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THE WORLD IS THINKING

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Good evening. How are we for signal, very good, I am Stewart Brand from the Long Now Foundation. You maybe wonder what this Twitter thing is about. This data, it turns out is helpful helpful for funders of Long Now and of these talks. They could find out what the sort of watershed of people that feeds into this of event is. How many people have been the one of these before? How many have not been the one of these before? Well thatÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s interesting. The drill on these things is, this is for questions and the back put your name on it and look for somebody in the yellow hat like mine pass it over to them it comes up with the friend Kevin Kelly combs through for the stuff that will really embarrass the speaker and I will get him with it. Another thing we may do with these datas as we move from venue to venue we find out who is well served by public transit things like that. WeÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢d like eventually to get a bigger place obviously and a place that we can count on being all the times so this data helps us move in the direction of being able to handle more of an audience with more regularity and more access for everybody so thanks for your help on that.

I should say who about the next speaker, since not everybody knows who Dmitry Orlov is, he is the sketch. He is a close student of how collapse went forward in the Soviet Union 20 years ago and notices interesting parallels going onto the US. You all stuck with the financial collapse climate change may figure into it by the time these things play out and one of his points is that the Soviet Union screwed up with it is was actually better collapse probably than we are. So we can learn something from their experience and move right on through the collapse and do rebirth. This is the long term of thinking we tried to encourage in this organization.

Saul Griffith who is also talking about long term stuff, the weird thing about climate is that its life times and its lead times and so much longer within quarterly report or an election cycle or a news cycle. They were still getting use the thing in terms of what one has to do to make something happen 40 years from now and failing to do that are you willing to live with the consequences 40, 30, 20, 10 years from now. Now Saul is a MacArthur Fellow, he got named last year, 2007, last year and one and MacArthur Fellows, itÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s a lot of money which was great, so lot of attention which is useful because it gets usually young, creative people a bigger audience and little more focus and also they connect with each other and so the fellows are in the sense of lifetime club they extremely creative people who infect and infest each other, which then gives them more to infect and infest us with thatÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s what Saul Griffith is here for tonight. Here he is.

Thank you Stewart, so I am super excited because this is the first time IÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢ve ever sold at a house I think. So I hope they with, and I hope desperately to neither infect nor infest you tonight.

Climate Change Recalculated is the topic of my talk tonight and I am not going to try and tell

you that everyoneÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s equations and all the science is wrong and if you recalculate it we going to
get a great result. The recalculation I am talking about is the type of recalculation that will help
you answer questions of this kind: do you prefer glass of wine every evening or do you prefer to
have an annual business trip. Would you prefer your taxes spent on schools or roads? Would you
prefer a hot shower every day or would you like to eat meat at every evening meal.
So they will turn out to be surprisingly relevant questions by the time we get to the end of the talk.
So youÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢ve obviously heard about climate change and thatÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s probably why you're here you have heard
about the concept of carbon footprints and you've certainly heard about energy
independence and we will hear more and more. But letÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s look at these things as though we are
sort of reconciling the short term us, the us that are seating here in the audience with the 10,000
future of us. So the 10,000 year of our childrenÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s childrenÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s children or something. Hopefully
doing that and so when the talk is called the climate change recalculated it should be maybe re-
envisioned through a very personal view. Hopefully we will now answer two questions how do
your personal actions affect climate? And given that can there actually be a global solution for
climate change? Which is another way say you going to see a big pile of numbers to show you
that climate change and energy issues are actually really aesthetic issues, itÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s really a question of
what is a quality life and what is the life that we all sort of want to live.
So, youÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢re going to see two stories tonight, the global big picture how much of all the different
types of energy are there, how can you use them, which ones are good, which ones are not so
good. But to set the context for that, I use to just give the talk exclusively about that very big
cold picture of the planet as a physicist would say it and people would say thatÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s a very cold
picture that a physicist paints and so I put myself in the picture and so youÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢ll learn more about
my personal life today than you probably want to know. And why? ItÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s because probably about
18 months ago in order to sort of understand my context in this picture I decided to ask this
question: how much power do I use as an individual?
So, super basics physics: energy is measured in joules if I were to lift an apple or this cup of
water from the ground to the podium that takes about one joule of energy. If power is the
amount of energy you use in a period of time, so if I lift that, if it takes me one second thatÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s
about one watt of power to lift that glass to the table. If I lift 40 apples per second from the
ground to the table you can imagine thatÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s quite a lot of effort thatÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s about 40 watts and thatÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s
about the amount of power thatÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s driving the computer thatÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s running this presentation.
So, these numbers are going to, yeah lot of you probably know this for those donÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢t know I am
just trying to give you some intuition for the lots of numbers that are going to come afterwards.

So here sort of some order of magnitude of the power certain things. So, the bio-energy thatÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s running you while you are sitting there in your chair or if you are standing more likely is about a 100 watts. Takes about a kilowatt or a 1000 watts to boil the water in your kettle. ItÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s about a megawatt is if you have seen a very large diesel locomotive or very large wind turbine thatÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s about a megawatt or million watts. It gets very hard to imagine power of larger sizes than that, so maybe you stood the edge of Hoover Dam and youÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢ve been awed by the power of the water thatÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s about a gigawatt in fact thatÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s two gigawatts of power and a terawatt which is 10 to the 12 watts was about how much power the world use in 1890. Hard to imagine a terawatt itÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s also about how much power you need to launch the space shuttle but that only lasts for few seconds.

If you are still struggling for an intuition about power I am going to tell you about my lifestyle and you can imagine my lifestyle and consequently your own in terms of the number of light bulbs that are burning at any instant when you are talking normally I stand in front of the slides here I know it wasnÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢t meant to walk out of the light and IÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢d like to stand here and say thatÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s not the glow of genius you see that is the number of light bulbs that takes to power on my lifestyle.

So, why watt? Why would you use power as a unit instead of energy? Because we hear about an energy problem, so why watts? The couple of good things about watts, watts allow you to compare activities you do on different times scales so you can compare the things that you do yearly like flying a certain number of miles to then things you do monthly like paying your electricity bill, to things you do daily like drink bottled water or energy drinks. You can merely add all those things together once youÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢ve got a watt value for all them, add them all up and that gives you the sort of power of your lifestyle. It also allows you to consider the non-carbon based effects of using so much energy or so much power and will get to that later in the talk.

So, as you can see I own my own airline this is the route map that it will fly you and in 2007 I flew 112,000 miles, if we assume that every one of those flights was on a fully loaded 747 operating as well as they can thatÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s about 18,000 watts of power. So thatÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s 8,000 watts all through the year is the equivalent of that. In terms of driving I drove about 10,000 miles in 2007 that was the equivalent of driving around the US on this route. In reality it was really just driving to the store or to work the first 4Ãƒâ€šÃ‚Â½ thousand miles were driving from San Francisco to New York via Atlanta in a Honda Inside a hybrid 55 miles per gallon jumped in a cab from New York to Boston rented a car you know one of the big rental cars from Boston to Key West up to Jacksonville in a van a diesel van the only safe way obviously to go across the southwest is in a truck.

Once I got to Tucson I jumped in my Vintage 1959 Volkswagen Dune Buggy and enjoyed Highway 1 all the way to San Francisco. So, 10,000 miles is less--the average American drives 15,000 miles a year. And in reality all of the cars, the majority of the cars that I drove in are much more efficient than the average American car so I drove less miles in more efficient cars and it was still 1,500 watts, the average American that value could be 2Ãƒâ€šÃ‚Â½ or 3,000 watts. I live in a small standalone house in the Mission and itÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s two bedrooms and I share it with my wife my half of the gas bill and the electricity bill in watts is about 625 watts. You can see here that I can break out the hot shower I have every day, the gas that we use for cooking I can even sort of single out the electric toothbrush and the fridge and phone chargers just using the sort of wall measuring devices for power so 625 watts there.

It turns out at my office nearly everyone runs four computers all the time 24 hours a day using 411 watts of electricity each. as you can see in the winter months January, February, December they all leave their windows open and use their gas to heat it so that was about I think about 600 watts if you divided out the power consumption of my company and divide that across everyone.

I eat hopefully you all do. It turns out that that also consumes a lot of power. I am using numbers here that I taken from reviewed peer journals in fact throughout the whole talk if anyone wants the reference list see me afterwards. I tend to believe actually that no one truly has a handle on the energy consumption for eating yet but this would be the conservative estimate in conservative in one serious plan and then one funny way.

The funny conservatism is that this is seems that I only drink two glasses of wine a night. And that that is equivalent 76 watts of power there is a funny guy he is quite a serious guy actually he runs a blog for wine aficionados called Dr. Vino he did a study of the carbon footprint or the energy consumed to deliver of wine anywhere in the world turns out if you live on this side of a line roughly between Chicago and New Orleans its more energetically favorable to drink wines from Sonoma County and if you live in New York you should drink French bordeaux.

So, more reasons to live in New York like you needed them, so anyway maybe I shouldnÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢t say that because I think local wines are much better than--I donÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢t like the French anyway. So, obviously I eat more meat or I use to more meat and fish than I should and that is the majority of the power considered to my life and everyone is probably aware that to create a pound of meat you have to feed it a lot of grain and so itÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s a pretty inefficient way to get your calories.

Surprisingly though the numbers for farming transportation and fertilizers so the transportation is moving that food around, the fertilizer is the energy in the synthetic fertilizers we use that is really just assuming that those are the US wide national numbers for those three figures and I have just assumed a one 300 millionth share. Very likely I have probably a better diet or more expensive diet it must be on the country so this is almost certainly an under estimate.

Speaking of taking one 300 millionth shares you pay taxes, your taxes get spent in all sorts of different ways so a number of government departments publish their use of fuel and electricity and if I took my one 300 millionth share of the US militaryÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s aviation gas and diesel bill thatÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s about 94 watts to keep all the silos warm thatÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s about 50 watts. The US government just to run all these buildings about 18 watts and your one 300 millionth share of NASA is 1 watt of power.

Hopefully there are some NASA people here, I would happily give them more of my watts. Get us out of here.

And then the US postal service use a little, this does not take into account all of the energy thatÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s embodied in the roads in the actual steel that makes the time etc, etc and will come that later. I also own an awful lot of stuff you can now see everything that I own. And so this comes to the issue of embodied energy so any item you own weighs something that itÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s made out of a material we know how much energy had takes to make those materials if you do very conservative assumptions for all of your objects you can figure out and you know how long those objects last you can figure out how much power they use. I own 11 bicycles so that little bicycle thing is not one but 11 but because my bicycles last 20 years and bicycles donÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢t weigh very much itÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s not a very big piece of my pie. You can see the cars my Honda, my wifeÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s Honda Insight that I sort of share and then a vintage Toyota Pickup and a very vintage Volkswagen thatÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s the red section.

Surprisingly, if you look at this and you think okay if I was to reduce the energy use of my life where should come from you go after the big pieces. You find interesting things so very big objects that weigh a lot even if they last a long time use lot of energy so your house your cars your boats the other unusual things for me are things that you get very regularly like the newspaper or detergent or washing powder or toothpaste, because you just get them regularly thatÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s quite a large portion of your power. And then the green section at the bottom is my furniture I think yellow is toothpaste, detergent, washing powder.

The purple section you should be thankful for because that means I am not standing before you naked thatÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s all my belts and shoes and clothes and the purple section I canÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢t remember I am sorry. The difference between this slide and this slide is that Kirk von Rohr, a designer who is hopefully sitting in the audience did this slide and I did this slide. Kirk is amazing if you ever have an opportunity to with Kirk von Rohr you should so this is actually my entire life. So 17,000 watts youÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢ll notice later in the talk that actually my new estimate is 18,000 watts itÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s because you keep forgetting that you do things that use power.

That big blue, green area are in the top right hand corner is your tax dollars at work and part of that goes in all of the energy that you saw previously for the diesel etc but lot of it is in unusual things like for example, if you did conservative assumptions of how much energy is embodied in all of the road infrastructure in the United States and you divide it by everyone and you assume that will roads will last 40 years the embodied energy in the road infrastructure is about 330 watts or 2% or 3% of the average AmericanÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s power consumption. Obviously the biggest--everything on the left hand side is basically my flying you can see my driving there so I wonÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢t beat this to death but you can--and it is in fact possible to understand how all of your energy is used.

So that was just me, this is me and my lady friend, you probably went to a high school with about 1000 people the same way I did you can imagine the 1000 people you live in a city order of magnitude a million people you can sort of imagine a million people you have no chance of imagining a billion people and thatÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s a really long and awkward segue into the demographics of energy use. So you would say Saul you used 18,000 watts is that a lot or a little? So you can actually use gross national data to get a per-capita power consumption by country for every country in the world. United States typically likes to think itÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s number one in anything at everything unfortunately its number ten behind Canada which are Americans who live somewhere colder.

I think I manage to offend 90% of the audience in one sentence I am quite proud of that. And then so there are some unusual things you know in Kuwait and Bahrain and Qatar, they basically burn oil to do air-conditioning all the time so those people to pretty high. Australia thatÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s my accent thatÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s in 15th place so you can sort of get a sense of the numbers of different countries and then the green line that IÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢ve put in there is the global average 2,200 watts is the per-capita global average. We might come back to this slide later but, so, the 18,000 watts I use really shocked me I thought I am a bicycle commuting guy who runs renewable energy company in hippie San Francisco I must be better than the average American, turns out I use about twice as much power as the average American.

So it was a little surprising and doing this process is incredibly illuminating for you. You can look at the historical increase in power consumption by country this is one of my graphics not KirkÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s. And I tried to put the maps in my last this is interesting a sort of yeah you know I couldnÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢t get all the little tiny ones. But, so America is increasing but not that rapidly compared to things like China and Russia which you can see up there and India. One of the most interesting things about this graphic is the big discontinuity in around, you know just before 1990 and that is the Soviet Union changing into lots of smaller countries. So this may be interesting politically.

How did the world make all of its energy and use it grossly in 2007 these are international energy agency numbers the majority of it was in producing electricity you can breakdown how we made that electricity by fuel type and you can see the scale there. Transportation was nearly all oil that was in second place you can sort of change these buckets around to mean different things but it sort of gives you a pretty good gross sense of how we use energy globally. So whatÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s the result of using all of that energy? It has lead to this problem this graph has been made by people who can fill every audience that they speak to and its going up so this is this the CO2 concentration as measured in Mauna Loa, a mountain top in Hawaii, and you can see the seasonal variation and you can see weÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢re now so I think at the last date appoint I have is 2003. I think we are now up to about 387 parts per million.

So youÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢d say well who put all that carbon into to the atmosphere I find this a particularly interesting aspect of the demographics. So you can sum the cumulative CO2 emissions from fossil fuel burning for every country in the world for all those that have kept statistics and it tells you this: of all of the carbon thatÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s in the atmosphere 90 giga metric tonnes or billion metric tonnes of that was United States so happily they are at number one position again. In number two is Russia, number three is China, number four is Germany you have to do some pretty weird political remapping of the data because Germany changed hands so many times in the 200 year data set etc, etc. But basically the first six or seven countries they have produced 90% to 95% of the carbon in the atmosphere.

So, in terms of who is responsible for solving this problem the evidence is fairly damning and I donÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢t think it leave you any choice but to figure who should act first and fastest. So, letÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s think about all the carbon this is the very, very cartoony look at where all the carbon in the world is. There is around about 700 giga tonnes of carbon in the atmosphere. We put another 8 giga tonnes of carbon this is not carbon dioxide but carbon if you want carbon dioxide numbers just multiply everything by 4.4. We put 8 billion tonnes of carbon in the atmosphere every year the oceans reabsorbs about 2 billion tonnes of that. We know how much carbon is in all the soils in the words thatÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s about 3,000 billion tonnes there is 40,000 billion tonnes of carbon remaining in the oceans. Both of those numbers are reassuring because there is so much there, there is a chance that we can take some of the carbon in the atmosphere and actually drive it back there. The scariest number on this graph is that the amount of carbon left in vegetation that hasnÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢t been burnt yet is equal to the amount of the atmosphere so we shouldnÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢t burn too much of that and the fact that there is still 1,600 giga tonnes of carbon in the ground.

Of the carbon that we burn is the atmosphere around about 55% seems to stay and linger there and thatÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s why you donÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢t sort of get 8 minus 2 is 6 going with the atmosphere you sort of ratcheting up by a couple of billion tonnes per year right now. Those carbon flows have resulted in this problem, this is the best graphic I have seen to very visually represent the temperature rises globally over the past 25 years so for every large red dot this is actually from the Stern Report in England. Every large red dot represents a one degree Celsius temperature raise per decade for the last 25 years. So thatÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s maybe 6 or 7 degree Fahrenheit in the last quarter of the century for every large red dot you see there, so be a little frightened.

All right, so here is my fantastic great question that I think we all really need to answer for yourselves really quickly, what temperature are we going to choose as the target for humanity this gets to the question of the statistics what type of life to we want to live on this planet that we have. So is it really terrible slide to try and if you could tell give you a way that you might think about how to answer the question of what temperature. So, there are climate models into those climate models are based on physics etc, we can actually they are actually doing a very good job of predicting the sort of matching historical data and predicting future data. With those models we can then come up with scenarios you've heard of scenarios, scenarios are where economists and scientists sit down and say if the world does this, how much carbon will that produce you feed that back into the climate model and it tells you what the atmosphere might stabilize at and after people have done scenario models then there are impact studies.

The impact studies are the climate signs to gets all the headlines the other thing is that say at 1Ãƒâ€šÃ‚Â½ degree Celsius that you can see on the left access here temperature we will loose 10% of all species. At 2Ãƒâ€šÃ‚Â½ degree Celsius we will loose 15% to 40% of all species so 3 degrees above where we are in 1990 is the base level, that 3 degrees above you will get 1 billion to 4 billion people facing water shortages you know 3Ãƒâ€šÃ‚Â½ it just gets worse and worse and worse. They are all the nightmare scenarios so basically you would probably like to say how far down you know how far up that list of nightmares do I wish to go before IÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢ve said enough and a lot of the consensus is being around about 2 degrees should be enough that will mean 100 million refugees

crossing borders I think the state department mobilizes troops if they hear of about 50,000 or
100,000 people crossing borders as refugees so 100 million means a lot of little spot wars around
the world anyway so 2 degrees you know the other problem with 2 degrees is might reverse the
thermohaline cycle which will disrupt the ocean's cooling mechanisms and throw Europe into an
ice age and everywhere else into hell.
And so okay letÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s stop painting the horror picture letÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s say 2 degrees is where you want to get
the consensuses is if we hit a target of 450 parts per million youÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢ve got about 30 percent chance
staying below two degrees. So you could argue that letÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s shoot for two degrees because 450
sounds achievable and letÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s cross our fingers and hope that if we hit 450 it really is 2 degrees.
But to give you an idea of how long IÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢ve been giving this talk which is about a year the really
encouraging thing to me is a year ago it was scandalous to say 450 parts per million because everyone
like that seem possible thatÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s too low their consensus was 550 but fortunately Jim Hanson has
been out Jim Hanson from NASA being AmericaÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s leading climate scientist and he has manged
to get into the public dialog with 350 parts per million is the correct answer.
He has a much better way of arguing for 350 than I did in the last slide arguing for 450 he says
humanity evolved you know world that had always less than 350, if you want to have any world
that looks like what we evolved in letÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s stay below that I think thatÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s probably pretty wise words.
Well letÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s go back to 450, and assume thatÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s what we are going for and we are going to accept 2
degree temperature raise, what do you have to do? One way thinking about it is if kind of got
balance this equation youÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢ve got have about the same amount of carbon going into the
atmosphere every year as this being sucked down into the oceans. This is still not a rosy picture
because if you putting that carbon in the oceans you are increasing ocean acidity and that has bad
effects on fisheries and coral and all the rest but still cross your fingers, this is a better picture
then just going off the charts.
ThatÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s not an entirely--again this is a Kirk slide this is a Saul slide--what IÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢ve just presented to
you is not entirely an accurate picture because really weÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢ve carbon dioxide going in the
atmosphere its more about, its about how much carbon we can burn anymore right and so this is
sort of this actually a guy called Jeff Koomey did this work in the 80s, this is 20 years old this
was a very simple model that is largely still valid for understanding what affects putting a billion
tonnes of carbon into the atmosphere has on the parts per million concentration of CO2. So if
you put a billion tonnes of carbon in the atmosphere you get about .26 increase in the
atmospheric concentration or if you make one terawatt of power for one year using coal it
increases the parts per million by .2 for oil you can see it's .15 and gas is a better fossil fuel again
at about .11. So we are at about 380 to 390, weÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢ve got about 60 parts per million to go to get to

450 that means youÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢ve got about 400 terawatt years of fossil fuel burning. 400 terawatt years is a measure of energy it just sounds like power what does that really mean that means you have got about 40 years of 10 terawatts of fossil fuel burning or about 20 years or 20 terawatts to stop at 450. All right, so I have now sort of tried to ask a question okay you know if you have got to get the carbon going into the atmosphere down to one or two giga tonnes how much power could humanity get it turns out you know we have chosen two degrees we are shooting for 450 we understand where the equilibrium point will be you will only get two to three terawatts of power from carbon fuels to drive humanity if you want to stabilize at 450 if you want to stabilize at 350 it looks like zero so it turns out that it doesnÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢t make a lot of difference anyway. So hopefully you are now asking yourself well how much power does humanity use it turns out we use quite a lot some people say we use 18 terawatts thatÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s because they count all of the plant matter in the world and its various uses agriculturally and in burning for cooking etc if you ask the International Energy Agency that will say itÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s 15 or 16 terawatts because they pretty much count the more traditional fossil fuel sources I guess more recently traditional to be correct all right how do we use it this is how the world uses its power in terawatts all right so thatÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s obviously not going to last a ten thousand years so I told you we can only really burn two to three terawatts worth of fuel if we want to stabilize at 450 and have that sort of aesthetic world and this is telling us we want 16 terawatts to power humanity. So thatÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s not going to last what are the other options so how can we produce this 16 terawatts of power for humanity without putting too much carbon into the atmosphere this is the only slide that you need to remember in my talk this tells you this is basically the play book for humanity so in the top there we have 85,000 terawatts of sun coming in so thatÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s the amount of power in solar energy thatÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s hitting the surface of the earth at any instant you probably heard of numbers of 170,000 terawatts thatÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s what hits the outer atmosphere thatÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s the principle input we also get a little bit input from space in the form of tidal energy from the moon so as the moon goes around the earth and makes the ocean lift up and down thatÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s tidal energy the scary thing about that is if we built a 100% efficient tidal machine it would and we flattened all of the tide so they no longer went up and down you would only be powering 1/5 of humanity today. So itÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s not going to scale similarly we have coastal waves if you put 100% efficient wave collector around every coast line in the world you are only going to get about 1/5 or 1/6 of humanityÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s power supply so when someone submits you a business plan for wave power and says wave power will save the world you say wave power might save some cities in Northern California in the Bay of Fundy but it doesnÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢t scale to humanity. One of the sources of power that does scale the humanity is wind power thatÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s the second largest after solar there is 3,600 terawatts of wind thatÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s why I work on winds specifically high altitude wind we need to we

need
to figure out how to get at that. It turns out we know that the Hoover Dam is awfully powerful you might ask how many Hoover Dams are out there if you collected every rain drop as it hit every continent on the world and you ran all of those droplets of water through the Hoover Dam you would only get 25 terawatts if you waited for all of that water to get into river you only get 7 terawatts.

Surprisingly you know we hear a lot about bio-fuels what happens if we took all of the photosynthetic activity on the planet that means every mangrove every grass land every tree and we burn them every year and let them re-grow you will only get about 90 terawatts of that 90 only 65 is on land so to fully power the humanity with bio-fuels you would have to take one quarter of all the photosynthetic activity on the planet. There is some heat in the ocean you could extract ocean thermal gradient you donÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢t really want to screw with that as we are already screwing with the ocean currents there is also geo-thermal so geo-thermal is a hard one to express the renewable flux of geo-thermal is about 32 terawatt so thatÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s the natural rate that comes out of the earth you could extract that faster but you would be cooling the rocks faster than they replenish so that gives you the picture all right so what is the challenge humanity uses 16 terawatts you know we can only get two letÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s be generous three terawatts of that from fossil fuels we have got about one terawatt of nuclear today and about half a terawatt of hydro so you get one and half there so the new clean energy we need to make in the next 25ish years is around 16 minus 3 plus 1.5 so we need about 11 and half terawatts letÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s take a wild guess at how you might do that and in order not to offend anyone in the audience, I'll just make it fairly equal. We will do two terawatts of that with photovoltaic two with solar thermal two with wind two with geo-thermal three with nuclear and we will give half a terawatt to bio-fuels so that would actually be your 11 and half that sounds easy that sounds doable there is probably a lot of engineers in the room you just wanted to say well how fast do I have to build it and what do I have to build its pretty easy to do two terawatts of photovoltaic in 25 years and letÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s assume they are really good ones 15% efficiency thatÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s about a 100 square meters a second every second for 25 years so thatÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s probably every five seconds you have got to cover this auditorium with solar cells that gives you two terawatts out of your 11 and half for solar thermal you can get 30% efficiency if they are well sited thatÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s where you take a mirror and you heat up a pool of water or preferably a molten salt and then use that heat to drive generators steam or otherwise you need to install 50 square meters of mirrors every second for the next 25 years in terms of wind turbines you need to build 12 three megawatt wind turbines every hour so a three megawatt wind turbine is the largest wind turbine you have ever seen its about the size of this whole building in diameter it is about 100 meters in diameter.

So basically the other way to express that is roughly one every five or six minutes to get your three terawatts of nuclear power this is to be ambivalent about the political aspects of that you need to do one three gigawatt nuclear plant every week for the next 25 years I think the US has 8 or 10 slated for approval in the next decade so we are just a little behind schedule but I am sure we will pick it up with the Obama administration. All right geo-thermal two terawatts of geo-thermal thatÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s basically three 100 megawatts steam turbines every day for the next 25 years so 100 megawatt steam turbines probably the size of this room but it looks more like stainless steel and this is not counting the holes that you have to drill to do that. All right and just for kicks letÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s get our last half terawatt of bio-fuel so we can fly jets itÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s an Olympic swimming pool of genetically engineered algae thatÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s four times more efficient than the best genetically engineered bio-fuel we have today so we are being a little ambitious technologically but I assume we get that and you need to fill one of those Olympic swimming pools every second for the next 25 years then someone will say that cements really bad because cement we know that cement produces a lot of carbon letÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s not use that so letÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s not make swimming pools why donÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢t we just fill in a natural land formation it turns out this would be Wyoming I think so I didnÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢t mean to pick on any of the Wyoming people, I could've just as easily said New Zealand yeah all right so then you would say okay thatÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s pretty scary those sound like really big numbers is that at all possible industrially or in another way to phrase that is what should Detroit actually do all right well this is not really a Detroit question this is donÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢t tell Coca-Cola but this is the killer business plan for the 21st century. So Americans drink 110 billion cans of soda every year aluminum cans if you cut all of those aluminum cans in half and you flatten them out and you polish them as nicely as aluminum can you made them into mirrors that represents 200 gigawatts of solar thermal capacity every year so Coca-Cola is going to return to its original business plan of selling you really concentrated packets of sugar then they donÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢t have to ship the aluminum around and they just going to take their reserve aluminum capacity and in 10 years Coke and Pepsi will make two terawatts of solar thermal thatÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s awesome problem solved. Nokia again I think when I first made this slide Nokia in fact only made 9 phones every second I think they got to 12 I suspect next year it will be not 12 Nokia, Intel, AMD, Apple if you took all of them in their industrial plant they can probably do thatÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s roughly the scale to do this sort of the photovoltaic required GM yeah slides are really out of date GM used to make one car every two minutes they used to make one transmission every one minute General Motors and Ford together you could argue may be will make one wind turbine every five minutes so itÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s not impossible I think this a good example when we were retooling for World War-II in the United States they made 300,000 aircrafts I think they are making one or 2000 a year up until 1939 in between 1939 and 1945 they made 300,000 aircrafts. So aircraft its roughly the size of the wind turbine 300,000 wind turbines that would be close to half of the American electricity grid okay so not impossible at all but itÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s you know people say this is a Manhattan project this is an Apollo project sorry they are science project fusion is a Manhattan project or an Apollo project right we want fusion to come true but the rest of this is more like retooling for World War-II expect the Germans the French the British the American and the Japanese are all playing on the same team certainly doable but we have to think a little more like that so this is okay I have got all you depressed this is a super optimistic slide all right so what does this tell you in 1965 the planet was using was able to generate 5 terawatts of power in 2005 we were able to generate 15 terawatts so in 40 years we install 10 terawatts of generating capacity right 10 is not much different to a 11.5 there is precedent it is industrially possible.

So there is a note for feeling optimistic okay awesome we can do this but if you are thinking in the Long Now sense of the word you might want to think ahead because what we are about to do is in fact and indeed pretty awesome so what might what other things you might you consider and this returns to the question of why would you measure things in watts instead of carbon because we use watts you can do things like figure out you can translate into land area so how much of the planet are we going to use to build this engine to run us so for those particularly observant people in the audience you have just noticed that I say that the incoming solar flux to the earth is 1270 that is wrong I will tell you advance its 1,366 it doesnÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢t really matter anyway because thatÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s about how much power comes into the upper atmosphere we lose some in the atmosphere due to reflection obviously you lose 50% of it during day and night you lose some with clouds and with whether you lose some with geography and latitude and globally the average power density the solar flux is 90 to 300 watts per square meter and we have photovoltaic and we have solar thermal and those can have technology efficiencies between 10 and 40% itÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s unlikely that we are going to get ever get any of those about 50%.

So this is pretty good range and if you take all of that and then you also compensate for the fact that you donÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢t when you lay solar cells down you donÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢t cover every square inch you cover maybe 15% of land with solar thermal you really only cover 25% because you track so the actual solar energy influx to electrons gives you about 10 to 20 watts per square meter of land we may do twice as well but we wonÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢t do 10 times as well so keep that in your head 10 to 20 watts per square meter for wind turbines 100 diameter wind turbine is three megawatts is a capacity factor because the wind doesnÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢t blow all the time thatÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s typically 33% so a three megawatt wind turbine really gives you about a megawatt averaged over the year we space those wind turbines 10 diameters apart and 10 deep typically sometimes they can be three by eight.

So if you take that megawatt that we get and the kilometer square that we have you get about 1 watt per square meter may be two watts per square meter of land use hydro electricity I didnÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢t really know how to do this numbers so I cheated and I just said whatÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s the area of Lake Mead, the feeder to the Hoover Dam itÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s 639 square kilometers Hoover damÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s couple of gigawatts you get about three watts per square meter for hydro electricity thatÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s a map of the Hoover dam itÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s not an internal organ just incidentally bio-fuel so if you filled Lake Mead with 3% efficient bio -engineered algae and I mean filled it so you could basically walk on this algal mat, it will still give you about two or three watts per square meter so here is Saul's map of the world the land masses of the world are now square what you can see here this is actually every country in the world represented as area.

So that the largest land area is in fact Russia and you know so thatÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s it China is in second actually I have to now recant that because an angry Canadian insulted by my first comment last time I gave this talk he said Canada is the second largest country in the world it turns out thatÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s true then you know you can see this top six countries Russia, China, Canada, USA, Brazil, Australia they are pretty big in terms of land area so I would like to invent a new country called Renewistan, Renewistan is 10 terawatts renewable power two terawatts of wind five in solar one of hydro two by bio-fuels and itÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s about this big so Renewistan it turns out is the 7 largest country in the world so what does this say to you it says we're engineering machines that are country sized as we endeavor into this clean energy future and you want to probably be very careful you want to use the most efficient technologies by land area because if you use 2% efficient solar cells instead of 15% efficient solar cells that stripe becomes bigger than Russia for example so choose carefully there is another way of expressing that so this orange area here this is the land area of per person in the USA this lighter orange is land area of per person globally at square a 140 meters by 140 meters for my personal power consumption if I had those 15% solar cells I need a 41 by 41 meter solar cell to run my personal life that is a lot larger than roof on my house.

So please install solar cells in the roof of your house itÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s a great idea but just donÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢t stop all right put them on your neighborÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s house put them all over the place paint the streets with them the average US citizen is this green one and this is sort of 15ish meter on the side square that is the land area required for the average global citizen all right so you are got to choose carefully you got to act quickly it is possible and you have to be a little wise and you have to think couple of steps ahead or you can make mistakes in this challenge.

All right so letÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s come back to putting ourselves in the picture so you now realize that the 18,000 watts or 17,000 watts in Saul GriffithÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s life looks a little like extravagant because if everyone in the world went from 2,500 watts to 18,000 watts suddenly we are not going to need to have just Renewistan we are going to need that 6 or 7 Renewistans all right thatÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s not going to scale. So itÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s inevitable that China and India bring their power consumption per-capita up and probably we shouldnÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢t begrudge anyone in the less developed nations to do so and that sort of means that we have to go down this is what a lot of people talk about when they talk about efficiency my personal pet favorite hate is people who stand up and say efficiency is the biggest energy source we know efficiency is not an energy source efficiency is using less energy itÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s a lot more like abstinence then being energy source.

All right so this is my old life so we remembered my old life itÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s you even know how many watts it takes for my underwear this is my new life so I am going to shoot to be roughly at the global average 2,291 watts how would my life change to do that all right so this is my new route map my airline is got to strictly change thing I know get to fly once per year to the east coast return once every three years I get to fly to Australia to visit my parents once every five years I get to go it looks like I am flying to France but I think I want to go a little further and go to Italy once every ten years I get to go to Hawaii to go surfing that will still be 983 watts grossly half of my power consumption this is assuming again that I am flying fully loaded 747 I now get to drive quite a lot less 6 times a year I get to drive to Sebastopol in a 55 mile per gallon Honda twice a month I get to drive the same 55 mile per gallon car to Alameda where I work both times I am going to be carpooling once a month I am carpooling in a van with four people to go visit it looks like Google and then twice a year I get to take my Dune Buggy out to go surfing now obviously you know that I am lying, because those of you know me will know that I will go to Sebastopol twice a year to see my in-laws and go surfing 6 times.

So this is obviously a lot less driving then circumnavigating the country I now call myself 6/7 vegetarian I canÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢t kick the habit completely so I tried to eat very good meat once a week instead of bad meat all the time obviously I am lying when I tell you I only drink one glass of wine a night so this might be the really hard thing to do and the only value in my new lifestyle went up is vegetable use in terms of stuff I just have to own less stuff and make it last ten times as long or sometimes I call this the Rolex and Montblanc pen approach to life. So that just made me sound like a pretentious wanker. I am really not I am a deep green environmentalist and what you want is when your child is born or when you are born to be issued with a Rolex and a Montblanc pen and thatÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s the only writing implement the only time piece you get for your whole life. All right so we solved just now for writing and time reading but how about cell phones.

So I think this is actually kind of great challenge right how do you make the first company that makes the cell phone that will last a life time totally wins. That will be the most amazing for everyone in the audience who just got laid off please go and start a company to make a cell phone that lastÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s 100 years that would be the best thing you can do. All right I am not sure why that slide is there, how that was point about. Oh okay, now this is every business model you need for the next century pick any piece of that pie do it with 1/10 amount of power or make something that will last 10 times longer and you have just done your bit to save the world this is when people talk about the green economy you know a quarter of energy we use is just in our crap just go after this just take any one of those things and make it a better product. Ironically we use to have drinks in the fridge at my energy company called energy drinks they have a nutrition label that we use to seeing and ironically we have you know 2000 calorie per day diet is what we aim for if you weigh the plastic of the container of that material just assume that the water in it the sugar comes for free but just the plastic in the bottle and the lid and the cellulose and the label if you weigh those up and you figure out the embodied energy to make that and how much it would take to refrigerate it and to transport to you if you had a 2000 watt lifestyle drinking one of these per day would be 4Ãƒâ€šÃ‚Â½% of your daily value I think you would look at every product you ever consumed extremely differently if we had this labeling on all products I am sure you would choose a glass of wine each day rather than... At least I would.

All right so itÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s all possible and we have to think pretty radically different and hence it is pretty obvious that we have to change our lifestyles but we forgot a couple of other things which is possibly the hardest part of this entire project is going to be to turn off the current carbon dioxide emitters so historically when we figure out more efficient ways to do things we just use more of it so as we bring new power plants online that are renewable the temptation is to leave the old ones running you just canÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢t do that and the other very difficult thing to do is to stop deforestation so deforestation you know produces 10 to 20% of the CO2 in the atmosphere so you obviously have to bring a halt to that or the entire project just laid out is sort of lost now here is a super encouraging slide this is one of the more optimistic ones so this is a graph of the energy consumption of the US over the last century and it turns out that we have a fantastic technology for lowering power consumptions and you can see the first experiment in that was the Depression worked great during the oil crises awesome during the recession and then for the six months after September 11 when we didnÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢t fly very much we also did pretty well.

So I am really, really excited to see 2008 and 2009 energy consumption data because I am a numbers nerd and to see how it fits on this map so you can make light of this situation the good side of a down economy is the using less energy the bad side is as we are attempted to invest less into renewable energies and the solutions that we need obviously we should think carefully about our priorities and then obviously we also need to think about what happens when we come out of this economy right you donÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢t want to go straight back to the old work we should use this as the nucleating instance to figure out how to keep the trend going down if we had the sort of the downwards slope of the 80s recession or the 30s depression starting today that would be roughly the type and we just sustain that slope that would get us to our target.

So we need to figure out how to do that while improving quality of life and thatÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s to the aesthetic question in the Montblanc Rolex question so if you are living in this 2,255 watt world you have to think pretty differently the temptation is I will go and by my 100 mile per gallon equivalent Tesla and its all solved. It turns out if you had a 100 mile per gallon car you get to drive that for about 20 miles per day and that would be 500 of your 2,250 watts 20 miles per day is less than you are driving today so the average US person is about 40 miles per day so if you are driving half in a 100 mile per gallon car itÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s still quarter energy so you know that makes you think twice about that and is 100 miles per gallon really ambitious enough, this is the CitroÃƒÆ'Ã‚Â«n Deux Chevaux the French President went to Boulanger who was the designer for CitroÃƒÆ'Ã‚Â«n and said in 1932 can you design me a car that will carry four peasants to market plus their eggs it has to drive over an unplowed field as to do 60 kilometers an hour and it should get he expressed it 3 liters per 100 kilometers.

So Boulanger went away and in 1938 returned with this, the Deux Chevaux and indeed the Deux Chevaux had originally shipped with an 8Ãƒâ€šÃ‚Â½ horse power motor and could get 75 miles per gallon so these are 100 miles per gallon target 70 years after that really ambitious enough no why was this car efficient it was slow and it was really, really light weight the seats were hammocks, it had a cloth roof and it was dangerous so to that point one of the best thing that we could to instantly to make it really big dent is to reduce the speed limit and what would you reduce it to 55 was one shot probably you want to go lot further than 55 and it might sound shocking to reduce the speed limit just as the point of note the average speed of travel in any city in the world of more than a million people in a commute hovers between 9 and 12 miles per hour I suspect if you slow the traffic down you would increase the speed of commuting just because there will be less screw ups.

So I had an intern this summer I made him drive in circles on a runway and he had to do 100 miles at every speed you saw here it turns out the funnier aspect of this story it was three days he had been there whole summer and just wrote boring code whole summer and he was like a code writing robot and three days in the summer, I wanted this data point I went and said I would really like you to do something its little ridiculous he says well I had been really hoping that I got to do something ridiculous you donÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢t want to go back to school without a stupid story I said I want you to drive in circles for three days he says awesome and he says I learnt to drive stick last night which just makes my wife nervous is in the audience because itÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s her car and its stick and anyway so as he bunny hopped out of the driveway yeah so we had to remove the first few data points, anyway so the optimum speed to drive this particular car is about 30 miles per hour and you get 85ish miles per gallon.

So I think lowering the speed limit thatÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s a point there or do this even better do this I think electric motor scooters thatÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s the other thing if you are not making cell phones that last 100 years please make electric motor scooters all right so you might ask me okay Saul for a year now you have known all this data and you are trying to reduce the power consumption in your life how did you do? Well I did about 17 or 18,000 watts of power in 2007 I think this year I will use about 12,000 and my life has only improved so far so I am eating less and definitely more healthfully. I am exercising more doing more commuting by bicycle I am spending more time with my family by traveling less finding that living closer together with your friends and work people certainly helps I am doing a lot less business travel which is great business travel actually sucks higher quality better design products itÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s a really nice filter on your purchasing consumer self to just say I will only buy good things because you canÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢t afford many and so thatÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s totally working for me less junk in my house the house is clean because there is less crap and you know hopefully if we are all doing this we are breathing cleaner air and drinking cleaner water.

So I think there is a reasonable argument to say that we can have much higher quality lives while we sort of hit the goals we want here the one thing I didnÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢t mention here is I could have really reduced my power consumption for 2008 by another three or four thousand watts if I stop paying taxes now who knows how well we you know the US Government apportions the tax dollars but I suspect if I were running the show I wouldnÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢t spend the power on behalf of the citizens as it is now and its fairly serious point that we actually should be lobbying government to use the power that it uses on our behalf a lot better than it actually does and roughly imagine what portion of your salary that you pay in taxes thatÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s grossly the portion of the energy that the government decides on your behalf so finish with the obligatory photo of the world oh okay now thatÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s later.

All right so thatÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s it and I guess there is going to be hard questions thank you, oh actually I have called you up here too soon. You can stay around. So everyone is probably wondering why on earth did Saul bring his IV drip, so this is to illustrate a point a lot of the math that we put into making this presentation there is a fantastic guy called Raffi Krikorian and his crew at Synthesis Studios in Boston they have turned that into a website called Wattzon.com and you can go through and enter in your data itÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢s like a carbon calculator on steroids except it uses energy and once you figured out how much power you use and I am up to 18,000 watts you can say for example visualize for me you can do me versus light bulbs or how big is my personal wind turbine or how big is my solar panel but I happen to like the one you versus oil and if you look at my life if oil and in pints per day I am in bad I am in 90 points of oil per day person so this used to be a pint of oil imagine that is full 90 pints a day basically means that I am using one of these every 15 minutes to support my life all right so the average American is using one of these every 20 something minutes to support their life so I think when you reduce it to these terms you remove the invisibility of you know we donÃƒÂ¢Ã¢â€šÂ¬Ã¢â€žÂ¢t typically see how energy is produced or used but if you imagine it this way, you really get visceral feeling for just how quickly your addiction is. I think the joke here is this is jammed and my arteries are finally clogged with oil anyway so Stewart.