Intro (00:00:01):

This session of the 2013 Adelaide Festival of ideas was recorded by radio Adelaide through the support of the vast mid library, university of Adelaide, the university of south Australia library and Flinders university library.

Tim Harcourt (00:00:16):

Everyone, welcome to the Freemasons hall. Everyone. I hope everyone knows their secret handshake and you've got the ripe and ready. It's great to be here. I'm I'm Tim Harcourt. And I'm your chair for the electric planet? This afternoon now on the airport economist and also teach at the university of new south Wales. But most importantly, I work for the premier of south Australia as his advisor for international engagement. So it's great to be back in my hometown of of Adelaide and it's good that they let me back in at the border. I'm really pleased about that. I've got the great honor to introduce a very distinguished Australian professor Alan Finkel. I am now I had a really good look at Alan's CV this morning and I was gonna hire a forklift truck to bring it over here.

Tim Harcourt (00:01:04):

Cause he's got an incredibly diverse career of great achievement and and great accomplishment. He's had a very varied career. He started in life wanting to be a doctor you know, in in our family, either a doctor or lawyer and he can't stand the sight of blood. You become a lawyer. And he B he was thinking about being a doctor and he actually found out that he, he loved engineering and maths and physics, and he had a very varied academic career, but in graduating with a PhD in in, at Monash university in 1981, despite his young looks, he got a PhD 1981 from Monash university. He followed his supervisor to the, I knew he moved from engineering into neuroscience and then ended up living in the United States with his wife, Elizabeth. And not only did he make great breakthroughs in terms of science, but you also found out that he was an accidental entrepreneur and started up.

Tim Harcourt (00:01:59):

I was going to say Cosmo magazine, but essentially cosmos it's a, a startup magazine that's now restarted and is now going to be internationally launched. And also the Stoll education company that provides software technology. He's a very interesting guy and very interested in making sure that science and, and academic achievement actually comes up with practical solutions to save the planet and also to of course, engage Australia with the rest of the world. So he's going to talk about the electronic economy and I can, I can bet you that sparks will fly. Please. Welcome Alan Finkel.

Speaker 3 (00:02:42):

[Inaudible]

Alan Finkel (00:02:42):

Well, thank you, Tim. And it's true. I'm here to talk about what you could call the electron economy, but I called the electric planet. And I just want to take you on a journey to indicate how I feel that we should tackle strategically. What many will agree is the biggest problem that we face into the long-term future for our planet. So up there, I've got a picture of a house, a nice house living in Australia. Freightos a good chance that many of the people in the audience here live in a house that they love and would be judged by many, to be attractive. Similarly, we live on a planet that is attractive and a planet that we love. We take care of our house. We take care of our planet, or at least we should take care of our planet.

Sometimes things go wrong. Hopefully your house will never do anything quite as tragic as that. But if something goes wrong with something like a house or a car, maybe even a relationship, if you're lucky, you can often repair it and get it back to where it was.

Alan Finkel (00:03:49):

You can preserve your investment. We live on a beautiful planet. As I said, if something goes wrong with our planet, it's not as clear to me. And I don't think it would be clear to anybody that will necessarily be easy to correct. So the most important thing to do is to make sure that nothing goes wrong in the first place. Are we doing that? The answer is no. What you see, there is a graph of carbon dioxide concentration in the atmosphere, and I'm not going to make this talk about climate change, but it is the reason why I'm going to be proposing the electric planet to you. It's fascinating what you can see if you go back a hundred years, the concentration of carbon dioxide, and yet misfit was about 280 parts per million. And in the last 50 years, or really the last a hundred years, it's just been increasing, increasing and increasing in the last 50 years.

Alan Finkel (00:04:47):

It's been going faster than you could reasonably imagine. And you'll notice up the top there it's not slowing down at all. There's just no hint of a slowdown, no matter what has been done with the Kyoto protocol, with solar, with wind, with biofuels, with other investments, with good intentions, no matter what has been done, the concentration of carbon dioxide in the atmosphere has continued to rise. And in fact is rising now faster than ever before every year, the concentration goes up by two parts per million. That excess is in parts per million in percentage terms. It's very small. I actually find it almost offensive that people refer to carbon dioxide as a pollutant. It's not toxic. We breathe carbon dioxide all the time. If the carbon dioxide concentration was 10 50 times higher than it is today, you wouldn't even notice you'd be very happy, but it does have a physical effect on the planet because it creates this greenhouse effect, which causes ultimately through a complex process, heat to be retained and therefore global warming.

Alan Finkel (00:05:56):

And once there are a lot of people who dispute what the effect of this increase of carbon dioxide might be no one disputes that we are pouring carbon dioxide into the atmosphere. And that's why it's going up and is every good reason to think if the carbon dioxide levels go up, the heat retention goes up. We have global warming and global warming leads. Climate change exactly what that climate change will be and how it will unfold. And manifest itself is open to a fair amount of rigorous and reasonable question, but they will be changed. You can't do this at that level and not expect that you'll have an impact.

Alan Finkel (00:06:38):

So we've got these beautiful world and there aren't many others like it. If you look at our neighbors to the closer to the sun and further, if you look at Mars and Venus, they completely inhospitable for all we know there is no hospitable planet in the Milky way, galaxy or possibly anywhere in the universe. There's certainly no, there are lots of planets, but there's no indication that there's anything that is just so finely balanced, like our planet for the emergence of life and all the wonders that come with that finally balance. If you tip the balance, things will go wrong. We won't have the same planet to live on in the future.

Alan Finkel (00:07:22):

So who's the bad guy. Well, you could argue it's humans because we're talking about an anthropogenic effect, but I don't want to tackle population and getting rid of the humans. It's probably beyond my brief, the real bad guy that we can tackle is coal. Coal is the fuel that we burn for 30% of our engineers, 30% of the total planet's energy needs. But because when you burn coal per unit of work, that it does, or per unit of electricity that you produce, it emits more carbon dioxide than any other fossil fuel. It's actually the largest contributor by far to carbon dioxide emissions. So coal is the bad guy. He's the evil one in the room. It's our job to get rid of him. The next is oil. Oil is burnt to provide 33% of the world's energy, but it's a little cleaner. It's still pretty dirty, but it's a little cleaner than coal. And therefore it comes in second in terms of emissions of carbon dioxide. But we have to get rid of that as well.

Alan Finkel (00:08:36):

So coal and oil between them as 66% of the world's energy use and the largest contributors by far to carbon dioxide emissions. Now we don't want to do something that gets rid of them, but leaves us with a difficult situation, a dire economy, people out of work, or even a reduction in our lifestyles. You could argue that the solution to all our problems are to go back to primitive lifestyles, stop using energy people. Aren't going to do it. It's been talked about for decades, maybe for centuries. They're just not going to do it. What we need is a solution that can be delivered a solution that will be acceptable to people because it won't lead to Dole cues. We need a solution that preserves the economy and our lifestyles. So the obvious question, is there something better that we can do basic preserve the economy in our lifestyles.

Alan Finkel (00:09:33):

We need energy. Is there something better that we can do than to continue using massive quantities of call an oil? Okay, well, a lot of people have looked at this and propose the hydrogen economy, and I'm going to take you through the hydrogen economy fairly quickly and show you why, even though it sounds good, it's not a practical solution. Now hydrogen is an abundant element. There's more hydrogen in the universe than anything else. There's massive quantities of hydrogen on planet earth, but it's not there as free hydrogen. The good thing about hydrogen is if you do have pure hydrogen, you can burn it with oxygen to release energy and the byproduct is water. So, but you'd need to start having lots and lots of hydrogen. So the question is, where does it come from? It's all in the oceans bound to water, or it's in the ground bound to various minerals.

Alan Finkel (00:10:31):

So there, I'm just showing you a picture of hydrogen atoms floating around. It's a little double at a molecule. If it finds the hundreds and finds an oxygen, molecule is a spark or a little bit of heat, the oxygen and the hydrogen bind together and create water. You can't actually think of a better system. Can you hydrogen oxygen? The only byproduct is water, but the question is where to get the hydrogen from there's two places you can get hydrogen. You might not have thought of this, but the cheapest way to get hydrogen. And it's actually reasonably cheap is just that with guests, natural gas, the same guests that you burn in at home, natural gas is just a molecule called methane, which consists purely of carbon and hydrogen. So if you could strip out the hydrogen, you'd have tons and tons of views. There's a lot of natural gas around the trouble is when you do that, your byproduct is the carbon that was left over, which ultimately binds with oxygen and goes into the atmosphere as carbon dioxide.

Alan Finkel (00:11:40):

So getting the hydrogen from natural gas that you would need to run a full economy actually would leave to much, much, much worse carbon dioxide emissions than compared to us, just burning the natural gas to drive our cars or heat our houses. So using cheap hydrogen has no legs. Won't happen. It's gone. The other way you can get hydrogen is to use electricity, to break the water molecule, a water molecule. I showed it to you before is hydrogen bound with oxygen. You can use electricity to break that apart to separate the oxygen from the hydrogen. And that's great. There's actually no byproducts of like carbon dioxide. It's just like Tricity in into the water. The only things that come out of hydrogen from one electrode oxygen from the other electrode, there's absolutely nothing wrong with oxygen going into the atmosphere. We love it. And the hydrogen is pure hydrogen that you can use to drive vehicles or to heat houses or to run industrial processes.

Alan Finkel (00:12:41):

You can use to store intermittent electricity from wind and solar on the surface of it. It sounds fantastic. Well, is it reasonable? You have to start with electricity and water, tons of water available. We're not talking about the sorts of volumes that are used in agriculture. So availability of water is not an issue, but you've got to think about the electricity. So let's say we've got electricity coming from solar panels, and we start with a quantity of electricity. I'm just putting down a quantity quarter, a hundred kilowatt hours. A kilowatt hour is what you pay for on your bill. If you go home and look at your electricity bill tonight, you'll see that you're paying 20 or 25 cents per kilowatt hour. So let's say that you've been running the solar panels to produce a hundred kilowatt hours of electricity. And we're going to do a comparison.

Alan Finkel (00:13:30):

Let's use that electricity in one case to take water, break it into hydrogen and drive a hydrogen car. And there have been a few hundred hydrogen cars made as prototypes and demonstration vehicles, but big companies like BMW and general motors over the years. And we'll compare that to taking the same quantity of electricity and transmitting it down the transmission lines into an electric car and driving an electric car. So start off, we'll say that we've got a hydrogen vehicle. You can't tell that it's a hydrogen vehicle on the side. It says it's a hydrogen vehicle. If we take that a hundred kilowatt hours and with a very optimized process, take electricity, separate the water into hydrogen oxygen, grab the hydrogen, take it to where you need it. Compress it, put into a car and drive the car. And you'll drive that distance. You take the same hundred kilowatt hours of electricity.

Alan Finkel (00:14:23):

Put it down. Transmission line into a plug with your electric car. The electric car will drive three times further. The reason is that the efficiency of the processes of electrolysis to crack the water and transporting a hydrogen, compressing the hydrogen and using it in a fuel cell inside the heart from car to drive the car means at the end of the day, from the initial electrical energy of a hundred kilowatt hours, you only get 22 hours of mechanical energy energy to drive the car forward. Whereas you take the simpler alternative of just going down the transmission line into the plug into the electric car. It is such an efficient process. Electric motors are very efficient. Electric batteries are very efficient that you end up with 69 kilowatt hours of energy as mechanical energy to drive the car forward. So it's attached over a factor of three.

Alan Finkel (00:15:20):

So for those reasons that either you've got too much carbon dioxide emissions, cause you're using cheap natural gas to make hydrogen, or you're just frivolously wasting my Tricity. The hydrogen economy will never make it because even though there's in the second route, actually in both routes, you're not getting any carbon dioxide emissions. When you start with electricity, solar, electricity is clean, but it's not free. As you've probably heard is the most expensive form of electricity that we have. So you can't be frivolous and say, well, there's no carbon dioxide emissions. So it doesn't matter. You've got to use it. Optimally and electric cars are far superior at using that starting electricity supply. There are other problems. Carbon dioxide is hard to store. It's very explosive. So there are other reasons why you might not consider it. Every reason points to not going down the route of a hydrogen economy. So what's the next alternative. Is there something better? And I put it to you that there is, I call it the electric planet, any electric planet in my concept of the electric planet, electricity is king. Electricity will be used for everything. And I'm going to take you through over the next few slides. What I mean about electricity being used for everything and why it is that it's so special.

Alan Finkel (00:16:43):

So what you see up there is a pie chart that shows the sources of energy in the United States. Currently I've chosen the United States because a, the data is readily available and B it's very representative of any developed economy. And you could say we are, what about China? And what about India? The fact is though they are driving themselves towards the same kind of society as Europe and America, or for that matter Australia. And I don't know that you can see it too easily from there. So I'll quickly go through this electricity generation, which itself today is quite dirty. We're burning coal to make electricity and we're burning gas and oil to make literacy. The electricity generation provides 38% of the energy that we need for the various things that we do. Transportation, of course, primarily uses oil, whether it's converted into petrol or diesel, it's all an oil based fossil. It's an oil fossil fuel. That's 31% of the energy that we use then heating of buildings using oil or gas and industrial use up another 11 and 10% respectively water heating and cooking another 4%. So by the time I've done all that, I'm up to 94%. There's only 6% leftover. And that's things where fossil fuels are used or carbon dioxide is admitted making concrete or in some of the agricultural processes. Can we do something about that?

Alan Finkel (00:18:12):

The electric platter concept requires that we convert our electricity supply from a fossil fuel generation system to a clean system and they make a lot more of it. So let me walk my way through that. We'll take the electricity generation slice of the pie, and I'm going to turn it into green. How with wind solar, maybe gas and nuclear and other things I'll talk about. Then we take the transportation, which currently is all driven from fossil fuels with just the very, very beginnings of electric cars starting to hit the market. And that's 31%. It's not really practical to convert all of it to electric. Electricity is terrific for small vehicles for regular vehicles, maybe even light trucks. I actually drive an electric car. I've got a Nissan leaf and it's a wonderful car to drive is a terrific experience, but it gets a little hard for say container ships and jet planes.

Alan Finkel (00:19:12):

So let's assume that we can convert about two thirds and it's not a complete assumption that's been worked out. Let's assume that we can convert about two thirds of that 31% to work off electricity. So electric cars, rather than petrol. If you look at the space heating, it's actually easy. If you've got the electricity, you can do all of your space heating with electricity is that complete conversion. Let's look at industrial processes there it's more complicated. It's not just heat, but heat is one of the biggest consumers of energy in industrial processes. If you sort of look at what they're doing, you can convert probably half of the industrial processes to electricity, water heating, and cooking, easy, do all of that with electricity. It's a complete conversion. So now I've got my pie chart again, and you'll see that I've converted large pieces of it to green, but there are little pinkish pieces of the pie left over, but let me collect them all together.

Alan Finkel (00:20:12):

So now taken all the bits of pie that were green and brought them together. And what I end up with is a 79% reduction in the carbon dioxide emissions, compared to where we started by converting our electricity to a clean supply, and then expanding it to use it for these other purposes. That is a massive reduction. And it's actually achievable. It's not a policy waving of the ones from government it's actually achieved magic. It sounds like magic. Doesn't it? Why is it that electricity delivers such better value than fossil fuels? Even if you might get some of your electricity from a fossil fuel natural gas. So let's look at that. What I've got, there is a picture with a bottle of CNG, compressed natural gas in those little blobs around it. It just molecules of me thing, which is what natural gas is. And let's do the same exercise that we did for hydrogen.

Alan Finkel (00:21:18):

Let's assume that we just took the me thing out of the ground. Sorry, I'll call it natural gas. We took the natural grass out of the ground, got a converted car and drove the car. And we got that distance out of it. You can guess where I'm going to go. If we compare that to driving with the same amount of natural gas being taken away to a large generator that converts the guests into electricity, that cars can drive three times further. Again, there's something magic about it. What's magic is that electricity can run devices at something nearing a hundred percent, certainly over 90%. If you look at a normal car engine, extended carry engine on average driving around the city, you'd be lucky to convert 15% of the energy of the petrol into the mechanical energy to drive you along because internal combustion engines are very inefficient. Whereas electric motors can run at 90 to 95% efficiency. The battery, the process of charging the battery in a, taking the energy out of the battery to the motor 98, 90 9%. So there's a certain magic about electricity that runs through these extraordinarily high levels of efficiency.

Alan Finkel (00:22:37):

Another way to look at it is on heating. You can use natural gas to heat your water, to run a shower and are shown a certain amount of guests giving you four showers. You could take the same amount of guests, use it to make electricity, then run the electricity, not into a conventional hot water service, but in one that you might see referred to in some of the shops with the selling hot water services as a heat pump, it runs a little bit like an air conditioner on reverse cycle and a heat bump through another piece of magic actually can put more heat into your hot water. Then the heat energy of the natural gas that we burned in the first place, because what it's really doing, it's not directly heating the water. It's pumping heat from the outside environment into the hot water. That's a whole lecture on itself.

Alan Finkel (00:23:33):

It's a kind of magic, but it does mean if it's the same amount of the same quantity of guests to start with. You could get six chairs instead of four showers. So just a couple of vignettes to illustrate to you that there is something special about electricity. It's not just that I grew up and trained as an electrical engineer that I'm promoting electricity as part of the solution to the problem we face. Okay. Where is electricity going to come from for your electric planet? Remember I said, we need green electricity and we need a lot more of it. So I put a whole list of contenders there on the left-hand side, let's have a look at some of them, hydro electricity. You're all familiar with that big dams, but the water run down. Turns the generator. You get good, clean electricity, wind. You're all familiar with wind fantastic stuff.

Alan Finkel (00:24:20):

We can only hope that we get more of it. South Australia is an absolute leader in generating electricity from wind. And I think is a beacon to the rest of the country. Solar just take the light energy from the sun in these panels, you convert it to electricity, wave and tide. You don't have to be genius to recognize that there's a massive amount of energy in the waves. And equally there's a huge amount of energy in the tide. If we could just capture that, what a great source of clean electricity geothermal people are talking about it all the time. That's, we're using heat in the rocks, several kilometers under the ground to heat up some water that you pumped down in the first place, take that heat of water and run turbines to make electricity. Nuclear of course is sort of the elephant in the room.

Alan Finkel (00:25:13):

I say that because people have emotional responses to nuclear. The reality is 15% of electricity around the world. Today comes from nuclear nuclear at zero carbon dioxide emissions. So that's something we have to think about a biomed acids burning directly burning green mess for heat or converting it into fuel natural gas. That's the historic term we've used for gas where you just drill a hole in the ground. And if you're lucky, you find a bubble of gas and outcomes, but even if you're getting the guests from shale or from coal seams, it's the same guests. So when I say natural gas, I'm actually not talking about where it came from. It could come from conventional Wells or from coal seam or from shale and carbon capture and sequestration. It's a big term. What that's talking about is using a dirty source like coal, but capturing all the flue gases, separating the carbon dioxide out, compressing it into liquid carbon dioxide and pumping it into deep underground reservoirs, not easy, but technically valid concept.

Alan Finkel (00:26:24):

Well, which of these have the potential to deliver for us? I'm going to strike off carbon capture and sequestration because it's never been proven. And there are a lot of skeptics that will ever be possible. At large scale, geothermal people have been working on it for 20, 30 or 40 years. And the quantity that we've got after 20 or 30 or 40 years of effort is minuscule and is no clear path forward that would increase those volumes wave and tide the huge amount of energy out there, but it's extremely difficult to extract. And again, people have been trying for 30 years to, or even longer to get the energy out of wave and tiny. And there are some excellent examples where it's been done successfully, but overall it's too expensive. It's too hard. The sea is a harsh environment. You put a generator out in the sea and the sea water corrodes it smashes it.

Alan Finkel (00:27:17):

It's not easy. Hydro is fantastic, except there's a NIMBY phenomenon in IMB. Why not in my backyard. So even though hydro is clean, constantly available, the likelihood of us in Australia ever building another hydroelectric dam would be close to zero, if not zero and same in Europe and same in America, some developing countries, they're doing it, but it's got a limited scope to solve the problems at a planetary scale. It's really good, but it's unlikely to get much to be implemented much more than it's currently implemented. And by IMS, well, you know, the problems, the idea of trying to convert everything to diesel means we're competing for the same land that we're otherwise using for food means we're chopping down rainforests and even worse. You're doing all of that. You're suffering all those penalties, even worse. When scientists do the analysis, they find that you end up putting so much energy into their fertilizer production in the tractors and the harvesters that you don't benefit much.

Alan Finkel (00:28:26):

So you get, you take all the pain without much gain. So let's take hydro and biomass off. And what you're left with is for wind solar nuclear and natural gas as contributors, wind is fantastic. Let's make more of it. Solar is fantastic. Let's make more of it, but the wind doesn't blow all the time. It's intermittent. The sun doesn't shine all the time. It's intermittent. Sometimes there are nights where there's no wind, so you don't have either wind or solar. Even if you look at the whole country and everything's connected. So you have to give, you know, we need the commitment to wind and solar because they are actually ideal. They're perfect except for their intermittency, but we've got to give strong consideration to the two that remain, which is nuclear and natural guests to build up our capacity of clean electricity generation.

Alan Finkel (00:29:17):

Well, how much wind and solar could we really do in to what extent do we need to supplement it on this pie chart here? And it's a little difficult to read. What you'll see is there's a small slice here, which is the renewables, wind and solar. This is now looking at a global extent and the rest of the pie chart is what you get from the oil, the call, the guests, the hydro, the nuclear, everything else. What you see there is for all the effort we've put in over the last 20 or 30 years. And especially in the last 10 years in Germany and America and China, Australia, massive commitments to solar and wind in total. We're only getting 2% of our energy needs from solar and wind.

Alan Finkel (00:30:02):

And that's over a 20 year period say sadly, the growth of our energy needs across the planet just in one year. Last year was two and a half percent of that total. So the total combined wind and solar capability that we have at the moment, doesn't even meet one years of growth in energy demand. And it's hard to imagine that we're going to increase annually, our wind and solar by a factor of 10. And then if we did, we still got the problem. What do you do when it's not blowing? So we've got a tremendous quality, high quality source of electricity, of clean electricity, wind and solar, but it's not doing the job at the level that we need. That leaves two things, natural gas, which I'm represented with the guests ring and nuclear, which are representing with an atom, the nucleus and its electrons. So what would that mean for us in terms of generation capacity? So if you look at electricity today, my background, there is carbon dioxide molecules. You can ignore them every kilowatt hour that we generate. And I mentioned kilowatt hours before. That's the unit of energy that you pay for on your bill. If you take best practice in Europe and America and Australia is not as good as this, you generate about 600 grams of carbon dioxide just goes into the atmosphere.

Alan Finkel (00:31:30):

If we could use a lot of natural gas to replace the call and oil and preserve the nuclear that we've got, or maybe even increase it, you could quite easily with no new technology reduce that 600 grams per kilowatt hour to 200. And I can give you a perfect example. You've probably all come across the fact that France has a large commitment to nuclear power generation in France. 78% of the electricity comes from nuclear. 12% comes from hydro 78 plus 12. That means 90% of all the electricity in France comes from zero emission sources, 90%. And in France, the emissions per kilowatt hour, that consumers and industries are using is only 85 grams in Australia is 850. I mentioned to you before, we're not as good as the world's best practice, 600. So France with its combination at the 90% level of nuclear and hydro is at one 10th, the emissions level than we are, which also means that if you go and look at the statistics for France today, their per capita emissions are a tiny fraction of ours.

Alan Finkel (00:32:45):

So it can be done. Frances living example, I've been talking about generation, I just have to devote one slide to efficiency piece. Of course, the most important thing we can do is be more efficient in the way we use energy. It's the low hanging fruit, and that has been done around the world industry is trying to green itself up to use raw materials, more efficiently electricity generation by going to higher voltages and doing clever things, losing less in transmission insulating houses and buildings of course makes us more efficient. And there are some terrific improvements in agriculture. That mean we can get the same yields for slightly or somewhat less carbon dioxide emissions. So I just wanted to mention that because it is important, ongoing thing, irrespective of where the electricity comes from. And there's another application that it's unlikely that electricity can help.

Alan Finkel (00:33:41):

I love electricity, I'll drive electric car. I don't for second thing, I'll ever hop on a plane in Adelaide and fly nonstop to Los Angeles in a battery powered airplane. It's just not going to happen certainly in the next 50 to a hundred years. So what do you do? Well, you could just continue to use aviation fuel, which comes from oil. Or we could say we're not going to use biofuels for day-to-day transport because we can use electricity for cars. Why waste the precious biofuel resource for that? Let's keep our biofuels for places or activities that we don't have an alternative clean solution like electricity. So I envisaged that possibly large ships and international flights will continue to use a mixture of biofuels or conventional fuels, but at the end of the day, that's only a small percentage of our total fuel use. Okay.

Alan Finkel (00:34:35):

Let me try and summarize all of that. The up there is a picture of what we have today. So on the left-hand panel, I'm showing electricity generation using coal, just what you would see if you went out to one of the big power stations in south Australia or Victoria, new south Wales, anywhere in the middle panel, I'm showing something to represent. Today's conventional transport, filling up the car with petrol and the right-hand panel. I'm just showing you a picture of hating with a guests heater in someone's house. So the electric planet proposal says, the first thing we want to do is clean up our electricity. So I'm now shown that left-hand panel instead of being coal generation, like it was, it's now green, and there are four sources of electricity, solar, wind gas, and nuclear. Don't get me wrong. I'm not saying replace the world's electricity supply with nuclear, nor am I in any way, disparaging, solar and wind.

Alan Finkel (00:35:32):

I think solar is fantastic winds. Fantastic. Let's make hell of a lot more of it, but it's always going to have the problem of not being enough and being intermittent. It's the combination of the four best things we've got going for us. Solar wind gas and nuclear that will give us a high quality, not zero emissions supply, but near zero emissions supply close enough that I'm coming painted green stage two of the electric planet stage one being green up the existing supply stage two is to make a lot more. So I've just grown the bar, the total volume of electricity that we've got and use that to replace our transport system to the maximum extent that we can with electric transport and similarly make even more electricity and use that to replace our heating. It's easy to replace heating either with reverse cycle electricity or a direct heat pump or even direct electrical heating. So the picture of tomorrow is green electricity, a lot more of it than we had today. And using that to replace fossil fuels to the maximum extent that we can in transportation, heating and cooking and all those things.

Alan Finkel (00:36:49):

I see that as a positive approach to the problem, I, I personally get tired of people having a doomsday view of where we are. I think we can control the outcome. I just put a picture there of a million symbol. Many of you would have known that last year on the 21st of December, the world was meant to come to an end as it was a key 500 years into the main calendar. It didn't happen. You didn't really think it would, but many of you will have grown up. Like I did being aware in the sixties that there was a dire food shortage, but the world didn't run out of food because through human ingenuity, we came up with the green revolution in the seventies, there was the threat of peak oil in the world running out of oil, but human ingenuity, engineers scientists solved that problem by coming up with new ways of extracting oil and finding oil. In the eighties, we were growing up with mutually assured destruction with nuclear bombs, but that our Macedon was solved by social and political means in the 1990s, I, as an electric engineer was worried that we'd run out of making computers faster and cheaper. It's never slowed down why human ingenuity. I really believe that by applying ourselves with ingenuity and strategically, we can solve the problem that we face, but it can't be done without some leadership.

Alan Finkel (00:38:13):

That's a problem, isn't it. There's not enough leadership. We need strategic leadership from government because you as individuals can't achieve a planetary wide solution and tiny, tiny little things, little behavioral things that you might do or put a solar panel on your roof. Really what you're looking at cumulatively around the world, these millions of millions of small contributions, and the reality is millions of small contributions. As up to something small, it doesn't necessarily add up to something large. So we need government leadership at the national and international leader level. Now governments have been trying to provide leadership by doing things that have been proposed to them by lobby groups or with special interests. And it hasn't worked out well. You get the emission trading scheme in Europe. The first time it was done, turtle disaster got rotted. The prices collapsed. He said, we'll fix it up.

Alan Finkel (00:39:11):

It did it again, got rotted. The prices collapse. It's not going to work. It's creates volatility in the pricing of carbon dioxide. Permits companies have no surety of what's going to happen. And it gets frauded by both governments and companies or they put in mandated requirements for 20% of all vehicle fuel has to be biofuel. And as a result of that food prices in emerging countries go up. There's a difference between doing grand schemes and being strategic. Well, I think the most important and effective strategic thing that we can do is put a price on carbon dioxide emissions. You've all heard about the carbon tax. You all heard about the emission trading scheme. One I'm trashing the emission trading scheme, but both of them are trying to say there has to be a price on carbon dioxide emissions. The unit that you charge for is a ton ton, one ton of carbon dioxide. You're going to put a price for 10, 20, 30, 40, or $50, some price that will mean that there's an incentive for companies to change their production processes, to use systems that are less carbon dioxide intensive. And for you individual consumers to buy sources of energy, that will cost you less, maybe an electric car instead of a petrol. Yeah.

Alan Finkel (00:40:34):

Question is how do you do that? I already mentioned a couple of reasons. There are more why the emission trading scheme hasn't been successful. And for all the talk about it is unlikely to ever be successful because don't forget that the winners in an emissions trading scheme at brokers and traders and bankers, not the industries or the individuals it's not delivering what it's put out to deliver. The alternative is what we briefly in Australia, or we still have, but it won't last long. And that's a carbon tax carbon Jackson, simple governance is a certain we'll apply this year. And maybe if they're really strategic and thinking longterm, they'll map out how that price might increase over the next 10 or 15 years. And if they make it out, map it out for a sufficient length of time, by having some bipartisan support that enables them to do that.

Alan Finkel (00:41:26):

Industries could actually plan with confidence how they will recapitalize and retool their production processes. But we haven't seen it. We've seen the techs come in, go out, turn into an emission trading scene, come in, go out, come in, go out. No one can cope. We need to make a long-term commitment. But then we've also got to say, which carbon dioxide are we texting? Strange question, which carbon dioxide are we texting? Well, turns out there are two different types of carbon dioxide. I'm not talking elementally or chemically, but in terms of how you count it, I've got a little map there of the United Kingdom. They're very proud of themselves from 1990 to 2005, the carbon dioxide emissions in the United Kingdom went down by 15%. That's really impressive that you might think that's because of their solar and their wind and more efficient houses, but it's not the main reason why the carbon dioxide emissions in the UK has come down is because of de-industrialization the coal using industries, the heavy machinery industries that they used to have, have just left.

Alan Finkel (00:42:40):

They've gone to China and Thailand and other places. And so the emissions associated with the goods that they're buying and using in the UK, those emissions have shifted off shore. But of course, when they do their accounting, when they tally up the carbon dioxide, what they're counting is the carbon dioxide production. How much carbon dioxide did they produce in their own islands? And they're ignoring how much carbon dioxide was produced to make the goods that they consume. And that's what we do in Australia. We've got a currently it's not going to last, but we've got carbon dioxide techs on producers. Now, not only is that texting the wrong thing, but it leads to self-harm because if we did that without any exceptions would be hurting our export industries. If we make a car in Adelaide and is a $500 carbon dioxide tax attributable to that car, it's more difficult to export.

Alan Finkel (00:43:41):

But under the current law, if we import a car from Frankfurt and it was $500 worth of carbon dioxide that was generated and admitted in making that current Frankfurt, no one in Australia pays it. So we're actually making it cheaper to import vehicles than to make them here. And that applies to everything that we do. And so of course, when the government brought in the carbon tax, they made exemptions for export intensive trade exposed industries, but that's just the start. You end up finding exceptions that we can the whole system from the beginning and make it impractical. What we should be texting is consumption. Let's look at the United Kingdom again. Now I'm showing it in red because at that same period of its same period from 1990, 2000 and the carbon dioxide attributable to the goods and services that they consumed went up by 19%.

Alan Finkel (00:44:40):

So yes, they felt great. They were meeting their Kyoto protocols and international obligations. But as I said before, just by shifting the carbon oxide of trivial to their attributable, to their own consumption, can you do it? Yes, you can. You just have to have people trained as auditors to work out how much carbon dioxide was admitted in making various classes of goods. And you can generalize that. And then we have a very efficient system of collecting it. It's called the tax office, got a lot of experience. You've noticed they do it all the time, not just income tax, but sales tax is goods and services tax. This is no more difficult than a goods and services tax. Why did I do it? I don't know. It's partly because governments are short term, partly because they hate the word techs. They quite texts with lots of votes. I equate the fear of loss of votes with their inability to go out and articulate a clear message. Also the, take the opportunity to introduce it at a small level and grow it up over a 10 or 15 year period, because they've only got a three-year time horizon. So it's difficult, but it's not impossible. It's strategic. And it's the right way to go.

Alan Finkel (00:45:58):

What do you do with the money you collect? It actually doesn't matter. There's only one thing you can't do the good things to do with the money you clicked in a carbon tax to you can give it back. It's not a bad thing. Let's say that you collected $30 billion of carbon tax in Australia in 2014. And you wrote a check to every man, woman and child in Australia. In other words, a revenue neutral scheme, it's still doing its primary job, which is to influence behavior away from buying products that have a lot of carbon dioxide to encourage companies to lower their tax burden by investing in low emissions technologies. So the behavioral goal is achieved and doesn't really matter what you do with the money, as long as you never, ever, ever give it back as a subsidy to create somebody's carbon costs. So if you use some of that revenue to reduce the price of petrol, because you're scared, you're gonna lose volt votes, you've ruined the whole purpose. So you can do anything you like with one exception, which is you cannot give it back specifically to cancel its effect, but a very good thing to do with it would be to invest in more technology development. Because even though I can tell you that we have already in hand the technology and wind and solar and nuclear and guests to do what I'm talking about, we can do it better and cheaper if keep optimizing processes. So really good thing to do with some of the carbon tax at least would be to invest in innovation.

Alan Finkel (00:47:38):

That's it, my vision for a planet where electricity is king, the electric planet, our, our earth hanging on a electric cord. If we do it right, it'll glow and we'll have a bright future. Thank you.

Speaker 3 (00:48:03):

[Inaudible] Well,

Tim Harcourt (00:48:04):

Thanks very much, Alan, for the stimulating presentation. Now, Ellen city wouldn't get on an electric plane, but he did tell me before that he has bought three tickets on the Virgin intergalactic flight to space. Next year says the airport economist. I thought I had a lot of frequent flyer points, just so he takes off now. We, we thought it's such a stimulating session that we'd have a bit of time for a couple of questions. If if anyone wants to ask something, there's a couple, I think there's a microphone. We can just ask, ask the question only. So I'm

Alan Finkel (00:48:39):

Not sure that everybody would have heard that the question was, would I like to comment on the beyond zero emissions scheme, which I'm thinking of the right scheme is a proposal that within 10 years we could be using renewables for all of our energy needs. I admire optimism, but realistically, the technology is not there primarily one area and that's storage. If we don't use natural gas or some other means to supplement wind and solar, we have to have massive storage. Now, there are, there is one technique of doing massive storage, which is very effective and it's called

Speaker 5 (00:49:20):

Reverse hydro, which is where you pump

Alan Finkel (00:49:23):

Water up hill. You'll know about hydroelectricity. That's where you use the water coming downhill through a generator to make electricity electric motors. I told you, electricity is magic in the motors are extraordinary. The other thing that's extraordinary bathroom is you can run them backwards. And if you take an electric generator that would ordinarily be used to make electricity from a big dam, like in the snowy mountain

Speaker 5 (00:49:44):

Scheme,

Alan Finkel (00:49:47):

You get electricity out of it. If you flick a few switches and push electricity back into that, what was a generator it'll run as a motor and pump water back up hill. And it does it very efficiently. So there is one known technology for storing the electricity from wind and solar, but because we'll never gonna build, we're unlikely to build any more hydro electricity dams. The extent to which we can utilize that in America, Australia, and Europe and other emerging countries is very limited. So I just don't have any confidence that in a 10 year timeframe, we're even a 30 year timeframe. We can use solar and wind wave and geothermal to meet our needs. I don't think we can do it without a very substantial commitment to natural guests and maybe nuclear to go with it. So commit to solid commit to wind, but don't forget. You've also got to put in a very big commitment to natural gas, electricity and nuclear. Okay.

Tim Harcourt (00:50:57):

I'll take one question here.

Alan Finkel (00:51:04):

So the question was around solar and that is to not just rely on the panels that I showed you, which is solar photo voltaic that use solar thermal with thermal storage. It's another nice technology, but when you do the numbers, what you find is you have to, if you want to get overnight electricity in 24 hours of generation from solar thermal, you have to cover around about eight or nine times as much area with your collection panels as you would do for just getting that peak electricity without the thermal storage. So it's clean. It's nice. It makes sense, but it's not going to scale up to the level that we need.

Alan Finkel (00:51:55):

16 of thermal. Yeah, no, that's fine. It's terrific. But don't forget. Take the thermal out of it. Cause it makes it more difficult to do some calculations, but it fits in at the end of the day, electricity from solar, I say a kilowatt hour or live no, not a kilowatt. It, let me talk about a gigawatt. When you're talking about large scale, you were talking about 4,000 megawatts sets, four gigawatts. When you talk about large scale, you talk about gigawatt. So megawatts. So let's say you've got a big coal generator in your lawn in my state of Victoria. And it's putting out one gigawatt it's cheap to build. You could build less than a billion dollars, dumped big numbers, but gigawatt, you can build it for less than a billion dollars. Now you go and build a one gigawatt solar

Speaker 5 (00:52:51):

Array. Well, first of all,

Alan Finkel (00:52:55):

It'll be say four or $5 billion to build, but at least you're getting clean

Speaker 5 (00:52:59):

Electricity,

Alan Finkel (00:53:01):

But a gigawatt from solar is not the same as if you gigawatt from a lake from a cold generator. Because on average, during the course of a day, over 365 days a year, it's only working at, at its peak capacity on average, about 15% of the time compared to nearly a hundred percent, not quite, but nearly a hundred percent from your call generator. So you really have to build about

Speaker 5 (00:53:25):

Gigawatts of solar for

Alan Finkel (00:53:30):

Two to get the same total energy as a one gigawatt coal generator. It's a big difference. So now your price has gone up from 4 billion to maybe 24 billion compared to the 1 billion on call. If you wanted to get one gigawatt, thermal your costs go up again and your collection area goes up again. So it's great. I'm not against solar. I love it. Let them build 4,000. Then we should build 10,000 megawatts in our desserts and truck. It in one of the things I should mention is that a lot of people say don't do that because you lose too much in transmission. It's not true. Transmission loss is a very small, that's an urban legend. So it's great that they're doing that. And we should do more, but it's not enough because every year our global requirements are going up two and a half percent. And the totality of solar and wind today doesn't make that two and a half to save. So we've got a long way to go. I have

Tim Harcourt (00:54:28):

Time for two questions. So if two people could go to that microphone right there, right in the middle, go to that microphone. First two people there. Get the questions. All right. There's one. I've got a question about the storage. Haven't you ignored battery storage because in it's a Japanese NGK sell himself a batteries for large scale. You've got redox flow batteries for situations like king island, which are a lot smaller. And you've got Lucien on, which is now over the last two years actually changed quite a lot in terms of costs when people are putting in container sized modules. Yeah. So

Alan Finkel (00:55:11):

In what I've said, I've ignored it in my mind. I don't since fits into that second last slide called innovation, lithium ion batteries, vanadium redox batteries have come a long way. They're really good. But again, all the lithium ion batteries are delivered the maid and all the vanadium redox batteries that have been made with it. Even if they contain a size, I don't know the number, but I don't think that was saw 0.01% of a day is energy requirement for the planet. So for batteries come anywhere close to the capacity of reverse hydro as a storage means there's going to be a need for a lot of innovation and development. Lithium-Ion batteries need to get cheaper and higher density, and they've been making fantastic progress. A lithium ion battery has four times the storage capacity for given white a battery competitor, the best lead acid battery. So they're improving, but it's a slow rate of improvement. It's not like computers where every two years the speed doubles, every improvement in batteries is hard, won by thousands, thousands of chemists making tiny, tiny improvements to the electrode in the electrolyte chemistry. So I don't really ignore it, but it's not going to deliver, I don't think in the sort of timeframes that we need to think of timeframes like 20 or 30 years to start making a big difference to this ever increasing carbon dioxide emission.

Tim Harcourt (00:56:41):

I don't think you're right on that one. I think last question before students, first of all, thank you very much for a very persuasive presentation. I just wonder how you'd respond to the argument that the risks associated with nuclear power outweigh the benefits, particularly their arguments, concern, waste disposal, and nuclear accidents. Well,

Alan Finkel (00:57:03):

It's a very fair question and no one will ever be satisfied by any answer. So let me just give you a numerical analytic clients you ever heard of James?

Tim Harcourt (00:57:16):

Yes. I had the pleasure of listening to him when he visited her.

Alan Finkel (00:57:19):

Fantastic. So James Hanson is possibly one of the most esteemed climate scientists in the world and really did a lot to promote the concerns. He's now become an advocate for nuclear as part of the mix. And what got him to change his view was he went back with a colleague whose name I don't remember. And they did a study, which they published earlier this year. And they looked at the safety record of nuclear compared to the known annual deaths due to the coal industry, as well as the respiratory, this, that the general population suffers. And you can do that analysis on call on oil, on guests, even on wind. There are disks in the wind industry during construction, even in solar, they're a desperate cause people fall off roofs when they're repairing and installing. But the reality is that the deaths directly attributed to nuclear in the 40 or 50 years of we've had nuclear, a very, very small Genobles the only one only accident that actually led to measurable deaths either directly or over a 40 year period from manifestations of respiratory and thyroid cancer.

Alan Finkel (00:58:28):

And even then it was, I see different figures, but it was less than 4,003 mile island. No one died. Fukishima no one, not even the workers, not a single person has died from radiation poisoning and the world health organization has done a big study, the United nations commission and an independent big study that both of which reported a few months ago. And they both concluded the same thing, that there were no direct radiation deaths that if they looked over the statistically expected, increase in cancer related deaths, due to the known levels of radiation, it would be actually indistinguishable from the background noise. That was, I couldn't put a number on it. It's so small. It doesn't feel right. You don't somehow you can't trust it when I say those numbers to you, but those are the numbers. So in James Hanson took all those numbers and did an analysis.

Alan Finkel (00:59:23):

He concluded that the existing use of nuclear power to create electricity over the last 40 years, he started from 1971 and look from 1971 to 2009. So just a tad under 40 years, that by virtue of the fact that we were producing electricity from nuclear and therefore not having to produce electricity from a mixture of coal and oil and gas during that period saved 1.8 million lines or four Wint 1.8 billion deaths. So if you look at just on the numbers, nuclear is extraordinarily clean, but people feel uncomfortable looking at that because of what's called the fear of the sort of Damocles that if there is the ultimate disaster, that it will be just beyond belief, but Fukishima came close to being an ultimate disaster. And Chernobyl probably was both of those of what's called second generation nuclear designs, which required the available to people at Tricity to run the safety systems, all the stations that are being built now in India and China and America, and even parts of Europe use third generational, three plus generation designs where the safety is passive and the sizes are done so that they can't be or sizing is done.

Alan Finkel (01:00:42):

So you can't really sort of get contamination from one building to another. So purely logically, I think it's very clean, but I share people's concerns. You mentioned waste specifically. There haven't been any significant deaths due to waste, nothing like what you get from the coal industry. And yet it's, it's a concern and that's where government comes in, because we all know that there is at least one way to store waste long-term and that's to let it sit for 50 years until it loses its high level radioactivity, then encapsulated in sort of a car type of concrete in buried deep, deep, deep in stable rock formations. And that's supported by the sort of taking community, but you need to find a state or a county that would allow them to do that in their backyard.

Speaker 5 (01:01:43):

So it's solvable, but we're not solving it. Okay. Well,

Tim Harcourt (01:01:48):

Helen Yogi Berra said we lost it with my good time. Could you please, Ellen [inaudible]

Intro (01:02:05):

This session of the 2013 Adelaide festival of ideas was recorded by radio Adelaide through the support of the vast mid library, university of Adelaide, the university of south Australia library and Flinders university library.