation of this next generation climate projection plan.

The CHAIR: Just one follow-up question. So there is an amazing body of science that has been built up now over a significant period of time, and sometimes it sort of occurs to me that the challenge has always been to get that body of knowledge in a format that the community can understand, that different parts of the community and the economy can understand, maybe right down to a farmer understanding what it means for their particular district so that they can make long-term practices on their farm (a) to adapt and (b) obviously to reduce their emissions profile. It seems to me that we do not necessarily globally do that last bit that well, where we get the science from eminent people like you and translate it down to individuals. Are you hopeful that that body of work that you are leading on behalf of the Victorian Government might enable that to happen in a better way? Like, here is an opportunity for you to make a recommendation about how we might do that.

Prof. KAROLY: So I actually think that the Victorian Government, at least for the last five years but also prior to that as well, has been doing a very good job, as much as is feasible within limited resources, of trying to communicate the science of climate change to a range of different sectors, whether it is the water resources, agriculture, even going out to communities and doing a community briefing. We have currently been involved—we being the Earth Systems and Climate Change Hub and CSIRO—with doing stakeholder engagement with a range of different sectors all around Victoria around these most recent Victorian climate change projections, and engaging with them. So there is an active program. It is just that there are a range of different opinions about the need and urgency for action.

Mr HAMER: Just a quick clarification: so the zero emissions by 2050, where does that get us?

Prof. KAROLY: Where does that—

Mr HAMER: In terms of you were talking about the temperature chart.

Prof. KAROLY: If the world was able to go to zero net emissions by 2050, there would be a good chance of limiting global warming to below 2 degrees.

Mr HAMER: By 2100.

Prof. KAROLY: Well, yes. There might still be an overshoot, but the fact that you have gone to net zero emissions and then continue at net zero emission—hopefully negative emissions; you are sucking carbon dioxide out of the atmosphere then—then temperatures should start to fall. If the world hits net zero emissions, net zero emissions allow for some continued emissions but also uptake of those through the vacuum cleaners that are being designed to remove carbon dioxide from the atmosphere. We do not have very good vacuum cleaners like that yet, but I am sure Dyson will try to invent them!

Mr FOWLES: We have heard some evidence about local councils, for example, in their infrastructure renewal programs needing an understanding of what is coming. To what extent is granular climate change data scientifically achievable? Can we get to the point where we can say, 'Well, the suburb of Hawthorn or this square kilometre is likely to receive this much rain in extreme events and on that basis needs kerb and channel that is 20 per cent or 40 per cent or 100 per cent bigger'?

Prof. KAROLY: So the granularity of the sorts of projections as we look at them is not the critical factor in influencing, if you like, the need for flood rain being mitigated, because we know that what drives the spatial variations is just natural variability. We know that when there are hailstorms or when there is extreme rain from thunderstorms it is highly localised, and what is going to affect Hawthorn might not be what is going to affect Ringwood and therefore what the best information will be is the broader spatial scale changes in risks, because then you can use the historical risks as well as that for planning for the need, if you like, to mitigate or avoid the damages associated with some of these extreme events. The climate change information is happening at broad scales—but it is affecting regional changes as well—but natural variability is the dominant factor.

Mr FOWLES: So to put it another way, if the Victorian Government was to come to you—and this might well be one of our recommendations—or whatever scientific body is out there, and say, 'We actually just need to know how much water our stormwater systems need to cope with', 'We need to know what plant species ought be planted in streetscapes over the next 50 years', those sorts of questions, are they questions that can be answered?

Prof. KAROLY: Yes to both of those and now, but it will not be different between Hawthorn and Ringwood.

Mr FOWLES: Sure, I appreciate that.

Prof. KAROLY: Or it might be, because Ringwood actually on average gets a bit more rain than Hawthorn does, because it is a little bit higher, but—

Mr FOWLES: Right. So that is why I am asking about the granularity: to what extent can we provide LGA-specific datasets?

Prof. KAROLY: Information, yes. And a lot of that is determined just by the spatial differences, if you like, in the councils. I mean, whether you are in—

Mr FOWLES: A southern council, yes, Monash.

Prof. KAROLY: Monash, which is built on the area where they decided to plan that VFL football ground, in the wettest area of Melbourne—anyhow, we will not go there, but that spatial variation is quite large. So what happens in Werribee is quite different from what happens in the eastern suburbs because of the spatial differences.

Ms GREEN: I mean, with stream flow and those sorts of things—I live in Diamond Creek, not far from the creek, and have really followed the variation on that, and one thing that was just bizarre I felt was we funded a sport facility on the banks of the Diamond Creek.

Prof. KAROLY: And it flooded—close to it.

Ms GREEN: Well, no. Council actually sought the funding, but they actually had not checked with Melbourne Water even what the current 100-year flood levels were, and then they wanted the Minister to

override Melbourne Water, and I was really glad the Minister said no. So there is no accounting for common sense, I suppose, sometimes. But that is the variation.

Prof. KAROLY: I do not think I need to answer that.

Ms GREEN: No, you do not.

Prof. KAROLY: I will take that as a comment.

The CHAIR: Thank you so much, Professor Karoly, and sorry for—

Prof. KAROLY: Everyone else has now got to cope with being delayed.

Mr FOWLES: We have opportunities to compress things like lunch.

The CHAIR: We do; we will have a shorter lunch break. But we very much appreciate your time.

Mr FOWLES: Thank you very much. That was terrific.

Witness withdrew.