

A global effort to make the way we use and produce energy as efficient as possible is essential to slowing global climate change.

We spoke to Chris Rapley, the director of London's Science Museum, about climate change, population growth and the part the energy industries have to play in tackling one of mankind's greatest challenges: the supply of clean, secure and sustainable energy for our future.

Q: What can mankind do to tackle the need for more energy while reducing CO₂ emissions?

A: It is absolutely clear that there is no silver bullet. There is no single technological, social or leadership solution because our demand for energy continues to grow and will continue to grow. It's allowed population to grow and of course that population all want a better quality of life and a very large proportion of them have a quality of life that is not really defensible in the modern world. The Millennium Development Goals are driven towards a greater use of energy because the only way you will increase the quality of life is through the use of energy.

So what we have to do is look at all the different ways that are available to us to reduce future emissions by a significant quantity. Currently we are at eight giga-tonnes (eight thousand million tonnes) carbon equivalent of emissions per year. The business as usual projections, which some people think are even conservative, show us going up to double that by 2030 – 2050 depending on what rate you take or models you use. Yet there is a broad consensus that a two degree centigrade rise in global mean temperatures is about the limit beyond which some really rather unpleasant things will start to happen. The harsh truth is that we are probably committed to that already even if we stopped emitting carbon dioxide tomorrow. So this is a bit of a startling realisation, particularly when if you look at the human carbon emissions over the last eight years since 2000. These have been at or above the business as usual line in spite of the fact that we knew back in 2000 that to stabilise at two degrees we would have to be turning emissions down quite rapidly.

What we know is the temperature that we stabilise at will be dependant the total amount of carbon dioxide that we pump into the atmosphere and which sits there because of course we are being helped at present by the ocean and the atmosphere, both of which take about a quarter of our emissions, and so leaving about half there. All of the evidence is that in a warmer world they will weaken as asinks so that makes the situation worse.

So what are we going to do? Well there are lots and lots of different things that we can do. This leads to what has been called the “wedge approach” and is what Al Gore describes as the silver buckshot as opposed to the silver bullet. So for example if you take motor transport, then a very significant improvement in the number of miles per gallon, doubling the fuel economy of cars and trucks in 20 years, this would have a big impact.

Providing of course people didn't drive them twice as far! So there is a technological side to the solution as well as a social side. You could gain the same impact by persuading people only to drive their cars and trucks half as far as they currently do, if you did both you would get two wedges which would give you a reduction of a quarter instead of a reduction of half. So that's a good example of this ying yang of the technological solution and the social solution in changing patterns of behaviour.

Another issue is how we supply electricity. If you want to kill a city then turn off its electricity supply. Everything depends on electricity these days, if the Internet fails or if computer systems fail we couldn't function even if we were able to feed and heat ourselves. So keeping the electricity supplies running is clearly very important. It has been recognised widely that a contribution to this will be the next generation of nuclear reactors. Now that's a hugely contentious issue because of the security and all of the long history of the association with nuclear reactors with nuclear weapons. But it seems to me personally that it is inevitable that nuclear energy must play a significant role in the future

We live in a world where the supplies of gas, oil and coal are increasingly uncertain. They are coming from unstable parts of the world and it is not at all clear that the reserves out there exist in order to supply the world's energy demands in 30 years time. So nuclear will play a role, bio fuels, not the first generation ones which seem to be more trouble than they're worth, but the second or third generation ones, wind, wave all of these sources of energy will all have to be deployed.

The one that will make the most difference if the technological obstacles are cracked will be solar. If we could capture even a percentage of the solar power that the earth is bathed in every day that would make a huge impact.

The other thing of course is that we need to be looking at ways of taking CO₂ out of the atmosphere. At present that is not economic and it's not even sensible from the CO₂ point of view because you would use so much energy to do that that you would generate as much CO₂ as you would actually remove.

However if there were a breakthrough in solar power for example you could use that energy to drive machinery to extract CO₂ from the atmosphere, if you like, making up for what we have done over the past 150 years to some extent.

Q: On that point what do you think about the cap and trade mechanism for putting the cost of CO₂ emissions on to industry?

A: It's very interesting as a similar system has been quite effective for sulphur emissions and acid rain both in the US and in the EU in the past.

There is some reason to believe that it is a mechanism that can work but it is not at all clear that it can really work at a global scale, particularly when it is so difficult to get everybody who needs to commit to it to participate in a single unified scheme.

I have to say, I am more convinced by a scheme in which those who demonstrated that they have extracted or sequestered CO₂ are given certificates and if you like, permissions to extract hydrocarbons from the ground. I think that is a scheme at least in principle, whether it is practical is questionable but at least in principle it is the right approach.

Q: You have called population the “Cinderella” of the sustainability debate; can you explain this?

For all sorts of reasons people are very nervous about talking about population. There is a bad history if you like of the topic in general, eugenics and all of those awful things but also the interventions that have been made which have often violated people's human rights and so on. This is not what I'm talking about here.

It turns out that there are many many more children being born today than people actually want. This is simply because they do not have access to contraception or education or the wherewithal for them to decide, and for them to control the size of their family.

We know from the campaigns that the United Nations have run, how much it costs to provide all of those factors that allow population rates to decline very rapidly and completely naturally, and without any coercion and without any unpleasantness.

If you then look at not only the carbon emissions that would be saved by those people not existing because they are not born in the first place, but also all of the non impacts of someone not being present. If you just look at the cost and the benefit in terms of carbon emission of course it varies very much depending on whether you are saving a person in the developed world where they have a much bigger carbon impact than in a very poor country. Nevertheless if you take the average you will find the savings in giga-tonnes carbon in the future cost you a thousand times less than any of the other technology solutions like nuclear, wind, all of the things that people are talking about have trillion dollar bills to save yourself giga-tonnes of emission by 2050.

If you do the population management right your Dollar, Euro or Pound spent will give you a thousand times the leverage if you address population. This issue gets terrible fraught when you start to talk about the people who will be affected by climate change and the very large number of people who will be forced to migrate around the world. This will be in a world where migration is extremely difficult and hugely politically charged so again if we are dealing with eight billion people rather than ten billion people it has to be better.

Q: Do you think we have reached the “*tipping point*” where consumers are willing to pay more for cleaner energy?

A: I think we might be teetering on it. Again this is my personal view, my view is that if people have an issue explained to them and they are convinced that there is a problem and if they are also convinced that what they are being asked to do is fair, that is that

other people are taking on their fair share then by and large they will willingly do it. After all that's why we pay a tax, it is a fair open and transparent system and there is a need to pay them; none of us particularly enjoys it, but we do it because we recognise there is a social need.

That's why whatever international agreement is reached is so critical.

In this particular case I don't usually have a huge amount of sympathy for the Bush Whitehouse but one element of the Bush Whitehouse is their stance on Kyoto was that it was that it was intolerable that China and the other developing nations weren't part of the deal. Although I think there were all sorts of reasons why they took that stance I think there is some justification in it because if you were to ask either the US citizen or the UK citizen or the EU citizen to take a manifest reduction, however minor in their quality of life then they would only be willing to do so if they feel that it is fair and everyone else is stepping up to the bar too. And if they can turn around and see no constraint on China, despite the fact that the Chinese would say well hang on a minute you've had yours it's our turn now. I don't think that argument will cut much ice with people whose livelihoods or quality of life is threatened even if it's only marginal.

So I think that is why it is so important to get a deal in which everyone can feel that they are part of the solution and a proper balance and fair part of the solution

Q: What about the energy industry, what part do they have to play?

Well the first thing I would say is I think there is a lot of humbug spoken about this by the environmental movement. In this country but very generally, the majority of people are urban dwellers. I couldn't survive for about more than ten days without oil, coal and gas. Whether I like it or not that is the truth

We saw that with the tanker drivers strike in September 2001 the country was more or less on its knees in ten days. The supermarkets were stripped, if something hadn't happened at that point people would have suffered severe hardship in large numbers.

So I'm very pleased that the oil companies are out there trying to find more supplies of oil and gas to give us time to figure out how to de-carbonise the energy supply. Now I happen to know and I am convinced that Shell in particular is a company that generally recognises that there is a serious problem and is committed to trying to find a way forward to do something about it.

After all it's not individuals or governments that will find the capital to invest in whatever the technological solutions are that will contribute to solving the problem because the technology will only do so much. Governments have a role in the social behaviour, the regulations and setting the scene, so that industry can play a role without shooting itself in the foot.

But in the end it's companies that will find the capital and the talent to do this and it does seem to me from the people I know in Shell that it is a company that is committed to doing it.

I can't say the same for all oil companies, one in particular has played a very unhelpful role and that is in the US and that's a pity but clearly the oil companies with their huge turnover, their huge capacity for financing new technologies with their huge reserves of talent, and their capacity to organise that talent will play a crucial role.

Q: And do you think that the incentive is there?

I think that governments need to do more and the international framework in which oil companies can operate certainly is crucial to their being able to do so

After all in the end their obligation is to their shareholders and the bottom line, they can make a lot of progress because many companies have found that the technological advances that help reduce carbon emissions also as it turns out help the bottom line, so that's win win.

However they will reach a point, they may already be there, where some of things that have to be done, don't actually help the bottom line in which case they need a regulatory framework in which to operate so that they're not losing out relative to the competition.

Q: In terms of science and innovation, what do you think will be the next big thing that will impact the "energy challenge"?

A: Again I would say "silver buckshot" not "silver bullet" as there will be a number of things. To me if somebody were able to develop a carbon-sequestering engine that operated at a profit it would actively suck sustainable quantities of carbon dioxide back out of the atmosphere and sequester it in bricks or sludge or something so that it could be pumped away back into the ground where it came from. If that were economically viable then that of course would be a huge breakthrough. But I don't see it happening just yet.

Q: What about Bio-Fuels?

A: It is clear that there are some big issues with 1st generation bio fuels not least the impact that they have on food production because they compete with agriculture.

So anything that can align itself with agriculture using soils and regions which are not agriculturally productive, or even better as a bi-product of the detritus of agriculture then I think that would be great. There are also the direct bacterial digesters that would generate the fuel from the air and a few nutrients, that would also be a way forward and there seems to be some encouraging signs in this area.

Q: What do you think of Al Gore's "An *Inconvenient Truth*" in comparison to presentations you make on climate change as a scientist?

A: Firstly I must say that I worked with Al Gore when he was in the UK and I was hugely impressed.

It's interesting isn't it that Al Gore should have made such an impact, wherever or not you are on this debate you cannot deny that he is a tremendous force in this. You have to say to yourself of all of the visionary scientists who have been involved in this issue over the last 20 – 30 years probably only Jim Lovelock and a few others have had anything like the public impact that Al Gore has. Of course Jim Lovelock isn't a traditional scientist he is an independent scientist so he feels able to speak out more freely perhaps than his academic colleagues.

So why is that? So if you look at what Al Gore says in *An Inconvenient Truth* there are a number of illustrations, theatrical devices, statements that he makes, that a scientist would not make. This is because when a scientist speaks to a public audience he/she has the audience in front of them and he /she has their professional colleagues behind them. And what are those professional colleagues looking for? They are looking for a degree of rigour, including an accurate and precise account of all of the uncertainties and complexities that a public audience finds too complicated to understand.

It's stripping away a level of rigour that the science community demands of itself and if you do not satisfy those demands your standing in the community will be reduced. And so many scientists won't engage in this debate at all, because they think it is too risky, because they know that when they engage with the media this stuff will be stripped away and at the worst they may be completely misquoted so it is a very dangerous game for them.

Al Gore's whole career has been about a public communicator. He grew up in a southern Baptist culture so it's almost in his genes. But he has been a senior American politician on the stump; he knows how to deliver a series of simple messages very effectively using all of the tricks of the trade of an orator. This combined with the huge experience of Hollywood and all of the other people he has access to so it's not surprising that he can get the message across very effectively. A scientist simply could not say some of the things that he does and a scientist could not do some of the things that he does in order to get the message across.

So when I give similar talks they are much more sedated than Al Gore's *Inconvenient Truth*, or the versions of it he gives.

The other thing I would say about Al Gore is that I have heard him dissect and deconstruct *An Inconvenient Truth* and explain why it is the way it is, why the rhythm is the way it is, why the chapters are the way they are and so on. It's very interesting because he realises that audiences have certain capacities, he calls them permissions, so that an audience will permit you to tell them so much and then they shut down because they can't cope. They can't cope because it is too complicated, it's too long, too heavy

and in particular he refers to the hope and despair budgets. He points out that one of the ironys of climate change is that it is such a big issue and so daunting that ironically the more effectively you communicate it the more likely you are to drive people into despair, into paralysis. Therefore he is very careful in *An Inconvenient Truth* to lay the story down in layers and chapters and revive people at the appropriate moment so that they leave the room fired up to do something about it and not completely crushed.

Again these are the sorts of techniques that scientists aren't familiar with as this is not the way that you deliver a scientific talk. A scientific talk is what it is. You just deliver it and that's the way it is. Here you are dealing with people's reactions to a very serious issue and you're trying to be part of a movement that marshals a response that will hopefully avoid the worst possibilities that confront us. Again scientists are not particularly used to thinking in those terms.

Q: What are your thoughts on the reliability of climate change models?

A: Models are tools, and the outcome of the use of any tool is as much a measure of the skill of the artisan as the tool that they are using. There is no question that the models have all sorts of shortcomings but on the other hand they are jolly useful in giving us insights into the way this hugely complex system, with all of its feedbacks and interconnections, is a sort of system that the human brain often operates in a counter intuitive way. The human brain is pretty good at saying if we do this then there is that consequence, in a linear way.

If stuff starts to feedback the human brain isn't wired up very well for predicting how that will happen. So this is why many social schemes seem to end up, with the opposite result than what was expected, because what seems logical leaves out some un-thought-of consequences i.e. the law of unforeseen consequences.

The climate system is one of the most complex objects in the universe. And is where the laws of unforeseen consequences are going to play out more strongly than any other time.

So the models are incredible helpful if you connect them up right, they've got good physics in them. You've got to get all of the coding errors out, that's not easy, because you have hundreds and hundreds of thousands of lines of code, if you do all of that then if you change one parameter and run the model a number of times you get an outcome which becomes a testable hypothesis. You can then go out and see if you can find some data that suggests whether that is true or not.

I'm an experimental scientist and physicist and so for me in the end monitoring what the planet is doing and uncovering what it did in the past and making measurements on whether the models are right is absolutely crucial. Therefore the models sit in their rightful place as part of the whole range of tools that can be used to understand what the best course of action is. But I do think that it is possible to hyperventilate on the models as we always need to have that caution about what the models are telling us, as so often we find that the models are not right for an inexplicable reason, we then improve it but

that doesn't mean that it is perfect. Models cannot be simulators of the planet but they do give you tremendous insights.

Q: Are you optimistic of mankind's ability to find a solution to the energy challenge?

A: People ask me if I am an optimist or a pessimist and I say yes!

I have to say that there is a science museum angle on this. We recently opened the science museum library. We've just spent a substantial sum of money to move our entire collection of books and documents to join the Imperial College collection. There are 32km of shelving, 350,000 items, so when you wander around a museum and you see the rocket and locomotion engine, what you're seeing is the tip of the iceberg. If you pull out one of those volumes you will see this huge record of human ingenuity and activity. Lets think of the digital camera, how many different digital camera designs have there been since the first Casio came out 15 – 20 years ago? And clearly there is a market out there otherwise people wouldn't be selling them. But having worked on space projects, I know how much effort it takes for a team of engineers and others to design an object, to trial it in the lab, the effort of the people designing the computer chips and the light sensitive devices that make a camera possible. So when you see a camera on the shelf in Dixons it represents a huge amount of innovation and effort and sheer hard work on behalf of a team of goodness knows how many people. You then say to yourself if we had a large hanger we would probably be just about able to fit one example of every digital camera that has ever been designed in there and there are hundreds and hundreds of them. So that represents an amazing amount of human ingenuity and effort and if that were marshalled into this problem through appropriate leadership then I don't think we would have any trouble solving it. It would be hard, there would be changes in lifestyle and we wouldn't be able to organise society in the way that we do now. So you would have to look at all aspects of the problem as well as the technological fixes. But the human capacity to do this is out there it just needs to be marshalled and that just is not happening at the moment, not sufficiently anyway. So that leaves me marginally on the side of optimism.

Ends.