Professor Maria Hinfelaar: Well good evening everybody, nos waith da, welcome to the next one in our series of public lectures this academic year, er very proud to introduce David Sparke, a colleague of ours who’s a real expert on the subject of climate change and I promise you cause I have heard him speak before, he is really excellent. He has a perfect storm as we can see here on the screen. David’s going to share with us the science behind climate change, what are the data telling us, how far does it actually go back, what are the options as we go into the future and how clever do we need to be as humanity to address these challenges. So that is going to be the theme for this evening, quite a wide ranging conversation, so David is going to take us through it all and there will be ample time or questions and discussion afterwards and I really look forward to the session, so over to you David.

David Sprake: Thank you very much, I’m just going to set my timer so I don’t run over. So I’ve got quite a lot to get through, and in the next 45 minutes or so I hope to answer these questions:

How did climate change come about?

Is carbon dioxide really rising; where does it come from and why is it a problem?

Do we really need to worry about climate change?

How are UK electricity and heating generated today and what part of that comes from Russia?

Are there effective low carbon alternatives and how much will they cost?

What is holding up progress on climate change?

What will the consequences of inaction be?

What did COP 27 achieve?

What are other countries doing?

So quite a lot in there, I can’t go into this in very much depth but I’ll try and get through it n the time allowed. So how did climate change come about, well as engineers, we got very good at thinking big. We created bigger and bigger machines, this is one of the biggest moving machines in the world and it’s used for mining coal, and you can actually drive quite a big truck into one of those buckets there. And that’s all to fuel power stations, to produce electricity and supersized engines came about. This is a diesel engine off a ship and you can just see how big that is by the uh truck that it’s on. Bigger and bigger machines to use more and more fossil fuels. And that has created a big demand for energy, and this is a graph of energy demand of the global industry, and you can see from 1900 or so, the industrial revolution really took off and we needed more and more energy to feed that industry. And most of the energy we see came from coal, crude oil, and natural gas, and all those are what we call fossil fuels.

One of the other things that humans got really good at was farming, we can create bigger and bigger machine to harvest more and more crops from bigger and bigger pieces of land, and also create fertilisers to get more crops per square meter than we did before. And that had a knock on effect of population because when there’s unlimited amount of food, that allows massive growth in population, and that’s a really sobering graph. That’s the population of the globe going back in time from about 1000bc, and we can see this is out of date now because we’ve recently passed 89 billion people erm and it continues to rise exponentially. And this really is an unsustainable model because we’ve only got one earth with a finite resources. And the scale of this industry is truly staggering, and just to give a few illustrations of that, these are the planes that are in the air at the moment

And here we have some data, this is the current world population and how fast it’s growing in real time and we can just see how many births there’s been this year so far and we’re only in January and just how fast that’s rising. And the births are far outweighing the deaths so it creates a population increase. And all of these new people are going to want energy and lifestyle that we enjoy that’s energy dependent, and just whilst we’re here, we can have a little look at this. This is the number of cars that’s been produced this year so far, again we’re only in January, and the number of bicycles and computers. So often sitting in north wales here we don’t really realise how much is going on out there and the scale of this industry, and of course all that requires energy, the burning of fossil fuels and just at the time that humanity started burning coal, oil, and natural gas, sure enough the concentration of carbon dioxide started going up in the atmosphere started going up. These are reading taken by actual scientific instruments. A guy call keeling stated to do that in the 1960s, before that we relied on ice cores from the artic which is a whole other lecture. And I’ve actually lined these two graphs up just to show you that that is where the carbon dioxide has come from, the increase in carbon dioxide.

Just to visualise how much carbon dioxide we’re pumping into the atmosphere, these researchers imagined what one ton of carbon dioxide would look like if they pumped a balloon up with one ton of carbon dioxide and how big that sort of sphere would be that held one ton, and it’s actually a sphere 33 feet across so a sphere 33 feet across is one ton of carbon dioxide. And the researchers were from New York City, so they decided to visualise how much carbon dioxide New York City used in a day. And that’s how much. And that’s how much it uses in a year, and that’s just one city, so this is really significant.

As well as pumping carbon dioxide into the atmosphere, we’re actually taking the things away that suck up carbon dioxide and produce oxygen, trees, because a tree is a beautiful machine that takes carbon dioxide out of the atmosphere, and these researchers looked at forest cover in the world and from satellite date tracked deforestation from about 0201, and the pink areas are areas that have been deforested, so it’s a double whammy really. We’re putting lots of carbon dioxide into the atmosphere and we’re also taking away the things that soak it up.

So why is this a problem, well I’m sure we’ve all heard of the greenhouse effect, and basically what happens is solar radiation or sunlight comes down from the sun and goes through our atmosphere unhindered by the greenhouse gases, and that heat energy is absorbed by whatever it hits, like a car bonnet in the sun for instance, gets really hot, and then that heat is radiated out as longer wave radiation or infrared radiation. And critically the greenhouse gases act as an insulation to that infrared heat, so it lets the sunlight in but it won’t let the heat energy out, just like a greenhouse, and that’s the greenhouse effect in a nutshell. And going back in time, this is a paper from 1896 and the scientists back then realised that if ever greenhouse gases built up in the atmosphere the earth would begin to warm up.

10.57

So from ice cores, scientists were able to tell what the previous temperatures in the past were, and also what the carbon dioxide levels were, and they produced this graph from ice core data in Antarctica, and the red line here is the concentration of carbon dioxide in the atmosphere and the blue line in temperature. And you can see that the greenhouse effect is real because when there’s more carbon dioxide in the atmosphere, the temperature goes up, and vice versa. So this actually proves that the greenhouse effect. So I’ve mentioned so far that humanity’s been pumping carbon dioxide into the atmosphere, now let’s have a look at where we’re at today. We’re right up here. so when these climate scientist first saw this back in the day, they realised that the blue line, the temperature, is likely to follow the red line because of the greenhouse effect as it’s done in the past and they obviously got quite worried about that. And just to put this into some kind of perspective, the climate’s been relatively stable for about the past 5- or 6000 years, but if we go back here to 20000 years ago, this was the last ice age, and if we go back to Wrexham 20000 years ago, there’s a km of ice above our heads right now, most of the UK was covered in an ice sheet. So the difference between here and here is an ice age. The difference between there and there is temperature follows it, it’s going to get very hot indeed, and if these temperatures go up with carbon dioxide, we’re not talking about just milder summers, or being able to grow grapes in Scotland, we’re talking about a major shift in the earth’s climate and it’s going to get very hot indeed.

So, do we really need to worry about climate change? Well this is the historic concentration of carbon dioxide in the atmosphere, and if we carry on business as usual, that’s what’s going to happen to it by the end of the century. And again, the difference between here and here is an ice age.

So I just want to show you a little video from NASA, about what the consequences of this might be, moving forward [insert link from video]. So uh, this is just kind of the first stage of this warming, and unless we do something about this, it’s going to get worse. Some of the biggest temperature increase have been in the arctic on the top of the world and this is the extent of summer ice in the artic, so each year the ice melts in the summer and then expands again in the winter and this is the minimum extent of that ice over a 30 year period. So we’re already starting to see the first stages of this warming that’s happening right now.

So “the era of procrastination, of half-measures, of soothing and baffling expedients, of delays is coming to its close. In its place we are entering a period of consequences.”

So that was a doom and gloom scenario, so what’s eh solution to it? Well if we can imagine the stock of carbon dioxide in the atmosphere as a bath that’s full up with carbon dioxide, and at the moment we’re at 417, I think we’re at 420 now because it just keeps going up, and all we need to do is get this carbon dioxide stock in the atmosphere down to what it was pre-industrial levels, around 280 parts per million. So that looks quite easy, we just need to take some of that carbon dioxide out of the atmosphere. And there’s two ways that we can do this, first of all we’re going to have to stop pumping it into the atmosphere and also we are going to have to figure out a way of getting rid of the stuff that’s already there, because we’ve pumped quite a lot in there. So I’m going to sort of outline the methods of how we can do this, because we do have the technological solutions to do this.

First of all, where do the greenhouse gases come from? Well most of it come from producing energy, as we’d expect, but also some comes from agriculture forestry, transport and so on, but really the stuff in agriculture, forestry and transport, they’re energy related. So if we can decarbonise the energy system in some ways, that will have knock on effects for agriculture, forestry, and transport and so on. Also carbon dioxide isn’t the only greenhouse gas, there’s also methane, nitrous oxide, hydrofluorocarbons and so on, but I mention and use carbon dioxide in this lecture just because that’s the most abundant one that’s having the most effect but there are other ones as well.

Let’s have a look at the UK as a case study. 18.57

Where does the UK get its energy from? First of all we’ll have a look at gas, about 50% of the UK gas supply comes from the North Sea, but that is drying up as we speak. This is the UK continental shelf production from 19080 to the year before, and you can see that back in the year 2000 we were producing a lot of gas and oil from our own shores. Whereas now a lot less. But that accounts for about 50% of our gas usage. So where does the other 50% come from? Well it mainly comes from pipeline important, net and liquid petrol gas, a little bit of that as well. But also you might be surprised to hear that the UK exports its own gas as well. We actually sell gas to other countries. You can see that there in the year 2000 we were a positive producer of our own gas, we could sell it to other countries and have enough for ourselves, but right now in 2021, couple of years ago, we had to import well most of about 50% of our gas. So, where does it all come from? And how much does Russia send to us? Well most of it comes from Norway, but there are some, little bits from Qatar, united states of Puerto Rico, Russia here is just this little bit here, so not a great deal really, but it has a significant effect because in any supply and demand model, if the supply is reduced only by a little bit, then that causes the prices to increase cause there’s a shortage of gas on the market. And also there’s been an increase in usage and that coupled with our own dwindling supplies has caused the effect that we’re seeing today in terms of the gas prices. Interestingly enough we export gas to Ireland and the Netherlands, France, Belgium and a little bit to the rest of the world.

So where does the UK get its electricity from? Well there’s lots of power stations around the UK, these are biomass plants, these are the coal plants, \*technology fail\*

So the UK produces electricity mainly from wind and solar, but also gas, gas is the sort of major usage. So this is a live feed onto the national grid; the electricity that’s supplying these lights and this data projector right now, this is where it’s coming from. And it’s actually a mixture of loads of different producers and we can see at the moment about half, 49% is coming from gas, that’s CCGT stands for combined cycle gas turbine, about 10% is coming from nuclear, about 20% from wind, the other interesting one is solar, we haven’t got any solar energy at the moment. But it’s combination of all these things, that’s where we get our electricity from.

That’s the current state of play; are there any low carbon alternatives? Yes there are. The bigger and easiest kind of win is to lower demand and we can actually do that by insulating our homes and creating and using insulation in our homes and using energy efficient appliances in our homes. And the great thing about insulation is it last in perpetuity. It’s there forever basically for the lifetime of that house, once you’ve installed loft insulation and wall insulation it’s there forever and you just carry on saving for the rest of the lifetime of the house. And there’s also we can tell people to switch things off and start measuring our energy systems and turn down our thermostats. There’s been some research about which one of these is the most effective method, and what the researchers found was that measuring worked really well, because I don’t know about you, if you have a smart meter put into your house or an energy monitor, when you first get it you kind of go around the house switching things off because you can see how much it is using, so a great way to save on energy is just to measure it and give people that data and they’ll start turning things off automatically.

So there’s also wind turbines, and these have been around a while now, so this one is the biggest one, it’s a 15 megawatt wind turbine by Vestas. And what that means is that every time the wind’s blowing it produces 15 million watts and to give you some idea of the scale of that, an LED lightbulb might take 10 watts. Now the problem with wind energy is that the wind doesn’t actually blow all the time. And if we have a look at historic data for wind power, it’s this blue line here. This was the wind energy going into the grid last week, and this red line here is the amount of gas that went into the grid to produce electricity. And you can see that when the wind drops, we switch on gas fired power stations to make up for it, so really wind is reliant on the wind blowing and when the wind’s not blowing we have to switch on gas. And you can just see how sporadic this wind power is, that’s over the last month, and we can see that it’s been quite windy towards the beginning of the month, so we didn’t use much gas at all. And if you have a look at the yearly view of wind energy into the grid, you can just see how sporadic it is. That’s really good in isolation, but what do you do when the wind’s not blowing?

Well we got solar panels of course, and if we have a look again at solar power going into the grid, that’s today’s solar power that went into the grid, and you can just see how it peaks at midday, but really at night, as we’d expect, there’s no solar power. This red line here is last week’s solar power that went into the grid, and really we’re in January so there’s not a lot of sunlight about, but if we have a look at a yearly graph of sunlight energy, it’s this one here, the red line, and we can see how little we get in January but it peaks in the summer and then goes back down towards December. And again, that’s really good, but what do you do when the sun’s not shining?

And then finally there’s river, tidal and wave power. We’ve got one of the biggest pump storage hydro schemes just up the coast in Dinorwig. That acts like a giant battery actually, can be used to pump water at the top of the hill when there’s abundance electricity and then it sits there like a giant energy store for when we do need it. But there’s also tidal power, and we live on an island surrounded by water and that holds a huge amount of potential. And also there’s wave energy and lots of different designs to capture the energy of the waves have been invented. This is one of the biggest dams in the world, and it’s in China, and this is an amazing 22 and a half gigawatts, and this dam alone would power about half of the UKs electricity grid alone, this one dam. But we haven’t really got a river that big in the UK, but just as an illustration, that’s a possibility. And with each of those three technologies, wind, hydro, and solar, the fuel is completely free, don’t have to buy any more fuel once you’ve build one of these things and paid for it.

So how do you make all of that work in an energy grid? Well we have something called a smart grid, and if we have solar power, wind power and hydro power but we also combined that with nuclear power, and energy storage, and then we start looking at hydrogen to heat our homes, fuel our cars or electric vehicles, then the engineers have done the calculations, it’s entirely possible to run the UK on a system like this. We have enough resources to do that, and in fact every country in the world has the power to do this and to create a green infrastructure. Technically it’s entirely possible.

How much land will be needed if we wanted to go down this route? This is a really amazing bit of research and if we wanted to go down the solar energy route all on its own, these black dots here, if we filled these areas with solar concentrated power, that would produce enough energy to power the whole world, so we wouldn’t really need that much space for it. Now don’t get me wrong this black dot in the North African desert, that’s actually about the size of Wales, but it’s entirely possible to do in terms of land area. And if we went down the wind energy route, that’s how much space we’d need, these yellow areas here, if we’d filled these with wind farms offshore then that would produce the equivalent of the whole world’s energy demand.

30.13

So why are these so good in terms of carbon dioxide, well if we have a look at the carbon emissions that are created when we burn coal or gas to create electricity, and for coal it’s about a kilogram of carbon dioxide for every kilowatt per hour that’s produced, and gas it’s about 500 or 600 grams, and even with carbon capture and storage, where the carbon is captured before it goes before the smoke goes up the chimney, then that’s still about 200 grams per kilowatt per hour. If we have a look at the renewable energies, the worst one of the renewable energies is solar, and that’s between 50 and 100, half of what gas carbon capture and storage is, but wind and nuclear and river, they’re very small amounts of carbon dioxide. And that carbon dioxide is the embodied energy in actually building the infrastructure, so if we had to build a dam for instance and a hydro plant, all the energy it took to make it, that’s where that comes from. But I would argue that this is the first generation of these things, and if we build any more in the future with cleaner energy systems, this value will become less and eventually in theory, you could have zero if you build this infrastructure using clean energy in the future. But with gas and coal, we just carry on shovel into this fuel and it just goes up into the atmosphere.

#in terms of cost, this was done prior to the increases in gas and electricity prices, so basically what these researchers basically the UK government, found that large scale solar pv and onshore wind is the cheapest way to produce electricity and that was a levelled cost estimate for a project commissioned in three years’ time. But since then, the cost of gas and cola have actually doubled or tripled, so it makes even more sense in terms of costs. And we’re actually starting to see that happen in terms of the costs that are in the grid at the moment. That doesn’t include the future costs of climate change, because if we allow climate change to carry on, it’s going to cost us a lot of money, the air pollution that burning fossil fuel creates, which is a kind of hidden problem, and possible large swings in price of oil and gas, which really, businesses struggle to deal with. The thing is with renewable energy the cost of the wind and solar and water never really changes too much.

This is what’s happened to the price of electricity. And this has what’s happened to the price of gas, and really the price of electricity is a knock on effect from the price of gas because we produce about half of our electricity from gas.

This is just a recent article I read, record low price for UK offshore wind is nine times cheaper than gas.

So the sort of final piece in this jigsaw is once we’ve actually cut the emissions down as much as we can, we need to really start taking out emissions by planting trees perhaps, but there’s also as engineers, a technology called carbon engineering, and these huge machines that suck in the air and take carbon dioxide out of the air and store it safely, either in the ground or it can be used as a fuel.

All that infrastructure to convert to low carbon is going to be quite expensive to build that infrastructure, and the latest estimate that I could find here is 10 billion pounds per year, and that’s by the office for budget responsibility. That’s quite a big number, 10 billion pounds a year. However, the value of UK support to fossil fuels amounted to about 12 billion pounds a year. Now you might read in the papers that the price of our electricity is so expensive because of renewables which is complete rubbish, what’s actually hidden is the UK support for fossil fuels in terms of tax breaks, and that’s actually more than it would cost the UK to become carbon neutral. And I tried to look at another comparison cost of what 321 billion looks like in terms of other things the UK, and the UK spent 376 billion on covid and prior to that, there was kind of no money for green infrastructure, and yeah the government can find money when it’s required.

So if we put all those things together, lower costs, lower air pollution, lower carbon emissions, this is a kind of way that this can be done. We could have our energy system based on 25% renewables, 25% energy efficiency, we could electrify our transport and heating systems by 20% we could convert some things to hydrogen 10%, and fossil fuel based capture and storage 6% and renewable energy based CO2 removal, 14%. And it’s entirely possible to do.

One thing that’s not considered with the cost of that 10 billion pounds a year is once these have been built, they produce energy very cheaply, so the UK as a whole would start saving on its energy bills, and this sort of negative value here is the actual savings moving forward if we did start saving this money, so sure it would cost a lot, but eventually, in about 2044, it would break even and then we’d actually be saving. We’d be saving more than we’d be spending.

So why have our energy bills gone up? I’ve got a green tariff for my electricity, and the wind hasn’t got any more expensive, so why has my electricity price gone up? This is the makeup of a fuel bill and we can see that well over half of it is the actual wholesale cost of producing the energy, there’s also networks costs, actually getting the electricity where it’s required through the national grid. And operating costs and policies and VAT and a couple of other things. So really when we look at our energy bills, only about half of that is the cost to produce that energy. And as I mentioned earlier, the UK grid has got lots of different inputs into it, and the way that the cost of our electricity we buy is worked out is, they take the most expensive one and charge that for everything. I’ll just say that again, they look at which is the most expensive one of these going into the grid, and we pay the most expensive one for that for everything.

What are other countries doing? Well, this is a map of Europe and the rest of the world, and these colours represent the carbon emissions of the electrical grid system, and if we have a look at the UK right now, and of course this changes cause when it’s a windy or a sunny day this comes right down, and it’s about 290grams per kilowatt/hour of energy produced. But if we have a look at Iceland up here, just 27g, 100% renewable energy, all geothermal energy in Iceland, if we have a look at the Scandinavian countries, 99% renewable energy, and if we strip away the transmission costs and the taxes and just concentrate on the actual cost of the producing the energy, these have got some of the cheapest energy costs. France has gone down the nuclear route.

In terms of carbon emissions per person, the average kind of person in the UK sort of footprint if you like, is about 5 tonnes carbon dioxide per year. And we can actually see how the effect of building those wind turbines and solar farms are starting to impact. So we’re doing ok in the UK, not enough but a lot better than some other countries. Shall we have a look at United States of America? So that’s America, they’re starting to decarbonise, but the average American has a much higher carbon footprint than the average UK person. Now Mr Trump said a few weeks ago that the air in China was filthy, so shall we have a look at China? So up until about two or three years ago, per person, was actually less that the UK and a lot less than United States. Mr Trump also called the air in India filthy. So let’s have a look at India.

So this was some research by Oxfam, and what they found was that the richest 10% of countries in the world produced about half the carbon emissions, and the poorest 50% of the population only produced about 10% of the total emissions, so really it’s up to us as a relatively rich country and we kind of started all this off with the industrial revolution just down the road in Ironbridge, maybe we have a responsibility to lead the world in fixing this problem.

Every year or so there’s a COP meeting, conference of parties meeting, where the world’s leaders get together and experts get together and try and do something about this problem, and the 27th meeting was recently in Egypt, and my take on this was there was no real progress in keeping global warming under 1.5 degrees and to phase out the use of fossil fuels, we didn’t really make any progress on that. But there was also the creating of a loss and damage fund, which is great for the countries that are affected by climate change, but I see this as a sticking plaster, it doesn’t really get to the heart of the problem and climate change is going to get worse, so we’re going to have to spend more money on that next year as the effects get worse for these people, and more people will start to be affected by it. And if we have a look at carbon emissions, and I’ve overlaid COP meetings on there, the first one was actually in Berlin in 1995, the famous Kyoto protocol was made in 1997 and we’ve recently had the 27th one in Egypt, and you can see what we’ve done so far has not had any effect, the carbon emissions carry on rising.

So what’s holding up action on climate change? Sure we know it’s a big problem and what’s causing it, and we know how to fix it, why aren’t we doing more about it? Well I can only look really to the UK and our Climate Change Minister, and by the wonders of the internet we can see how he voted on various different issues, and I know government is a complicated sort of beast, and there’s other things to think of, people’s jobs and people heating their homes and so on, but if the Minister for Climate is making some of these votes and decisions, then if they’re not going to do anything about it, then who is going to? And our Climate Minister recently said that fracking and oil drilling is good for the environment. And I often wondered why what was driving successive governments and all parties kind of come up with these decisions on how we create our energy, and this is a great piece of research, and this is the amount of money donated to political parties from these companies last year.

To sum up, there’s this famous Chinese symbol and it’s often misconstrued as being opportunity but what it actually means is crisis and a crucial point where something begins to change, but I kind of like the crisis and opportunity concept being part of the same thing. And I think we’ve reached that point now; there’s a tremendous opportunity to build this green infrastructure, and it would have a lot of opportunity in terms of benefits, jobs, and cleaner air.

So this climate change, Russian gas, and energy bills, I see this as a perfect opportunity rather than a perfect storm, and to sort of finish off, we’ve only got one earth, we rely on this for all the air that we breath, all the water that we drink, all the food that we eat and the beautiful countryside that we have and we should look after it.

To finish off, if you’d like to learn more about any of these subjects, I’ve kind of skimmed through quite a lot in not much depth but in my courses I run here at the University, I go into all of those things in quite a lot more depth. And just coming up next month, there’s an introduction to climate change, which is a short course, just a couple of hours a week in the evening for eight weeks I think. We do renewable and sustainable engineering degrees BEng honours, MScs and PhDs, there’s also low carbon degree apprenticeships for students who wish to come in just one day a week who are working, and there’s also electrical mechanical, automotive and aeronautical degrees. And if you have any questions, that you’d like to ask and you don’t get a chance to right now, that’s my email address, so any questions?