**Introduction to System Dynamics Modeling**
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**Lecture – 25.1**
**Modeling Example**

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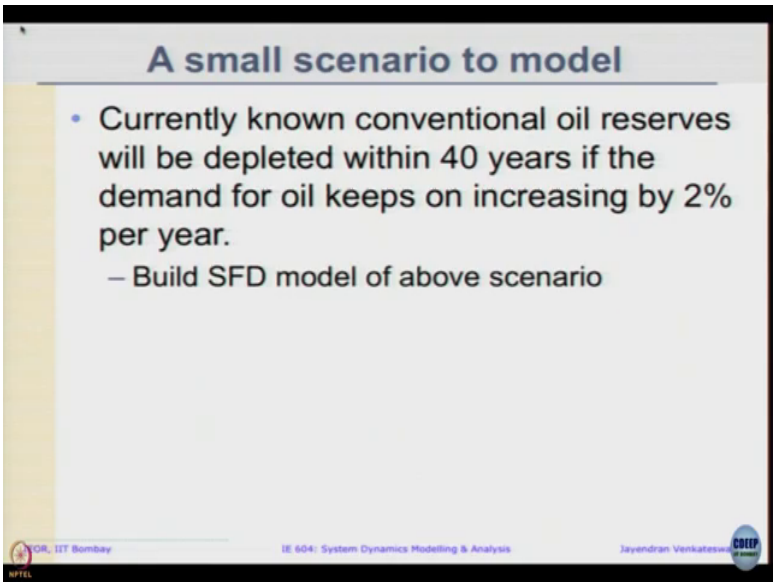


Just to test ourselves and our knowledge, let us try this simple one; not a very compact one. Suppose this is a description currently known conventional oil reserves will be depleted within 40 years if the demand for oil keeps on increasing by 2 percent per year. Can you build a stock flow diagram of this? The thing about description is it is very less first. Firstly, it is very less description. You can read it again, not much to read just one sentence right. There is some oil reserves which will be depleted within 40 years if demand for oil keeps on increasing by 2 percent per year.

So, there is some oil reserves, there is some demand which also keeps changing and we know the total time that it is to be depleted that is the 40 years right. So, if you ask if you want to build a kind of a model furthers, we need to ensure that the model actually the oil will deplete in that particular time. So, let us model it and see.

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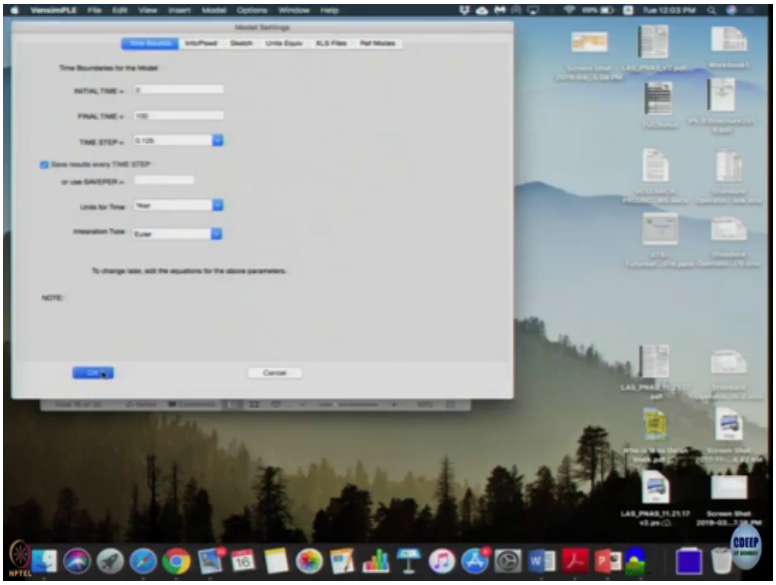

Let me just keep a small type structure just in case right. Here the only thing I know is the description said years.

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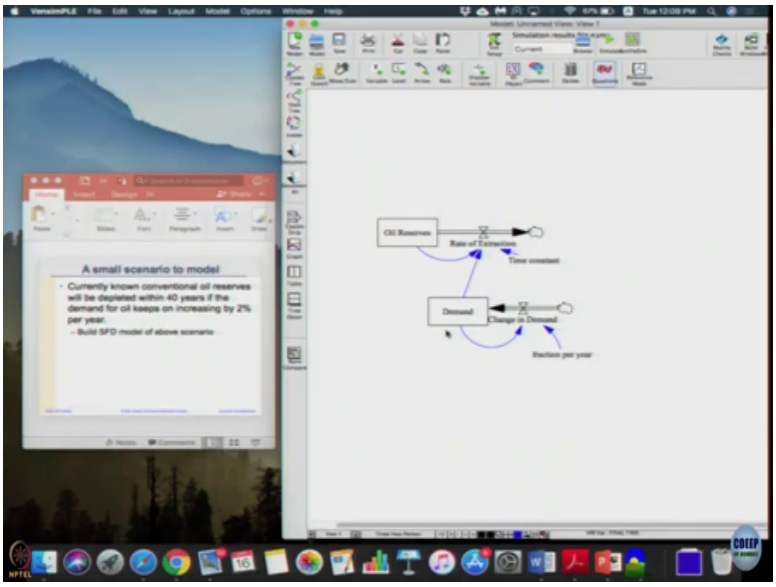


So, let us just take it years, let me have the description by here. Oil reserves will be depleted within 40 years if demand for oil keeps on increasing by 2 percent. What is the stock? Any suggestion for a stock? Oil reserves, the physical quantity there can be a stock. So, let us just put oil reserves. So, then this has to drain right meaning, we have to keep removing from this reserves. So, then there has to be a rate ok. So, let us call it extraction. I just modeled it as a just oil reserve and rate of extraction you ok.

Now, usually you would have put suppose rate of extraction would be affecting the demand, but now we got a information that demand is also increasing at 2 percent per year right. So, how do we model the quantity which keep increasing? Suppose when you say population increase a 2 percent per year, what does it mean? We have population stock on the net flow in

such a way that population; it is going a 2 percent per year right. It is not a linear; it is going an exponential thing, but perhaps we can consider that for demand.

So, let us define demand and then change; this change in demand; demand is changing 2 percent per year. So, this is fraction per year. So, demand has to increased by 2 percent per year.

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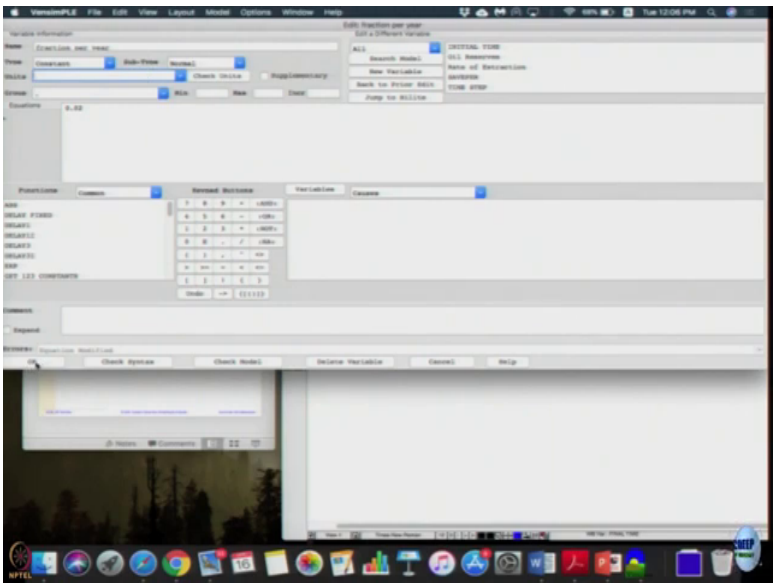

The way we need to model or we know how to model, it is you can give the fraction per year as 2 percent 0.02.

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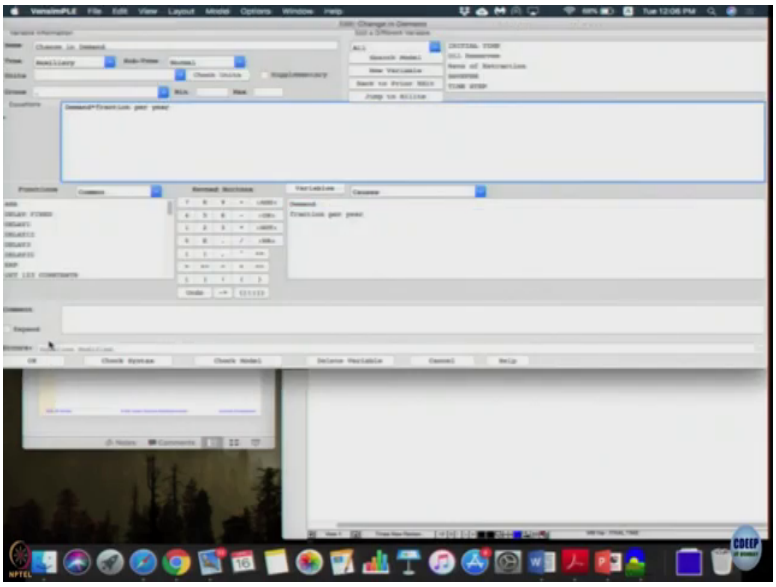

Change in demand is 2 percent of the demand. So, I will just multiply these two. Now I got change in demand. So, it is going to increase right and you can make a simple assumption that this demand, it is going to effect the rate of extraction and I can only extract until oil reserves fall down. It just says that oil will be depleted within 40 years. So, once it is depleted, I cannot extract any more.

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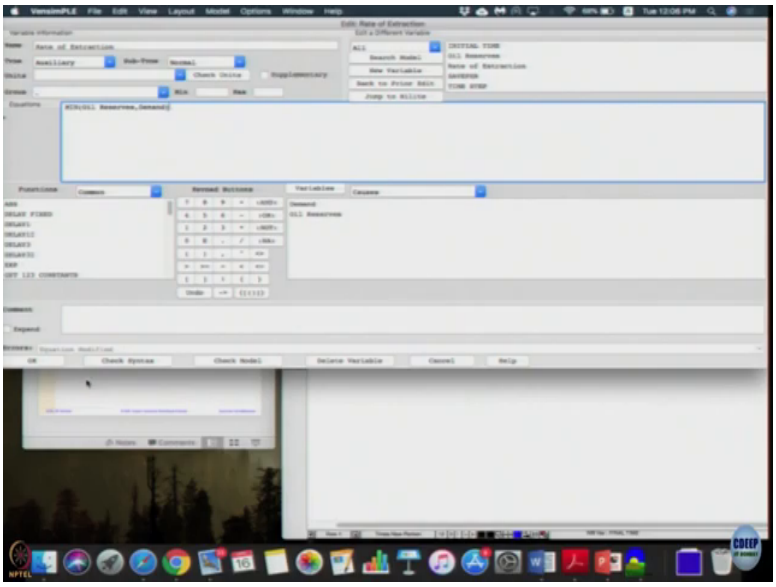

So, then the rate of extraction can be minimum of oil reserves and demand.

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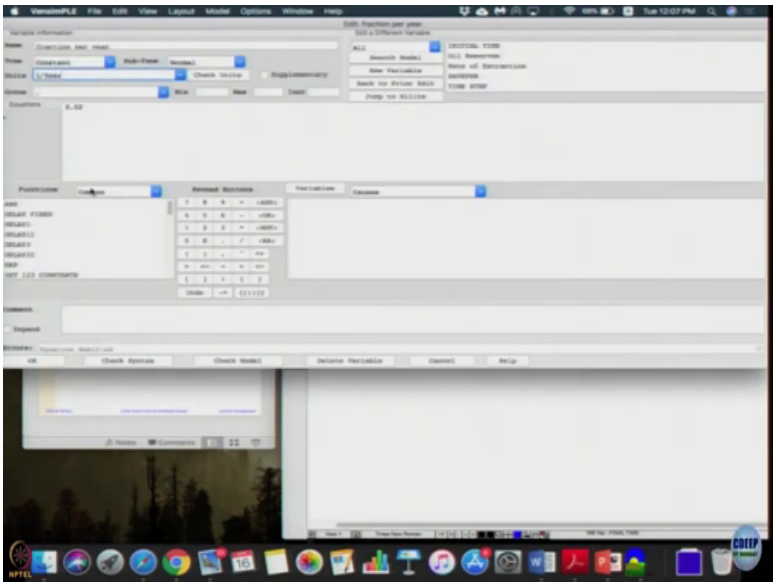

Let us just model it down. I have let us introduce units; let us make it fraction as 1 by year.

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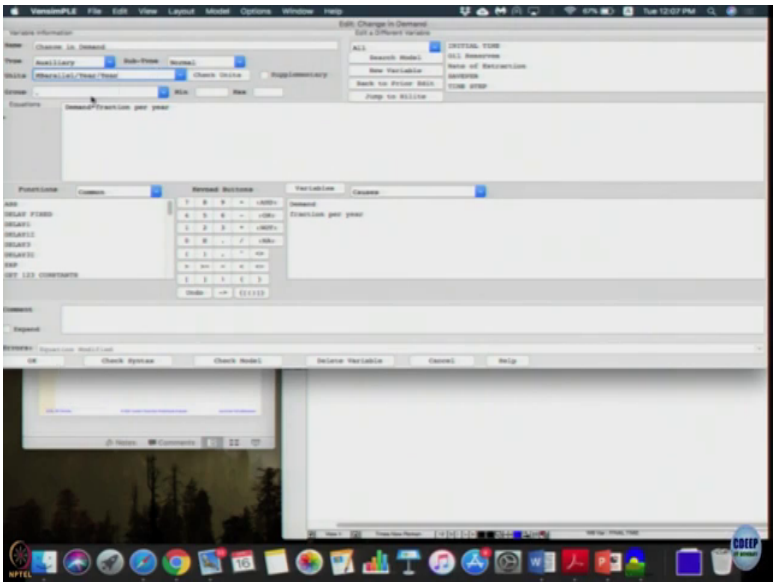

Change in demand will be a what you call, what is the units for oil reserves? Million barrel million barrel per year per year; demand is million barrel per year. Initial value I do not know, let us comes to that.

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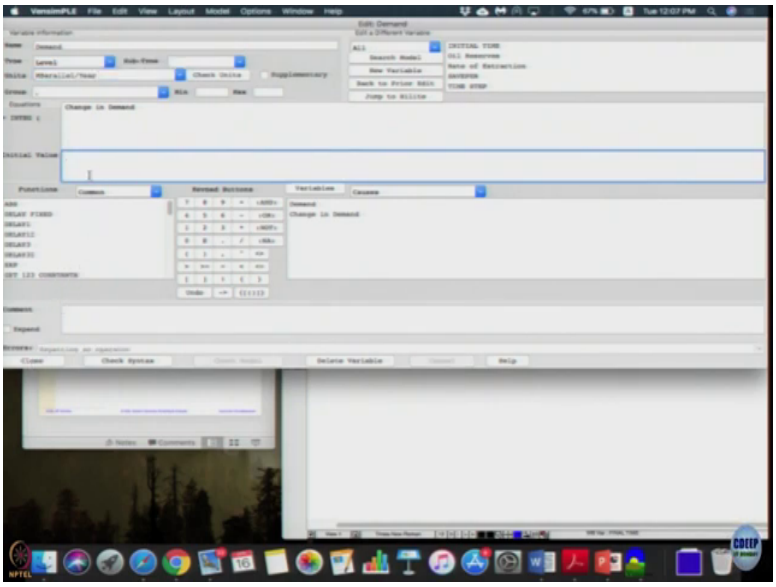

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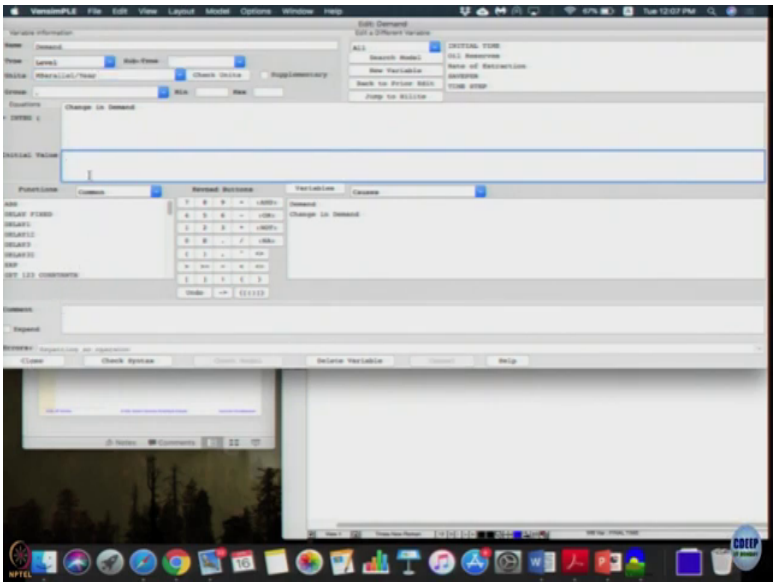

It is an rate of extraction becomes; so, I need a we will assume a simple time constant of 1 year every year because it will take an annual demand.

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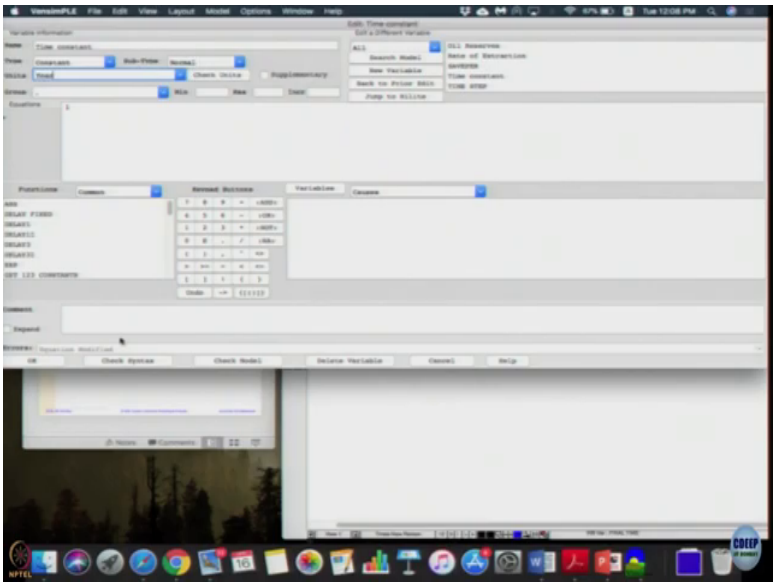

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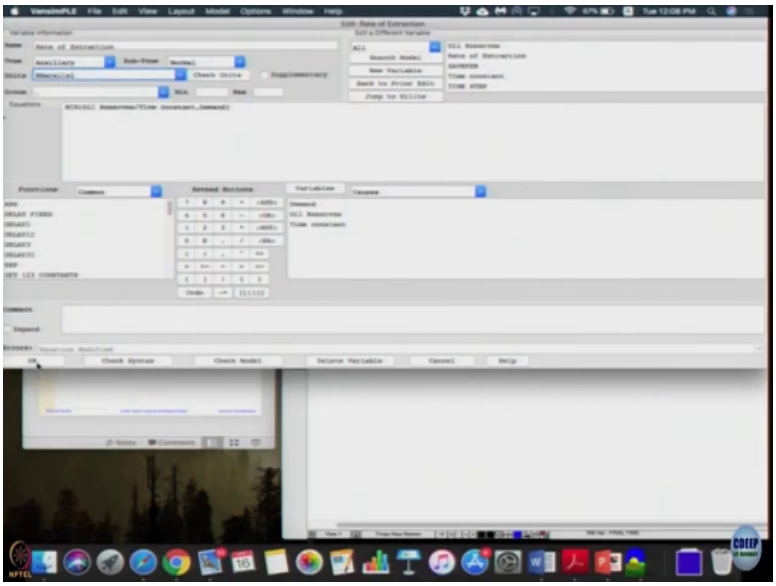

So, let us take a time constant of 1 year just to ensure my units match here ok. Even if you did not do time constant it is. What you did here is change in demand is demand time fraction per year, rate of extraction is when you have oil reserve and demand that is it that is all. This others are only for unit this thing.

So, what you assume for oil reserve and demand? Here what tell me some initial values? Start some arbitrary initial values, we can start we do not have anything else. So, let us just start. What do you want? Oil reserves how much?

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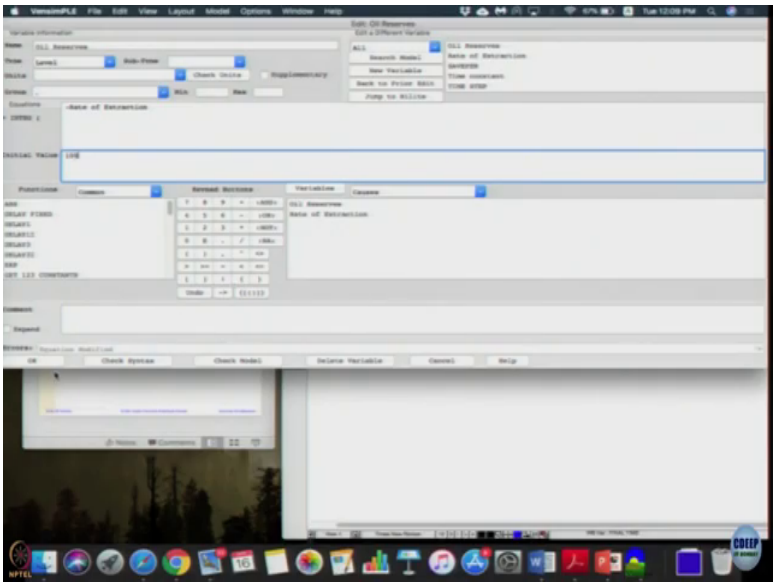

We take up numbers which are easy for our maths right. So, let us just take a 100; let us just take 100 whatever 100 million barrels of oil is there.

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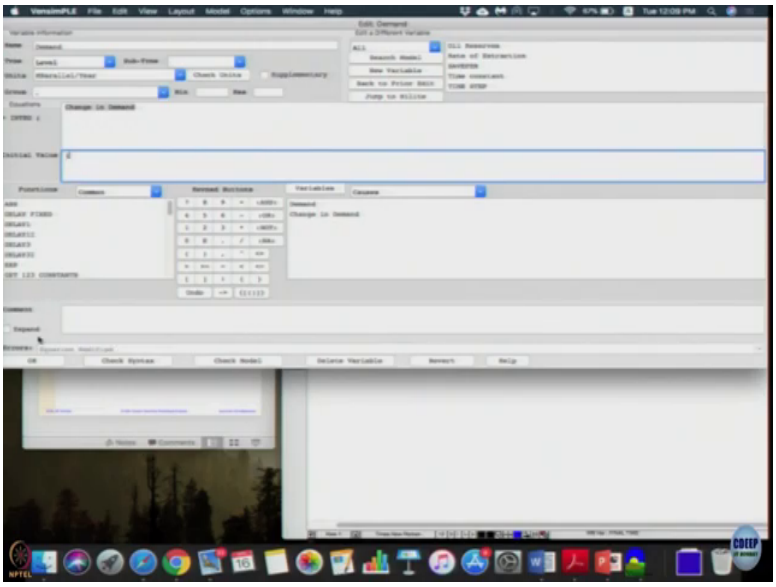

And let us suppose demand is say 1. Why to take complicated numbers when let us just with do 1 right. Now, without simulation itself we can actually do some things with it. Imagine if demand is always one constant, demand is one constant, oil reserves is 100. So, then it will take 100 years to deplete that is not the case we want right, but now 1 is also increasing at 2 percent per year right; 2 percent per year. Then from 1 unit to what will be its doubling time? 0.69 divided by 0.02 0.50 say 0.7 into 50, 35 years ok.

So, what we did was the doubling time for demand say demand from 1 unit to 2 units, it is going to take 0.7 divided by the fraction; fraction is 0.02. So, 0.02 is nothing, but 1 by 50. So, we are multiplying by 50; 50 times 0.7 is 35 right. So, above 35 years, it will take for 1 to become 2 right because, suppose it is always 2, then the entire thing oil reserve can finish in

50 years right. Now, on an average, now we have 1 to 2 it went in 35 years right. So, on an average for the 35 years, it was 1.5 million barrels per year.

So, 1.5 times into 35 will come to 35 into 1.5; 35 slightly around 50 54 million barrels would have been finish still I have another 50 million barrels to complete right. So, that will also take some time. So, again what you are trying to figure out is when the oil is going to deplete that is what you are trying to figure out. If it is always constant 1, it is going to take 100 years; if it is going to constant 2, it is going to take 50 years; if it is constant 2 million barrels have here that is the rate at it goes, then 50 years it will 100 barrels we will finish. But constant was 3, then it is going to take 33 years which is less than our 40 years what you want is 40 now.

Now, we do not have it constant ours is increasing ok. So, instead of figuring out how it is increasing by just figuring it ok; 1 to 2, it goes on average of 35 years. So, the average during the time is 1.5 litre so, but first 50 will finish in 35 years. The next 35 years the average is between 2 to 4 right. The next 50 years, average is 3; next doubling time next 35 years its average is 3. So, in that case it is going to take much longer to it will take 35 into 3. So, it should take about another 35 plus another 17 years to finish. So, 35 plus 17 comes to more 54 years to exhaust our resources.

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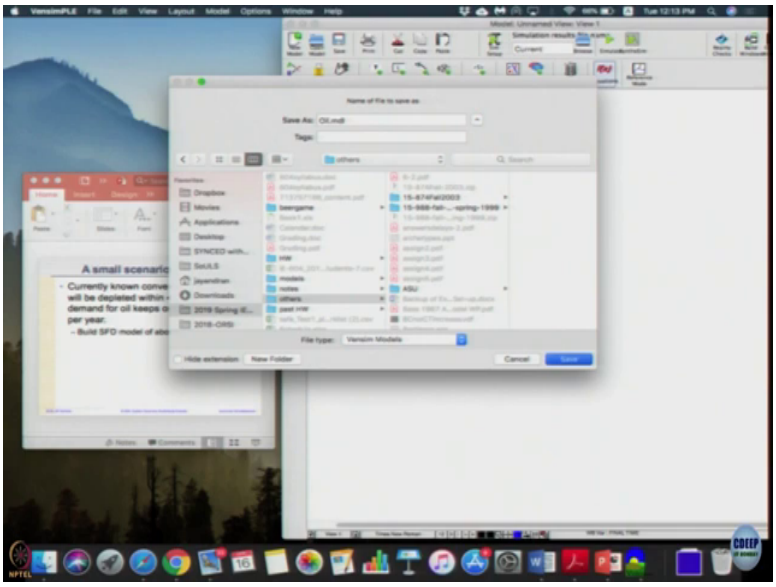

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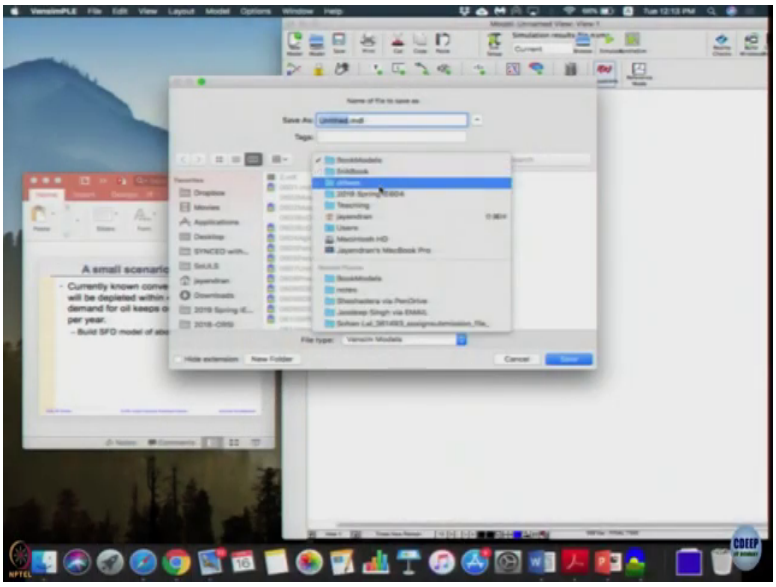

Let me what is this oil ok; let me before we go further let me just simulate. I have just simulated the model, let us look at oil reserve and demand.

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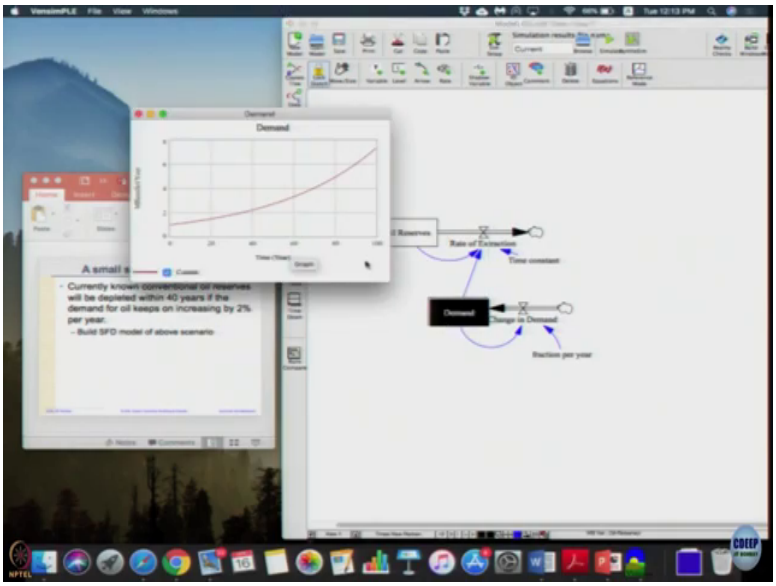


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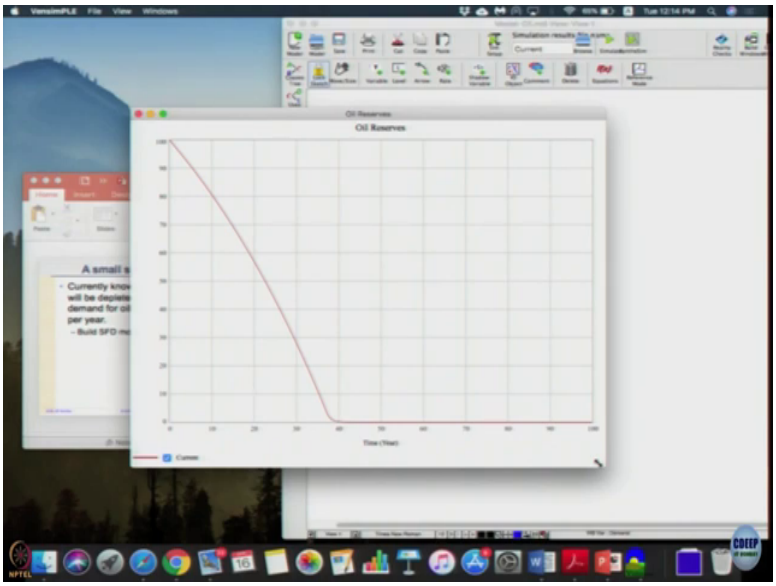


Demand increasing oil reserve falls down at you know 54 years that we kind of estimated now 55 years may be. What you want it is it has to finish 40 years.

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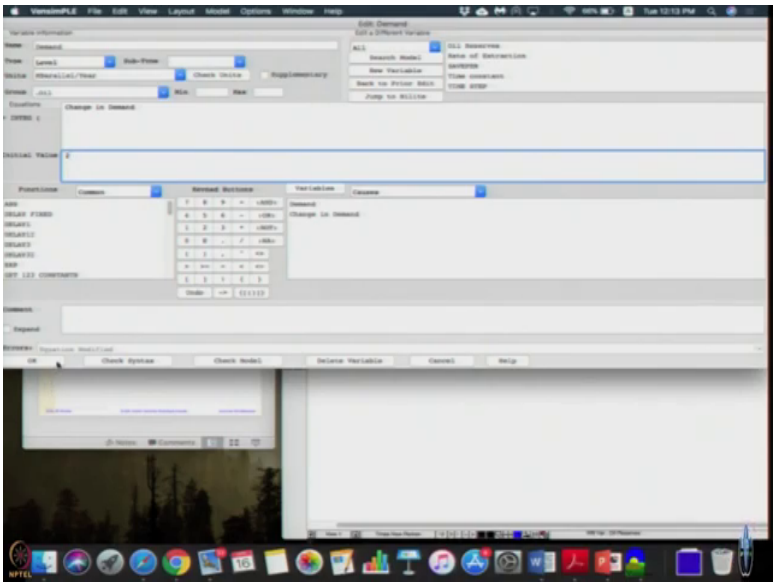

So, let us just go back if you do that let me just change the initial value of the demand. Let us assume that the initial suppose initial value is starting at 2 let us say.

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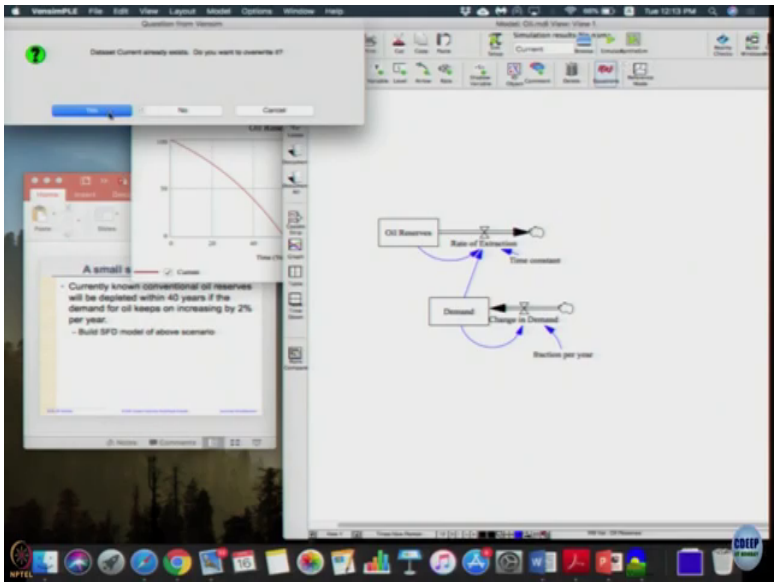


Then oil reserve ends in less than 40 years, your oil reserve depletes ok.

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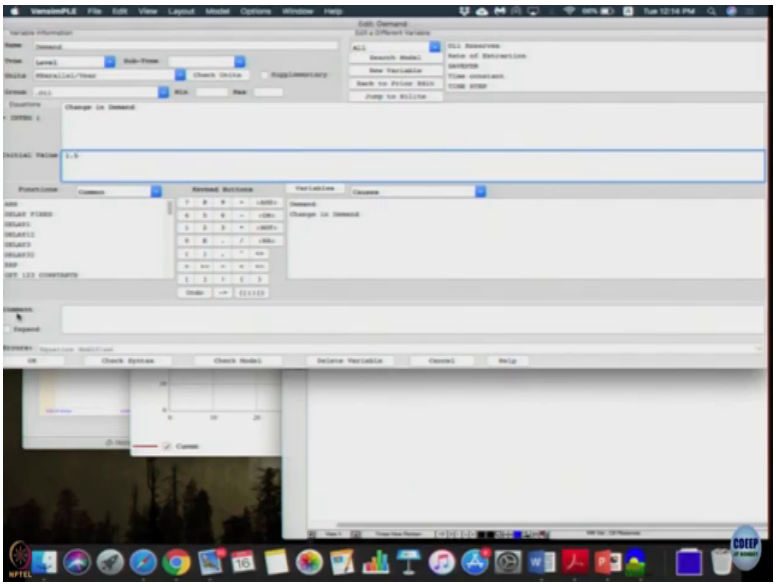

So; that means, my initial value should be between 1 and 2 so, let us try 1.5 comes to slightly more than 40 years.

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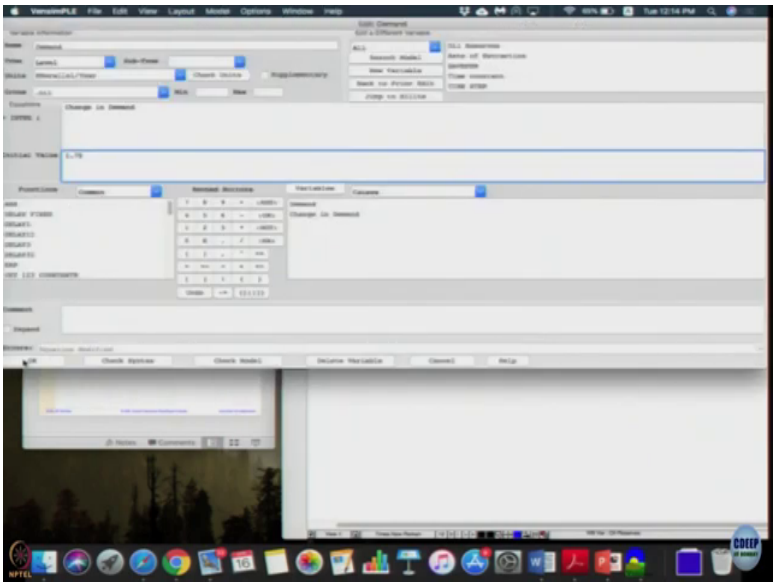

If you want to give it exactly around 40 perhaps I should try say 1.75 somewhere close to 40, it is able to kind of deplete itself if you assumed 1.75 starting point. Earlier thought process I was trying to look at when doubling time etcetera, it is trying to figure our these 1.75 as a thought processes because we can we already know doubling time, we know total reserve which is 100. So, you can always do our mental math we figure out approximately what should be the starting values where you want to start from.

So, this we must be able to try in a sense go with very simple descriptions not much. We were still able to build a stock flow model saying that if oil reserves depleted in 40 years, we can actually build a demand stock flow and oil depletion, then oil we then we played with the starting values until we actually it depleted. Any questions on that model? It is a small interesting one model to play with.