Kevin Anderson "Real clothes for the Emperor: Facing the Challenges of Climate Change"

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Thank you very much. Is this working, can you all hear me? Ok after that buildup I think that I might be a bit of a disappointment. So anyway I'll try and do my best. I'm going to spend the next 50 minutes, I'll try and keep it to 50 minutes, discussing this issue here, why I think the Emperor's streaking in front of us naked and while most of us are saying "aren't they beautifully attired", including many scientists.

I think actually if you stand up and say that the Climate Change Emperor is naked most people will shut you down they do not want to hear that however obvious it may be. So I think as an analogy it really works quite well. Hmm, so what do we need to do to ensure that the emperor can stay warm or cool perhaps in a climate change world. Hmm, So discuss this in relation to climate change .

Hmm I want to set a context up to start off with for this, this, can you all see the screen OK? OK, slightly lopsided but move a bit.

Right, this is from that well-known left-wing think tank the International Energy Agency hmm so this is from their Chief Economist so this is the conventional wisdom here, "We're on track for a three and a half degrees C temperature rise by 2040 and then looking at that compared with todays compared to pre-industrial times that's a four degrees C or so rise by around the middle of the century. That's what we're on track for at the moment according to the IEA

Hmm, and when Fatih Birol[1] looks at this data the trend is perfectly in line with a temperature increase of six degrees Celsius by the end of the century that is, which would be have devastating consequences for the planet. So the IEA are saying we're heading towards a six degrees C future, six degrees C global mean surface temperature rise. Today I think or yesterday PWC – PriceWaterhouse Cooper – put out a report[2] where they're saying also that we're online for six degrees C. I have to say I think its been pretty obvious fore the last ten years that that's where we're pointing towards, but it's interesting to see orthodox organisations coming out and saying this now. Hmm, Birol[3] went on to say that we have five years to change the energy system, or have it changed. So we'll either be changed by the climate and by the environment around us or or we can actually start to change it. Now note that it says energy system, it's not about supply, so real credit here to the IEA for thinking about this quite differently and being prepared to stand up and say things that many of us would not agree with.

Hmm The Copenhagen Accord, hopefully most of you are familiar with this, this is what we signed up to including most nations around the world have signed up to this including and in fact it was broadly followed by the Cancun Agreement hmm now they're not legally binding but like all International Agreements they're never really legally binding, but this is interesting because I think it actually says something quite important about how we see Climate Change. "To hold the increase in global temperature below two degrees Celsius", note it's below not a 50:50 chance of, "below two degrees Celsius and to take actions to meet this objective, consistent with the science", consistent with the science – that's quite radical – "and on the basis of equity" even more radical and most nations have signed up to this so I think we should always hold our leaders to account. Hold that in front of them and point out what it says – science, equity and therefore we stay below two degrees C, not a 50:50 chance of it.

1 Fatih Birol. Chief economist at the International Energy Agency
2 PriceWaterhousCoopers (2012) Too late for two degrees?
3 Fatih Birol. Chief economist at the International Energy Agency

So how consistent are these two, four, six degree futures with where we're actually going on emissions trends? Now there are a lot of graphs in this and I was told that graphs are a good thing by some people and bad by others so unfortunately I quite like graphs umm so hopefully you can see this here it doesn't matter too much if you pick up the numbers but this is basically CO2 in billions of tons up here and this is going from 2080 out to 2050 at the bottom. Now what I'm going to plot here is what's happening to emissions. Now the Intergovernmental Panel on Climate Change the big UN body which looks at these issues and was set up in 1988 – there first report was in 1990 – so these are emissions here in 1980. That's the report set up here which is the main body that pulls together the the science from around the world looking at these set of issues. The first report 1990, the Rio Earth Summit 1992, that some of you here with same colour hair as me will remember, or those with no hair probably can remember as well. The second report came out I think it was in ninety-seven from the IPCC Intergovernmental Panel on Climate Change, the Royal Commission report that laid the foundations for the sixty percent reduction in emissions by 2050 for the UK , the Royal Commission report came out in 2000 a third report came out in 2001 from the IPCC look what's happening to emissions during all this time. Emissions just keep rising. The most dangerous threat, climate change is the most dangerous threat that's a quote from the previous Chief Scientist David King 2004, the fourth report from the IPCC 2007, the Copenhagen event in Copenhagen in 2010. Look at the emissions now heading up towards double what they were in 1980. Then the Rio plus twenty event this year. We've had all of these events. All the great and the good flying round the world. We've had pop concerts we've had all sorts of nonsense about climate change and all that's been happening – what a surprise – is that emissions just keep rising and rising. That is the backdrop, that's the context against which we've got to put this in.

Now remember that globalisation is quite a new phenomena. I don't think we've really got globalisation yet. We might say thankfully. So we had the groundwork for globalisation that sort of lead up to 2000 but pretty much the OECD fed its own desires up until 2000, for manufactured goods anyway. More recently, we've seen China actively engage in the process of globalisation so this is the first time, I would argue, that we've actually got a globalised world with mass and transport of traded goods around the world. And it's really only China and one or two, maybe South Koreans and so forth, but lots of parts of the world are not involved in that. India's not really involved in it, African continent is hardly involved in it, so it's quite new.

And then we had the economic downturn, here. Now it's worth noting the economic downturn. In 2009 to 10 global emissions went up by 5.9%. That was at the start of the economic downturn. 5.9% - I think that's higher than at any point during the industrial revolution. And in the following two years – 2010 to 2011 – went up by about 3.2% and this year probably a little bit below three percent perhaps 2.6%, we haven't got the final data on that yet. But despite the economic downturn we're still seeing emissions rise, keep going up and up at the moment.

So what are the future for emissions? Well, let's just think that the energy system. Most of my work, most of my work and what I'm going to talk about today relates to energy. If we build a power station, if we build oil rigs and gas platforms which I used to work on they generally last 25 to 50 years if they're reasonably well built. If we build infrastructures, this building itself and grid networks, pipeworks, sewage systems, those sorts of things, road networks , train networks, they're going to last for 30 to 100 years so once you've put them in place that's typically how long you expect to see them live. If you build an aircraft and sell it or a ship you normally expect to see that living for or operating for about 30 years. So these things really lock you in to the future of the next numerous decades.

So if we think about the supply network – and remember that most of the world is fitting that like there's no tomorrow. And we're not changing our's – we're living with what we've got just

modifying it a little bit but the rest of the world is trying to build it as fast as possible. China at the moment is building about 150 International airports which we can't blame the Chinese because we'll be flying in and out of them no doubt – so a hundred and fifty international airports. So if they flew as much as we did they'd require 450. Now most of that's for academics, I think.

So let's just think now about some economic assumptions. Let's imagine that the economic downturn stops by 2015. Maybe that's optimistic, I don't know. Let's imagine that the wealthy parts of the world – the OECD – that our emissions reduce from 2012 from now onwards. In fact they're roughly stabilising as it is and not through judicious climate change policy, basically because we either have a recession or because we've exported the emissions elsewhere.

China emissions let's imagine that they follow their five year plan, let's imagine that there's some stabilisation in fossil fuel prices. We've seen that in the States that they're gas prices have dropped almost by 80% and that may or may not carry on that's due to shale gas. Let's imagine that India and Africa join in with globalisation some time in the next decade and that China peaks it's emissions by 2030. So Chinese emissions have stopped going up by 2030, that India peaks by say 2045, that Africa by 2060. You start to plot what that would look like and it looks something like that.

Now what's interesting with that – is that quite a few people I've spoken to about this say that is quite optimistic. They don't look at the area under the curve. The area under the curve there, which is what really matters, these cumulative emissions, hmm, relates to about five gigatons, five billion tons of CO2 that we're interested... Sorry that's completely wrong, that's say five thousand, that's a bit of an error isn't it - out by a factor of a thousand - almost like an economist.

Hmm, so let's just say five thousand gigatons not five and that's somewhere in the region of a four to six degrees temperature rise by the end of the century. But we have to bear in mind that when we start to talk about these higher temperatures the science is very uncertain because there's a lot of other feedback issues there a lot of non-linearities which are very complicated to understand . Probably you can't fully understand them at any point, but it looks as though in the orthodox way of looking at these issues this is a very, very high temperature future. That's where we're headed to at the moment. Just out of interest, that's the two degrees C that we're signed up to . So that's what we have to do for two degrees C and that's the gap between the void between the rhetoric. Here we are rhetoric; here's some reality.

Oh there's another couple of bits and the bottom there

The supply bit you can probably do something about supply about energy supply within say twenty, twenty-five by 2030 2040 you probably can't do anything about it this afternoon or in the next 5 or 10 years not significant. But you can do a lot about the demand side. So the argument that we make repeatedly is that actually it's demand that really matters and actually it's demand that brings issues down to the local level. Because it's us it's what we do that demands the energy . The supply side typically is a much more centralised issue and probably can't get away from that completely whatever we do. And most demand technologies actually you can change in one to ten years . Most cars actually most car journeys are travelled by cars which are under 8 years old 90% pretty much of all vehicle kilometres.

And behaviour of course can change instantly. We can change our behaviour now if we wanted to. We could switch all this off and go home if we wanted to do that. Or perhaps we're better off being here and having the heating off at home – that's probably better. Collective heat.

So now I want to think a bit about, hmm, the undergarments of the Emperor. Why, why is it that the

orthodox view is holding – at least they've got some underpants on. This is from the AVOID project which is a major Government initiative they've got lots of people involved including some colleagues of mine at the Tyndall Centre and the latest one is out which I've not put the quote up from but it's very similar "It is possible to restrict warming to two degrees C with at least a 50% probability that emissions peak in 2016 - don't hide that point global emissions peaking in 2016 – that's one year after Stern suggested – and a rate of reduction of 4% per annum thereafter. So basically very optimistic and upbeat. This is the Committee on Climate Change "to keep global average temperature rise close to two degrees C the UK must reduce by 80% blah, blah, blah, this bit "the good news", well maybe they believed it but I can't really believe that this really is the case, "the good news is that reductions of that size are possible without sacrificing the benefits of economic growth and rising prosperity" - because we mustn't possibly, whatever we do, question the astrologists.

Hmm, I'll be using that term instead of economic economists as we go through this. I particularly I mean a particular group of economists. Not all of you economists that are not neoclassicals then I don't put you in that group. And then this is from the Adam and Hugh (?) report European report (2010) "a low stabilisation target of 450ppm of $CO2e^{4}$", in other words lower than we have today, "can be achieved at moderate cost and a high likelihood of achieving this goal" (if you own a Tardis).

So these are important Government reports and people are saying these sort things – but they still look naked to me. I can't see any pants on the streaking Emperor. So with the alternative take that my colleague Alice Bows and I have put out in a paper in 2008 (it should say there) and indeed is in keeping with the IEA views today and the PWC views on this "it's difficult to envisage anything other than a planned economic recession" - we were told that that's too negative a term we should have used the word contraction, but I think most people know what we mean - "being compatible with stabilisation 650 parts per million CO2e", which is about 4 degrees C, there or there abouts. So that what we wrote in 2008 and then we revamped the analysis in 2011 for looking at the poorer parts of the world and the wealthy parts and if you peak emissions globally by 2015 to 2016 which is where most analysis peaks emissions this would require a prolonged period of austerity for Annex 1 nations – the wealthy parts of the world- and that's not talked about anywhere. Everyone's always talking about wine-win opportunities Green growth opportunities all these wonderful expressions that are completely meaningless when you think about the curves that I showed you at the beginning.

It would also be quite a change in development patterns for the poorer parts the non-Annex 1 parts of the world. For those of you who aren't familiar, I'll use this term quite a lot, Annex 1 nations they're not quite OECD, they're broadly OECD wealthy nations of the world so includes obviously Europe, US, Japan Russia so those, that sort of suite of nations. And then there's the non-Annex 1 nations which are all of the others and does include India and China. It's a better split than global but it's still a very, very, rough coarse level of language but they're commonly used Annex 1 and non-Annex 1 in the climate change negotiations.

So do climate scientists take any and I'm really talking about the people that work on the cusp between science and policy. People like myself but also a lot of other people in the Hadley Centre and elsewhere they don't necessarily get engaged with the really nitty gritty of the science in the lab, they work more empirically outside but they are involved in translating that into emissions scenarios and then feeding that into policy makers. They're the particular group I'm talking about here. So do we as climate scientists take no responsibility for this streaking Emperor?

Inconsistence in two degrees C. Now notice Copenhagen Accord holds below two degrees . The

4 Presumably this should be 350ppm of CO2e

low carbon transition plan must rise no more than two degrees that's the UK plan for this must rise no more than , the EU we repeatedly see documents which say do not exceed two degrees that sort of language not more than. Now if you look at the IPCC they're very clear about this that if you have language like this then would go along with the very unlikely to exceptionally unlikely to exceed two degrees C. They use a form of language which they then very conveniently translate that into a percentage probability. Now this is important because it tells you about how fast you've got to reduce your emissions, how fast you've got to come off the curve. So what we're broadly saying here is the sort of language we use would say about you might accept the 10% chance of exceeding two degrees C. Remember two degrees C is this threshold between acceptable and dangerous. It's not a scientific decision it's a political civil society international fudge like all of these things always are of course people coming together. It's informed by science but it's not a scientific decision 2 degrees C is the appropriate or not the appropriate threshold . We have come collectively together and whether we like it or not and come up with that as the appropriate threshold 2 degrees C and above that we say is dangerous.

So if you think of the busiest road in in Bristol, and at the moment we're going with a 50:50 which is what most legislation is built on, at best. That's every time every second time you cross the road you close your eyes that's what we're aiming for. It would be quite good for the emissions, it would bring the curve down quite quickly, hmm, so there are merits to it

Anyway, so 10 percent chance. Now, despite this the Committee on Climate Change, their most optimistic, the UK Government has a committee on Climate Change for those of you who aren't aware of this this, hmm, is said to be an independent committee, it's not really independent committee to be honest but it is an important committee and all credit to the UK Government for establishing this and all credit to the CCC they do some very very good work. I still think they very much sweeten the pill far too sweet in my view. The Committee on Climate Change their best budget is for a 56 percent chance of exceeding 2 degrees C so that's their best one. And the UK Government adopted their not quite so optimistic one of a 63% chance of exceeding 2 degrees C and so we're all signed up to hold to two degrees C but our policies put in place with a really high chance of exceeding that target. And actually for our national policies we're being very very unfair to the poorer parts of the world in terms of issues like deforestation and so forth that should be much we should have a much tighter constraint on that for the UK. If you might want to ask about that later you can do but we're being very unfair on some other parts of the world in making that decision.

The argument I want to make is can that sixty-odd percent chance of exceeding 2 degrees C can that be reconciled with hold the temperature below 2 degrees C and take action on the basis of science? Course we can't, and yet scientists say nothing about it. Our job as scientists is to stand up and say “hang on”, that doesn't really fit.

We and I'll make this point throughout the talk, the scientists repeatedly stay quiet. Like old Thomas Moore's Maxim silence is consent[5]. In other words we stay quiet, because we want to keep our paymasters happy, and by staying quiet we agree with what's going on. So that process of consent I think is really quite invidious in the whole climate change story.

So what we've now at least there's some scientific framework for that. Let's think about this a bit further, what else have we typically seen? We see these sorts of things all the time. Hmm, large reductions in emissions 80% by 2050, by not in my term of office, by I'll hand the problem on to my children, I'll have left being the CEO of the company by then so we all like this. It's big reductions it's big great grand schemes for somewhere a long way away when we'll either be dead or retired. So, this is something we all like; it has no premise in science. And yet scientists have repeatedly

5 Sir T|homas Moore “qui tacet consentire videtur” - he who is silent seems to consent

used this language and do not criticise it; they still repeatedly use it. One of the major funding councils for universities, the Scientific Funding Council if you like, the EPSRC[6] uses this for overarching energy research. It has no premise in science but it does fit with the policy-makers demands.

The CO2 from this event is in the atmosphere for one hundred two hundred years roughly. Keep this projector, keep the lights on so we are changing the climate tonight whatever else we may do we are changing the climate as we sit here now using fossils fuels to do this talk. 2050 targets therefore are irrelevant. It doesn't matter about what happens in 2050 it's about what happens today about what happens tomorrow really what's happened in the past as well but we can't do much about that. So it's about the build-up of carbon dioxide in the atmosphere and other greenhouse gases and that's really important. What matters are the cumulative emissions, the build-up of emissions, day in day out. That's what's important for climate change, not some mythical long term target that's got nothing to do with science or climate change that keeps us all happy. So we have to move back towards cumulative emissions carbon budgets. But that rewrites the chronology rewrites the timeline of climate change takes it away from wind turbines in 2030 or nuclear power, carbon capture and storage other great schemes way off in the future. These things are no longer adequate. What it tells you is you've got to do something immediately - urgent and radical reductions. You've got to come off the curve now and you can't come off the curve with supply technologies not quickly enough.

Now I'm going to be quite explicit here, I'm not saying the supply side is not important but it cannot get you off the curve anywhere near fast enough. So you'll have much higher temperatures if you just rely on people like me, engineers, to come up with technologies which will solve the problem in 2025 or 2030. Remember it's not just coming up with the technology it's getting that technology to penetrate the energy system . And that can take decades. So it's not just having a good idea - it's making that good idea actually work.

So how does this scientifically credible way of thinking about two degrees C , this idea of carbon budgets, reframed the whole debate? Well firstly let's look at the latest data, hmm it's not quite the latest data and we can plot this for next year and it'll be worse for next year and worse for the year after so we all know this and actually this curve could be for anything to do with humans really. Hmm, including arrogance, that always seems to go up exponentially. Hmm, so we have emissions of carbon dioxide here and we have from the pre-industrial period here back in the 1750, 26 years before Adam Smith's “The Wealth of Nations” up to today and what we see is a rising curve, And that could be plasma screen ownership, could be how many vehicle kilometres we travel, how many people there are on the planet, you know, how big our houses are all the rest of it . Whatever it is it's shaped like that really. Hmm, the growth rate in CO2 for the last century was 2.7% per year on average. Now remember that's a century when we didn't think about climate change and the growth rate was 2.7 From 2000 to 2007 the growth rate was three and a half percent. Remember it's a growth rate of a bigger number as well. That's why its exponential. So despite the fact that we've been rambling on about climate change for repeatedly the rate of growth of CO2 has actually gone up, not down.

Having said that it was 5.9% in 2009 to 2010, dropped a little bit now. Now what's interesting on top of that, so it's really disappointing completely the wrong direction . Exactly opposite of the direction we should be going in.

This may not mean much to some of you but just to say that the models, we have a whole set of models about what might happen to emissions in the future and the highest set that we consider, that we did used to consider until quite recently was appropriate for the future, hmm, had a growth rate

6 The Engineering and Physical Sciences Research Council

at 2020, the scenarios go right out to 2100, but their short-term growth rate was only 2.2%. So the highest ones that we modelled, and we didn't ever fully model those, we used lower ones of about one to one and a half percent, weren't even in keeping with what the emissions that we were doing at the time. They were pointing in the direction they were pointing in so we've always underplayed everything we possibly can we've done exactly what the sceptics said – but in reverse. We've underplayed on every single occasion what we can do on climate change. Now I'm talking here about the scientists engaging with emissions scenarios. They're not the other ones that do the more detailed bits of work that are really important behind all of this.

So what does our abject failure to reduce our emissions hmm and this idea of cumulative emissions together what do they say about the 2 degrees C pathways?

Hmm, if anyone wants the papers to this or you can pick them up off the web because we made them open access or I can send them to Phillip or some of the organisers and you can get to see the papers if you want. Basically, the earlier you can peak the emissions the earlier you can bring the emissions to a head and then bring them down the lower the reduction rate has to be after the peak – by and large, there's a few caveats in there. If we peaked emissions, these are for roughly a 50:50 chance of 2 degrees C, there or there abouts, if we peaked emissions by 2015 then the Stern has many of you here heard of the Stern Report[7]? Quite an influential report. I don't know if you know but Stern report is premised on global emissions peaking in 2015. He didn't speak to Africa, India, China or anyone else like that – I'm sure he spoke to a few folk in Oxford – but hmm yet there again very typical. We take a very parochial view of the world. It used to be our world but it's not really anymore. Hmm, so 2015 peak. Now this is our emissions here, and probably a few of you will struggle to see this. These are our emissions going up here to this peak in 2015 then coming off . And then this bit here. You can never get emissions down to zero because you've got to feed the population. And feeding the population as far as we can tell you won't get emissions down to zero because even just ploughing a field releases methane into the atmosphere. Fertilisers will put you N2O into the atmosphere. So there's all sorts of things with agriculture. Even if you're very efficient you're still going to get emissions.

Notice it's the area under the curve which matters range of hmm plots here range of curves which are drawn and that's because science, all good science is quite uncertain. So we plotted the range. This is from the AR4 report, for those that are interested.

Now if you peak in 2020 what you'll notice is that peaking a bit later the emissions have to come down faster. And if you peak in 2025 it's like lemmings off a cliff. When do you think global emissions are going to peak? If you think about it yourself you probably think that it will be here or later. So this is for remember a 50:50 chance of crossing the road safely in Bristol. A 50:50 chance of dangerous climate change.

So if we take the one in the middle there the 2020 one and let's, I'm going to strip out from that because that was emissions of all sorts, I'm going to strip out deforestation emissions, I'm going to strip out the food emissions and I'm pretty much going to leave with just what's left for energy, the area that I focus on.

Already by 2012, infact by 2010, we've blown the budget. If you think of what the emissions are from deforestation over the century, we think of feeding nine billion people, seven to nine billion people over the century, we think about the emissions we've put out from 2000 to 2010 we have no emissions left for energy, for most of the scenarios. So we have to be at the optimistic end of the science.

7 Stern, N (2006) Stern Review on the Economics of Climate Change

And if we then plotted that and that's not quite come out for some reason it hasn't worked out. Anyway, if you then plot that what you'll see is that early emissions have to go down to zero. Now that's interesting because if emissions go down to zero you can't have any carbon capture and storage and all these great schemes that are out there to try and take the CO2 out of coal or gas-fired power stations because you cannot get them down to zero. You can't get them close to zero. Probably somewhere between a 60 to 85 percent capture rate in other words 60 to 85 percent of the carbon dioxide going up the flue, or in the fuel in the first place, you can strip out. But you're always going to get something a 10 or 15 percent residue and you're also going to mine more out of the ground because it make the process a lot more inefficient. And as you mine coal or as you get gas you will always get releases of hydrocarbon gases into the atmosphere and you cannot stop that process. So you can't use Carbon Capture and Storage. All you can fit in this, I've been thinking about this are biofuels, which have a lot of problems with them, renewables and nuclear and they're all very low carbon. Very low to zero carbon as near as damn it.

So it says a lot about what we have to do. By 2035 to 2040 around the globe your cars your fridges, your planes everything. No carbon. Remember this is a global plot, not for the wealthy parts of the world. So I now want to think about that. What does this mean for the wealthy parts of the world? The OECD countries, the Annex 1 countries?

Well, firstly, I think it's fair that we think what could the non-Annex 1: India, China, continent of Africa some of the other poorer parts of the world. What could they do? This is from our later paper in 2011 hmm, published by the Royal Society. If we think about the emissions from the poorer parts of the world that's the emissions going up, keep going up here, and I made an assumption here that they peak, that they grow at three and a half percent per annum – that's growing lower than they are today – they probably grow at something like four and a halh to five percent per annum for the poorer parts of the world. So we're always saying to the poorer parts of the world "please don't grow your emissions as fast" and they're saying "no problem, we'll cut back just for you".

So they peak emissions in 2025. I don't think there's any country in the non-Annex 1 countries that thinks that's viable including the Chinese. But let's imagine that we can persuade them through logic, argument, good examples that we're doing at home here that they'll peak their emissions in 2025 and then they'll come off the curve at twice the rate that Stern says is possible with economic growth. About twice the rate that pretty much all economists will tell you is possible with economic growth. So then we say we now know what that looks like. That's a pretty ambitious curve asking the poorer parts of the world to do that. Remember that this is where most people in the world live, as well. And the area under the curve is what matters. So you then know the area under the curve, you know how much budget you've got for two degrees C for the globe, you say "well what's left for us?" "What's left for the wealthy parts of the world?" Well it doesn't look very attractive. For those of you who can't see it's a vertical drop off from 2010. Hmm, there's nothing left. For, this is for a 40% chance of exceeding two degrees C, roughly 50:50 or thereabouts. There's nothing left for us. If we ask the poor parts of the world to really pull out all stops we would have to stop putting any emissions out in at least 2010 to give ourselves an outside chance of avoiding what we've defined internationally as dangerous climate change – that we've all signed up to that we passed international negotiations on, that we've passed our own domestic legislation on. We never even bother thinking about any of this and the scientists stay quiet. That's a peak in 2010 coming down I like engineering and as an engineer with a good spec you can achieve a lot but you can't have an infinite rate of reduction. In this case it would be even more than that because you've got to do it in the past. They almost succeeded in that with that neutrino experiment but I gather it didn't work. So how come, this, I would argue that this is completely premised on Hadley Centre type analysis all the standard science feeds into this. We're not using any tipping point issues, no discontinuities, this is all the standard analysis that feeds in to everyone else's sets of emissions

scenarios. So why is it that we've come such fundamentally different conclusions?

Hmm, I'm going to think about this graphically and it's actually quite important this I think to get a handle on how much we've deliberately twisted the debate.

Another graph. Hmm, so we've got CO2 up the side and we've got the century 2000 to 2100 down the bottom. It doesn't matter much it's just really a symbolic curve really. First things, what are the current emissions? I'm asking, what do we assume globally until we hit a peak? When do you think that peak in emissions will arise? What reductions are there after the peak? What reductions are viable there? What's the emissions floor? In other words how much emissions related to food is in there? Can we suck the CO2 out of the air with some magic? And I don't think it's necessarily magic but I think at the moment it's certainly in the Dr Strangelove[8] category. What emissions are there for two degrees C? What budgets are we going to use for two degrees C because there's a lot of scientific uncertainty there. So let's just quickly look at those.

Hmm, remember what we're trying to say here is that the scientific community repeatedly underplays the story. That's what I'm trying to show here. Very unpopular with some of my colleagues. The Stern Report for those of you are familiar with the current rates now the Stern Report was published in 2006 so we had the data up to 2006 including research wasn't without a few pounds for writing the report. I've got a lot of time for the report except for the numbers. I like the ethos around discount was really important and he got mostly criticised for that by the economists. Hmm, but in terms of these numbers he had the growth rate of CO2e at 0.95% per annum from 200 to 2006. If you think about that that's the angle of the curve going up but the real data was 2.4% per annum. That's a massive difference. Now that's not a difference in a prediction, that data was available and was collected by governments and was submitted to the United Nations Framework Convention on Climate Change and Cideac (?) and all the other great people who collected this data. Anyone could have got the data off the web for nothing, but instead we used the 0.95 percent per annum. And actually loads of climate models, emissions models, have just done that they just continually use an extrapolation of 1990 optimistic trends they don't bother checking the real data. And us scientists say nothing. So an error of 250%. Hmm, and that would fundamentally change the subsequent analysis in the Stern Report. And what does the scientific community say? Absolutely nothing. Just stay quiet.

Now let's just put - this annoyed me a lot of the time now it's quite old 2006 but just to give you some idea of this, that's the growth rate he assumed out to 2006. That was the real growth rate. Now imagine you just extrapolate that because that's what you do with curves, you think where's it gone where might it go? So let's just extrapolate it out to 2020 and you already start to see a massive gap between the two. And of course 0.95% hasn't been what's happened nor is 2.4 it's just been going like this in reality, much, much faster. So to start off with we've not even got the current rate of emissions growth correct. Deliberately so. I think that's fair to say. Allegedly, deliberately so, to protect myself. I quite fancy an open prison – no admin and access to the internet! Hmm, lots of research!

Right, what growth rate. We've talked about the current emissions, what growth rate out to the peak do we see? They're almost every single anlysis shows the growth rate to the peak emissions of 1-2% per annum. Despite the fact it's been somewhere between 3 and 6. The latest analysis just to come out of the AVOID project same sort of thing relative, slightly higher but think somewhere between 2 and 3 . Basically all the analysis out there are way below those that we're actually seeing.

When do the emissions peak? This is quite interesting. Almost all analysis if you look at the

8 Dr Strangelove. 1964 black comedy film

details, look at the spreadsheets that they give you not necessarily graphs but the spreadsheets, they'll peak between 2014 and 2016. They're taking as their assumption feedback to policy makers their conclusions that global emissions will peak between 2014, two years from now and 2016 four years from now. The Committee on Climate Change, the UK Government's Committee on Climate Change goes for 2016. Stern (2006) assumed a 2015 peak, CCC uses a 2015 peak which means that China and India have to peak in 2017, hmm the Adam report[9], European report same thing again so what we see is a lot of reports assuming a 2014 to 2016 global peak. Everyone knows that's not going to happen, including all the people that write these reports. That's not the worst of it. The fact is there are lots of analysis that peak their emissions in 2010. Their 2006 in the United States climate change science program 2007 that's when it came out so this is when it came out and they're assuming a 2010 peak. Ackerman, report[10] came out in 2009 had global emissions peak in 2010. We contacted them about this – we didn't get a particularly satisfactory e-mail. The Hulme (?) report came out in 2010 had emissions peaking in 2010. That's challenging peaking in the past. I said the neutrino didn't work. Peaking in the past. Hansen 2008 report had emissions peak in 2005 in that report. Northouse (?) these are two ends of the spectrum on climate change, they had a 2010 report had emissions peak in 2005. If they're an abstract analysis then fine but what they then do is they then give policy recommendations on the back of those. Look at those reports and you'll see policy recommendations. So a policy recommendation premised on owning a tardis and this is then what we develop our policies from. This happens repeatedly and what do the scientists say? Nothing.

So that's the peaks, what about the reduction rates? So these we come back to our old friends the astrologists. Hmm, these are held in check by what the economists tell us can be matched by economic growth. Given the economists haven't really been very good at understanding the sort of economic chaos that we're seeing at the moment, I think it's odd that we take too much notice of what they say about the future. But here almost every single curve out there that reduction rate there is constrained at 2 to 4 percent per annum and that's because anything outside of that the economists tell us cannot be compatible with economic growth. So it doesn't matter if we wipe the planet out, if we all die, so long as we're not interfering with economic growth. So this bit here completely constrains the rest of the analysis. So this is why you have to massage this bit. And why you have to muck about down here because the economists have told you that and we daren't question them. The Osbornes[11] of this world the Vince Cables[12] of this world with their wonderful intellect we have to take every note of what they have to say.

The emissions floor. I'll go through this quickly. This is a difficult issue to understand because people have done their best on this and it's quite challenging to know what that's going to look like. I don't think there's been anyone trying to manipulate this really at the moment but this is the emissions floor here which I won't go into here but which relates to food production. If anyone wants to ask about that later they can do. But the bit that we do manipulate is that most analysis out there now assumes that we can suck the CO2 out of the air. So they almost all have geoengineering in there, negative emissions technologies. Almost without exception they grow biomass, combust it in a power station and then put the gas back underground. The carbon dioxide in the ground. They pretty much all have that in there so they're sucking the CO2 out of the air, or large numbers of them. That's used in report after report they use negative emissions in there. So they're ubiquitous in low carbon scenarios that we use geoengineering. We've never succeeded in geoengineering at any scale. So we're putting something in place which we assume will work and I'll come back to that in a minute.

9 Adaption and Mitigation Strategies: Supporting European Climate Policy (2009)
10 Ackerman, F (2009) Can we afford the future? The economics of a warming world
11 George Osborne, UK Chancellor of the Exchequer
12 Vince Cable, UK Business Secretary

Then the other thing is what size budget do we use? Well the Hadley Centre, the UK's premier modelling centre in this area, and one of the leading model groups in the world, for for round about two degrees C future they gave to the IPCC they gave a figure of 1400 billion tons of carbon that you could dump into the atmosphere over the century. The Committee on Climate Change and the Governments choice is to go for 2,900 Gigatons just look at the difference. One's almost twice as high as the other. So we're also changing what area under the curve we can use by changing those probabilities. So little tweaks here and there allow you all sort of ways to massage what you're doing.

Now the other bit I wanted to talk about briefly and I think this is really quite worrying this is the split between the poor parts and the wealthy parts of the world. So if you imagine that the wealthy parts of the world are doing this and the poor parts of the world their emissions have been doing this. And the point is, when do they cross? The point when they cross is a really important point. United States climate program this is the language it used this is a really important document in the States, we have something similar in the UK, used "meaningful and plausible" that's their quote reference scenarios from a perspective of highly regarded integrated assessment models. That's basically when scientists come together with economists and produce something that's expensive.

Hmm, at the moment I'm very unconvinced that they have any, I think they're actually more dangerous than any good they provide . So these, these, meaningful and plausible scenarios from highly respected, hmm, modellers they assumed that non-Annex 1 emissions would exceed Annex 1 in other words the poor parts of the world their emissions would be higher than the wealthy parts of the world in 2013, in Stanford at 2021 and MIT these are not minor institutions in 2023. The real date was 2006. Don't let the empirical data get in the way of a good story. So actually the empirical data that we have crossed over in 2006. Note this report came out in 2007 and these great modellers here assumed it happened way in the future. Because it allows you to do a lot more about giving more emissions space to the wealthy. So this is supposed to be science remember.

Now meaningful and plausible, I don't think so. United Kingdom's climate change Committee on Climate Change their budgets they describe they use the words feasible forty-odd times in their 2009 report and something similar in their more recent report and yet it has global emissions peak in 2016. So does anyone think that's feasible? They use the words feasible repeatedly. It portrays a language that makes it sound feasible. And they had Annex-1 emissions peaking in 2007 to 2010 – that doesn't necessarily seem too unreasonable, and they assumed that poor parts of the world would peak by 2018 and that China and India would peak by about 2017. So that's not in any way feasible in my view and yet that's what we're basing our analysis on in the UK for our climate change policy. So across the board I would say that we are underplaying the issues.

I'm not going to go into these in details here all I'm saying here is that the geoengineering issue is really important. Now I'm not saying we can't do it but we haven't done it, we have very few pilots that are moving anywhere near this at the moment. Everyone uses biomass and carbon capture and storage. You grow the plants you burn it in a power station and then you take the flue gases out and you put them deep in some reservoir somewhere an old gas reservoir somewhere. It's worth noting there's not one large scale Carbon Capture and Storage power station in the world. There's some moderate sized ones, well hardly moderate, some small plants around the world. Now there's nothing large anywhere on the planet at the moment. There are big issues about food and biodiversity with biomass so growing this biomass. Look at shipping it thinks it can use this biomass the car industry thinks it's going to use biomass the aviation industry thinks it can use biomass the power sector thinks it's going to use biomass and we're going to use biomass here as well. Everyone's thinking of using it. Every biomass plant, every biomass scenario out there has a lot of CCS. Is there enough space out there to put all this carbon dioxide is a reasonable question to ask.

Hmm, so that's that. The nuclear one is interesting as well . I'm agnostic about nuclear I'm not a great fan of it for the UK because we've got plenty of renewables but some poor parts of the world – maybe Iran being one of them – they could actually think of it as a low carbon fuel but we're awash with renewables in the UK so we're not required to have it here.

So look at these integrated assessment models virtually every single one of them has a massive increase in the supply of nuclear power. And yet you then start to say well have they thought about access to Uranium 235? Now there's uncertainty abut that. Some people say there's quite a lot left some people say we have less than forty years if we start to ramp up that supply system. So 235 is really important. Is there enough there? Those questions are not being asked appropriately. We can go for fast breeder reactors which would get around the fuel constraint but there are lots of questions around fast breeder reactors that make them very unpopular for very good reasons lots of bad reasons why they're unpopular these are questions that are not being asked. We may think about Thorium. People say well Thorium will help but we haven't got Thorium reactors. Thorium might work in the future but it's not going to work in the next 10 20 years not in large-scale, roll-outs of the technologies. And yet these are just assumed to be occurring in the scenarios. We're just rolling these things out. Scenarios are supposed to be an exploration of plausible futures but they're not they're hard-wired. These are hard-wired to the assumptions. What we're doing is pretending we're exploring the future and we're just hard-wiring them depending on what our paymasters tell us, broadly. And I think that is not the way that science should be done. Let me be quite specific about that. I'm talking about the people doing the emissions modelling here; not about most of the scientists who work on climate change but that particular group the group that I engage and I'm one of.

Hmm, so I want to now, what was the .. Oh yes, I want to understand (the previous slide here) I'm trying to understand why this is actually happening now. So with few exceptions the scenarios out there they hide or they massage historical emissions. So they change the framing of where we are today. That happens repeatedly. They always underestimate short-term growth out to the peak of emissions. That happens again with pretty much every scenario out there. The peak choice is Machavellian at best – no-one thinks that we're going to peak in 2016 and yet virtually every model will peak in 2016 which gives you a nice answer for your policy-maker. The reduction rates are just dictated by the astrologists so you're just told what you've got to come off the curve at. Geoengineering is assumed to work – not saying it won't work - but we should have scenarios where some include it some don't and probably only a very few of them should include it. The split between the poor and the wealthy parts – Annex-1 and non-Annex-1 – is pretty much either neglected or hidden. Hmm, great leaps of assumption about big technologies. As someone who used to work offshore I like big technologies but they're not quick to rollout, and they're not like they are in the textbooks. So you don't get the efficiencies they tell you you'll get in the textbooks The real world the big technologies is very different from the textbook world. And actually the economists have nothing to add to this. Not the neoclassical ones because this is a non-marginal world. This is a world where we are changing things so rapidly we're such fast rates the theories that most neoclassical economists, the market economists, use are based on marginal analysis. So it would be like using Newton to understand sub-atomic particles. You would not apply the theories of neoclassical margin analysis market analysis to understand the step changes we're talking about here. You wouldn't apply Newton to understand subatomic particles and yet we continue to do that there's real arrogance in there. And we also think we have a magicians view of time here. We think the bull can meander into the china shop, trash everything around it, come out and we've got some superglue will look like it did before. That's what we think about with climate. That we can somehow do all this, reverse our way out of it and then fix it which is quite an arrogant and doesn't fir with any of the science that we know about .

So why is all this the case? Why have we got this political creed around two degrees C? This is these are some quotes I put them into a paper and I informed the people that I've used these quotes I'm not saying who they're from. This is from a very senior colleague of mine I've got a lot of time for him a very senior political scientist, advises the Government a lot of the time . I spoke to him in 2010 after an event all about two degrees C stuff and he said "too much has been invested in two degrees C for us to say it is not possible it would undermine all that has been achieved it would give a sense of hopelessness that we may as well just give in". These are the exact words. This is my asking a question then, "Are you suggesting we have to lie about our research findings?" "Well perhaps just be not so honest". More dishonest. So that's from a political scientist who really understands this terrain of climate change policy and science. This is a senior Government advisor I won't say who it is, "we can't tell them, Ministers and Politicians that it's impossible. We can say it's a stretch, ambitious, but that with political will two degrees C is still feasible". Even when it's probably at three and four degrees C and we're swimming around in sea level rise we can still tell the ministers that two degrees C is possible. Hmm, he actually said that in a public place so I could name him but I won't.

Hmm, sorry, right back to the Department of Energy and Climate Change is it Ed Miliband the day before he went to Copenhagen I had a twenty minute meeting with him in Manchester before he got the ferry the following day. (Hmm, I'm not really sure it was the ferry, but anyhow) and he said so this was the Secretary of State for the Department of Energy and Climate Change "our position is challenging enough. I can't go with the message that two degrees C is impossible, it's what we've all worked towards". So across the board everyone's saying we can't be honest about two degrees C. I was at a event recently a Chatham House event so I can't tell you who was there but a very senior Government Scientist and someone very senior from an oil company, and it looks like something you might find on a beach, hmm these very senior people said "well, I think we're on for 4 to 6 degrees C but we just can't be open about it". But that is going on all the time behind the scenes that somehow we can't tell the public. Exactly the opposite of what the sceptics say but exactly the opposite direction.

So where does all of this leave us? If it all looks too difficult then how about a 4 degrees C future? There are some of you here who know a lot more about this than me but I'm using some numbers here based on the Hadley Centre and some other people's analysis. Very simple, bit of some assumptions here but I think it's important to think about a four degrees C future.

If we peak by 2020 we come down off the curve at 3.5% per annum that's the sort of stuff we've been talking about, we can hold to four degrees C. Four degrees C is doable. It's challenging but doable. Hmm, so I'd say it's achievable, so is aiming for four degrees C more realistic? Certainly I was at an event the other day and someone said I can't see what's wrong with 4 to 6 why can't we just carry on aiming for that sort of temperature? He was a very wealthy American, hmm, but you know I'm sure there's lots of other people say the same thing there somehow a lot of us think we can defend ourselves against this sort of changed world. Well, maybe some of us can. Hmm, four degrees C global mean surface temperature you're probably talking about five to six as your land temperature because remember there's lot of the global temperature is held down by the thermal inertia of the oceans . So the oceans themselves actually keep the Earth cooler. If the global temperature is four then the land temperatures on average will be higher than that but you'll see very large regional variations and that's what really matters are these regional variations. And let's just be blunt about that again, the science is really very uncertain on this this is an area that really needs a lot more work

Hmm, so if we think of the stuff that came out of the Hadley Centre. Look at the hottest days of the year so think of the year 2003 heatwave in Europe. Just think of China, Beijing and Shanghai. If you look at the buildings that are going up there and in other parts of the world as well during their

hottest days of the year you'd have six to eight degrees temperature rise and that could last for quite a long time. So the hottest days of the year for the four degrees C global average. Imagine the 2003 heatwave imagine that we knocked on top of that eight to ten degrees C. Now somewhere between twenty to thirty thousand people died during that. We've got Victorian infrastructures. Our tubes won't work. Lots of the things will not work in that sort of world. Not been designed for that sort of future certainly not with the populations that we have and the urban heat island effect on top of it. Ten to twelve degrees in New York. These are high really very high temperatures and the infrastructures and the way we live out lives could not deal with these things. Remember in London, what was it three days food, this could be a good thing, there's three days food in London? For those sort of temperatures you may find that there's no transport network. So in three days, you know, things won't be working. The fridge probably won't work because the air conditioning unit's been blasted away so you'll probably be blowing the fuses on the grid. So, you know, this is not a world that we know how to contemplate and at four degrees C hmm think at lower latitudes the estimates are that you'll see significant reductions, 30 to 40% reductions in some of the staple crops in maize and rice and so forth. At the same time the population is heading towards nine billion. So this is the sort of four degrees C world. And my, interesting, some people do know here will know a lot more about this than me and if they take this similar view.

This is my anecdotal polling of climate scientists who work in this sort of area. There's a widespread view that a four degrees C future is incompatible with organised global community as we see it today. Particularly with nine billion people and all the other stresses that we face. It's likely beyond adaptation. Lots of us will not be able to adapt to the impacts and just get hit by the impacts. Some of us might be able to adapt but many people won't and it's devastating for the majority of ecosystems. Ecosystems always change but this is a very very fast rate of change. Ecosystems are probably not tuned to this rate of change. And also there's a high probability of this not being stable. Many scientists suggest as you head towards these temperatures you get other feedbacks kicking in. Some people want tipping points, these non-linearities. I think we mustn't overplay what we know about those. What we do know is that the higher the temperature the more likely it is that they'll occur. So a prudent person would perhaps keep the temperature rise low. But then it would go up to some other temperature four, five, six, seven, eight whatever it might stabilise out at. Again, these are things there's still a lot more science to do. So I would say I would go so far as to say that four degrees C we should avoid at all costs.

Now, before we despair, hmm, this is all a sort of message of doom and gloom. What can we do about it? What can we in it is room what can another people what can policy-makers what can we do from the bottom up what can we do from the top down abut this? Has anyone got a clock? Is there a clock no idea what. Five to. Does that mean I finish now? Is anyone still awake? There's a little bit of good news coming up!

I'll whip through this a bit quicker sorry, I should have put a clock out so I can keep an eye on things . Hmm, just to give you a handle, this is the sort of reductions that we need to see in the wealthy parts of he world . This is for an outside chance of two degrees C. We need to have about ten percent per annum if not a bit more than that really from energy. So we need about a forty percent reduction in the next three years in our energy consumption. That's all of our energy consumption not just the bits you want to measure that includes planes that includes ships – forty percent. A seventy percent reduction by 2020 and basically be completely decarbonised by 2030 – fridges, planes, ship, cars everything we do. Projectors power systems everything decarbonised to give a little bit of space for the poorer parts of the world to help them develop and improve their welfare. So that's what we have to try and do and we'll all say that that's impossible. The question I was asked, which you probably can't see at the back is was well is living with four degrees C temperature rise by 2050 to 2070 is that any less impossible? The future is impossible. This is an academic I quite like you see lots of research grants saying well how can we make the impossible

possible? Well we don't get that how can we incrementally twiddle with this system again?

Hmm, but you know, whatever you do the mitigation future is impossible and the adaptation future is impossible and then we've got ourselves in this position. Tough, you know we've done nothing about climate change since Rio and we've never really done that. So are there any things that can move us in the right direction?

The first one of these I'm going to talk about is agency sorry equity and the second one is technology, I'll whip through these quite quickly. This is just a guideline but there's seven billion people on the planet. Who needs to make a change? It's not about population. Climate change is not about population. Climate change is about a small group of people, and we know who they are, we see them when we shave or when we put out make-up on we see them in the mirror. Hmm, so sustainability is a seven billion person issue. Climate change is not because its about the next ten days to ten years really .

Pareto. Italian economist. Eighty twenty rule I use this in engineering for years it was just called the rule of thumb. Eighty percent of something relates to twenty percent of those involved and its just a guide and there's some background to this information now. Eighty percent of emissions from twenty percent of the population. Run that three times in other words do the same thing again with that particular group there do the 80:20 rule do it again and you get about 50 percent of the world's emissions come from 1% of the population. Some of the other estimates out there, this is for energy, if you include food it might be that about 5% of emissions come from 50% of the population[13]. But actually food is more evenly spread because we all roughly the same the peasant and the pauper and the prince eat roughly the same amounts of food but they don't in terms of energy. Hmm, so roughly as a guide 40 to 60% of emissions come from 1 to 5% of the population and we know who they are. Who's in the 1 to 5%? Well I don't know if you're all in there but the sort of audience I normally engage with every climate scientist is in there, there might be an exception somewhere but they're had to find; every journalist, pontificator and sceptic every other OECD academic everyone who gets on a plane once a year and if you're on £30K a year which most students aren't probably some of you will earn that much then you're in that category already. So we're the major emitters – we know who they are. No-one else to blame. And that includes me.

So the question then is are people like us the Annex-1 people, but including of course about three million people who lead wealthy lives in China, hundred million slightly smaller than the EU was hmm, are we prepared to make changes to our lives now or have them forced upon us. Or are we prepared to hand over to our children, or even later on in our lives a much higher climate change future? So there's a lot we can do. We don't require the whole world to do something, we require a small proportion of the world to change what they do today for the next ten or twenty years while we put low carbon supply in place. Then we can go back to our old profligate lifestyles. Except there are some sustainability concerns that might step in but from a time perspective, climate change is a short-term issue we have to deal with and that's why it's not about population.

Hmm, is there anything we can do technically? There are lots of things we can do about behaviour. Here's one quick one . If we want to provide light – these light bulbs are a very good example of that. If we want to provide light we need electricity a transmission network a power station and some Venezuelans to dig the coal out of the ground for you. So you put the light in here, ten useful units of light using lumens the power here is eighty percent heats twenty percent light probably slightly better by halogen but not much better you'll lose six to ten percent probably eight percent in your transmission network but most of it in the low voltage distribution system your power station will, be a thirty five to forty per cent efficient and you'll lose ten percent of your energy getting the stuff out of the ground putting in onto a ship bringing it over here another train into the power

13 These last two figure should, of course, be reversed

station. So you add all that together, we can do something here but all of our focus is on this Remember this is what we do. So this actually says this is an issue for us we can do a huge amount here and have massive repurcussions across the system.

And about cars now notice this is without rebound assuming we're not going to drive further. The typical car and point this out to the politicians and ask well why aren't you doing it. Politicians ask me why they aren't doing this. The UK typical car 175 grams of carbon if it's driving at the moment. A new car in the forcourt in its per kilometre . The EU really stringent plan for 2015 is 130 gram of CO2 per kilometre and then you can buy your way out of that if you're a professor or Clarkson or some other fool. You can pay for your four-wheel drive if you don't feel you've got enough status and own personality. Hmm, so within what's available today there's a blokey car here or that sort of Clarkson-type car. 2008 BMW it's one of their three or five series its 160 horsepower four seats it will do 109 grams. I've got, a friend of mine has got one of these and he likes it because it's a sort of sporty boy-racer type but he puts his whole family in it and he's getting 65-70 to the gallon from the BMW. Particularly when he takes his family with him – he drives more carefully then.

VW is 85-90 grams, Audi came out in 1988 is 75 grams . Not admitedly when you drive these things they're not that good. They're about 10 to 20% more than that. But these are what we can do now. These are not new technologies of the future these are not hybrids they're not electric cars they're diesal cars you can buy now for no price premium. Virtually no price premium. So why isn't there policies in for that for 2015? If you actually said well the important point is ninety percent of all vehicle kilometres are travelled by cars that are under eight years old. That's according to the DFT, Department for Transport. So most vehicle kilometres are travelled by newish cars typically the first one, two, three years. So we know the normal scrappage rate. You can actually swap the system through if you put a decent policy in place to say you have to buy this sort of car, this sort of standard. You'd have about a forty to fifty percent reduction in CO2 by 2020 with no new technology. At no price cost. No hybrids, electricals. Reverse occupancy trends and so we have slightly more people per car. I think it's about 1.3 now went back up to 1.8 people per car. Now obviously, someone asked me recently about the 0.3. It's an average so we're not saying it's a leg or something. Hmm, so reverse that you can head back towards the sixty to seventy percent reductions by 2020 or 2022. In other words we can do what we have to do to give us an outside chance of two degrees C for the wealthy part of the world from cars. So there are plenty of things we can do technically. Hmm, so what's happened here? Final couple of slides now.

Think about some of the conservative assumptions I've made here . If the size is broadly right, if the non-Annex 1 parts of the world the poor parts of the world peak their emissions by 2025, 2030; if there are rapid reductions of deforestation; if there's a significant improvement in how we produce our food, eating less meat, different types of agricultural practises; hmm, if there are no tipping points out there if the feasible rates of reduction of three to four percent per annum are achieved as per the economist tell us, then two degrees C stabilisation is virtually impossible. So if we do everything we say we're going to do, but that we're not doing, hmm then we still can't hold two degrees C. Four degrees C by 2050, 2070 doesn't seem unreasonable if you look at the current projections of emissions .

That's quite a sad endictment of where we are. Quite a sobering message, but I chose to say that there are lots of things we can do, hmm, both from the bottom up and from the top down this Royal Society paper. This is not meant of a message of futility – it's often said this is just futile . It's a wake-up call of where our rose-tinted spectacles have brought us. Real hope, and that's the only thing I'm interested in, real hope if it is to arise at all will do so from a bare assessment of the scale of the challenge that we now face and that's what I've tried to show here. This is where we are today. If we know where we are today we know what the scale of the problem is. If a scientist keep

underplaying it we don't know it. And I'll leave you with a quote from Unger that I always finish off with "at every level the greatest obstacle to transforming the world is that we lack the clarity and imagination to conceive that it could be different". Clarity and imagination that's what we need lots more of that and then I think we could actually deal with climate change to a degree. Thank you very much.