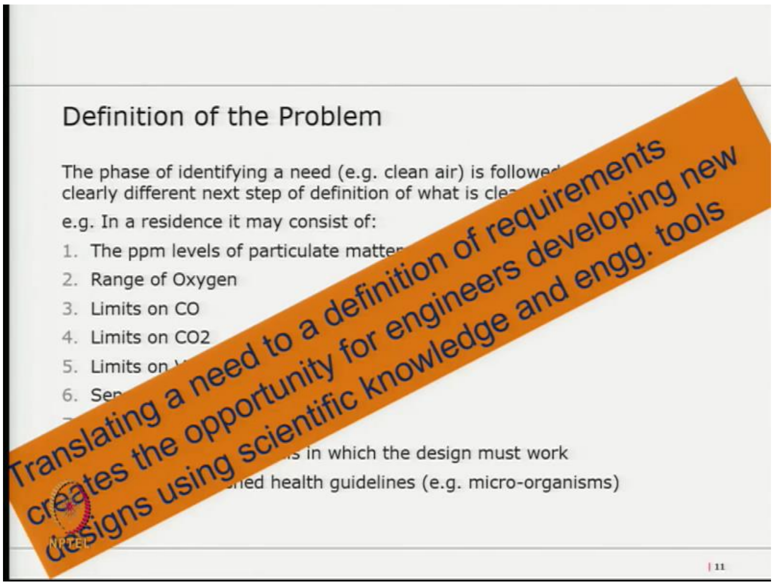
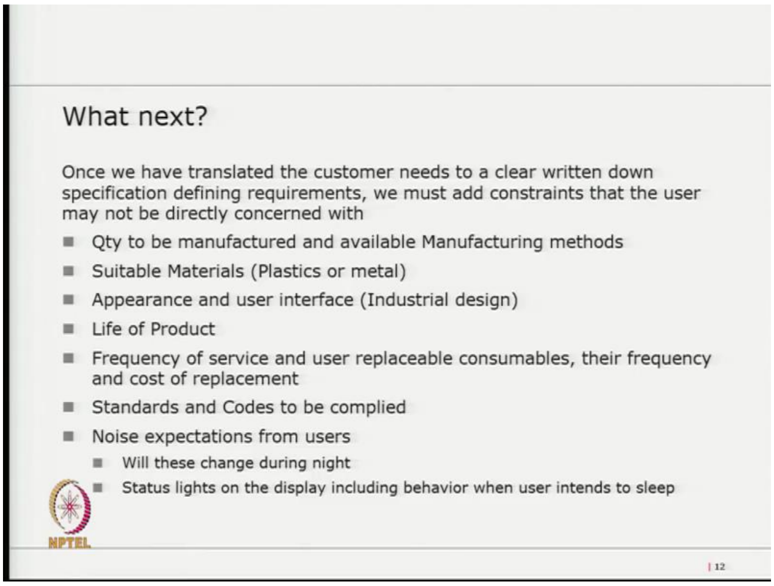
RAC Product Design
Prof. Sanjeev Jain & Bhupinder Godara
Department of Mechanical Engineering
Indian Institute of Technology, Delhi

Lecture - 02
Design considerations



See, there are so many needs out there, only when it has been translated into a firm set of requirements that you and I get the opportunity to invest our time, earn money doing it and finally, have a sense of fulfillment having done it right, because we want evidence that it did satisfy that human need which was so well defined. Before it is put into specifications like requirements we cannot do much about it and if we do anything about it, unlikely we will solve the design problem as the user or the person who first identified the need thought about it.



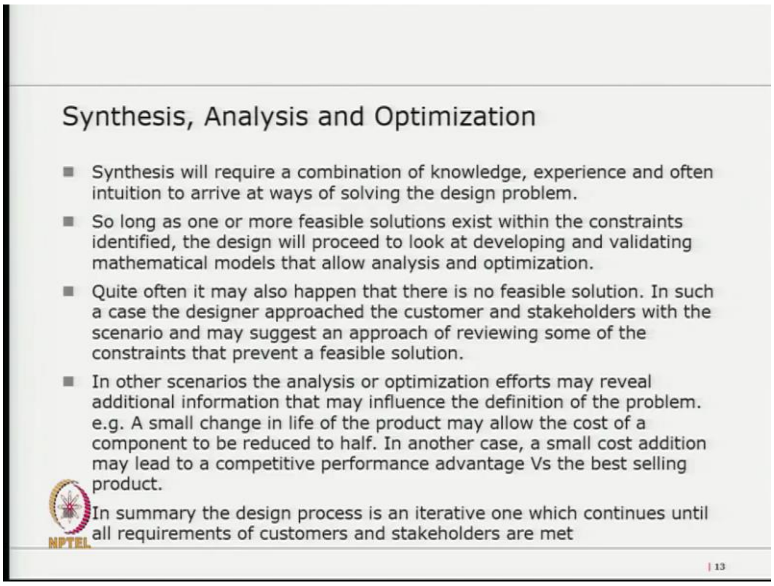
Now, what do we do after that? So, some of us will start thinking about synthesis, right. We synthesize it and when you synthesize you also start looking at volumes. So, how many homes in Delhi? If you really made a good product how many people would need that product? You know you can go to the population figure and you will estimate some average size of the household and come to a number, and then you will also estimate how soon people are willing to buy. So, you make some forecasts about it and then when you are designing it you will keep in mind that it has to be something which can be manufactured.

If I go by my experience of air purifiers, then the ones that are available in the market today are very expensive when you want to replace the filter. This may make you start thinking of what is something which can be cleaned, washed and is reusable as a filter. You will think about that and then you think about what material comes in handy. You might think of stainless steel, you might think of some other material or you might think of a fabric which is woven and which has the same ability and it is washable or something which can be cleaned with a vacuum cleaner and then put back, I don’t know.

So, you start thinking of, but something which is available, which can be manufactured, for which there will not be a resource constraint, so that needs to be integrated. This the end user never told us. People who need clean air did not tell us that it has to be manufactured. We are putting in the constraints now. Suitable materials plastic, metal, fabric, appearance and user interface. So, most of the time when we interact with the home appliance we are happy using it. We normally find on/off buttons, what to change if it is fan speed, it is cooling, temperature.

Now, we have to understand what the customer is looking for in an air purifier, that he has not stated, and some of the constraints that will enable us to make it a marketable product. What is the life expectancy? How long is the user going to keep it for? And then frequency of service, filter needs to be replaced once in a month, once in a year? What will be the cost, any codes and standards that we need to comply with? See in India we do not have that concern as much as it is in the US where there are laws which mandate that the manufacturer is liable for whatever is produced and if there is any hazard to life or property or anything then he has to financially compensate the user.

Then what are the noise expectations? I just mentioned, I was sensitive to the noise from the laptop fan. When you are wanting to sleep you are going to be more sensitive to noise. And if your air purifier is going to be used at night, we need to anticipate what level of noise will be acceptable to the user. What about lights? You switched off the lights and the filter indication is bothering you. So, all of this if we think through we are likely to address it when formulating the problem; so the constraints and the needs together.



We have some experience and let us say we get together I have experience, you people have some new ideas, and we start making a solution. So, the first thing we do is we’ll buy things available in the market. Before that we’ll ask some approval, are stakeholders willing to invest money with us, so that we explore what is possible. The government may be interested, some company may be interested or we may pool together our funds. Once you have that, we start doing activities like benchmarking.

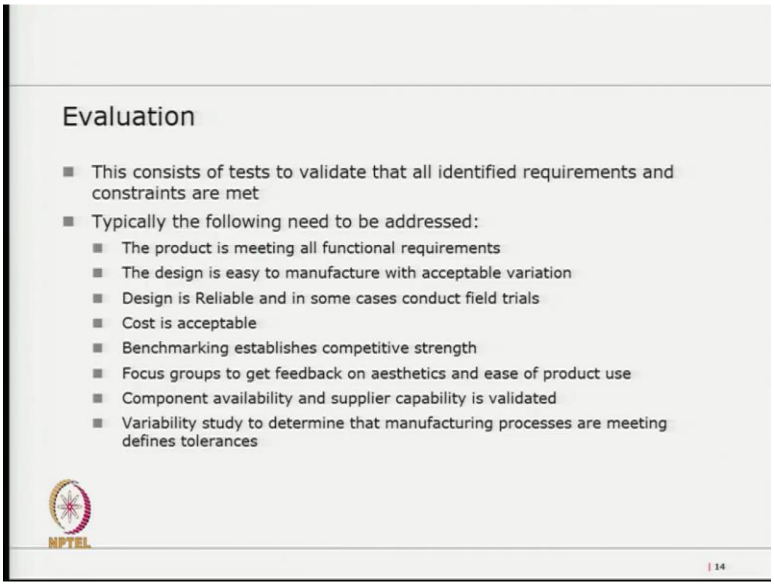
And then more than one feasible solution if available, now in this problem we know there are feasible solutions. Then there is no problem we can move forward and synthesize the product, but there could be scenarios where there is no feasible solution. So, there is one I think you pointed out something, right for which I didn't have a feasible solution.

Student: yeah

The book going back into the rack, right; so, it could be that the design team gets together explores options and say that we could not reach the point you wanted, because you wanted in the shelf at the exact same location where you picked it from, and we find that it is possible using a CNC machine, but it is going to be bulky it will add more to the house then the bookshelf itself and so we come back in terms of definition. Look this is not possible, but this is. So, you make an attempt to satisfy a modified form of the requirements and whether it will still satisfy that need.

Now, analysis and optimization efforts may also lead to additional information which could lead to redefining the problem. We said certain things and then we find that a small compromise can lead to a lower cost, say half the cost. So, we want to go back re-discuss or we get a major feature or performance benefit which is saleable, right.

Like we talked about filters selling at anywhere between Rs 10,000 and Rs 25,000 or Rs 10,000 and Rs 40,000 and you say like here we have a design which is going to sell at Rs 60,000, but it will never require a filter replacement. You want to go back and forth and use the optimization phase and therefore, those links between different parts of the design process and we already said that it is an iterative process.



Then we come to evaluation. So, if we did all this back and forth between definition of requirements, synthesis, optimization, analysis and we have come to a design, again continuing with the air purifier example we have a design which now is working or the design team thinks it is working. What next?

So, the best way I mean if we are working in a large organization then the best way is to have a validation process, to the extent possible, independent of the design team in terms of results and everything else, but managed by them. So, what you do is you create evidence. You said you will have CO 2 below a certain ppm, and we also talked about what is the extreme environment in which it needs to work. So, we create artificially an environment which has a high level of CO 2 and we put this system, and does it or does it not meet the objective. Same thing for the more riskier components of CO, VOCs and what was it sulfur dioxide and NOx, right, so all those.

We will create tests to validate. Does the product do what it said it is supposed to do. And what can happen as a consequence of all this? We might discover that the design team was too enthusiastic, when they said that CO levels will drop they did not take a large enough volume of air containing polluted gas, that could be one or they did not do it on enough number of pieces. So, one piece for some reason performed very well and we got the CO 2 levels where we wanted, but if we take a statistically significant sample size we are not getting there.

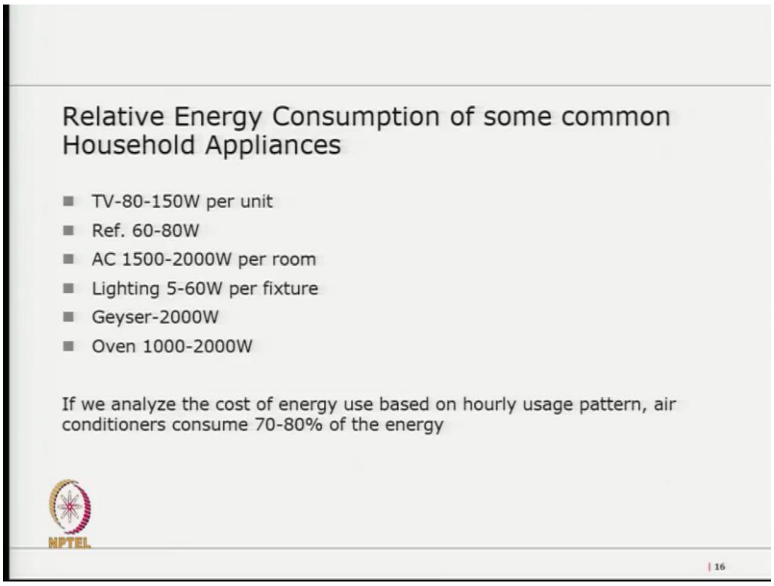
Now, some of this is not as interesting as it was, when we were talking about the creative phase of formulating the problem. It may not be as interesting as it was when you are optimizing, looking for alternatives, but then the rigor of design is that you cannot escape this process. Whether you want to make money for yourself, you want to help another company make money or you want to do social work, satisfying a need: irrespective of which of these you are working for you will need to demonstrate that the product meets its objective or design intent.

And what do we do for all this? Field trials is one option. So, some of the things that for example, life of a product, will it work reliably? Noise, when we are talking about noise levels we can measure that in a noise test room, but noise quality is something more to do with human perception. And there will be a set of variables that we cannot capture doing laboratory testing. If those are going to be significant, if we anticipate that customer choice of the product is going to be driven by those, then we might as well do a pilot, field trial. So, 100 units sent across a different categories of the population. Say you give some to people who have just 5 members in the household, some to households with just 2 people and all that and see what are their reactions. You give it to a set of sensitive people and you give it to people who are not very sensitive, but to those who are very quick with things. They want things working quickly. Then you strategize. I do not know what all you will include, but you strategize to make sure that you have a higher fulfillment rate of the human need.

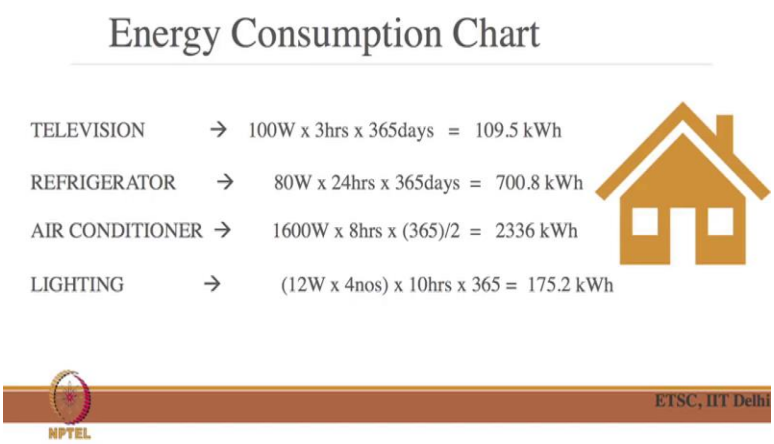
You can also then do focus group studies, people who used it, you talk to them and then look for clues on what is missing, and then also maybe a check on whether there are enough components that suppliers, vendors around can supply. See, so at this point it begins to become more a disciplined approach than a creative approach and then when we want to manufacture the product we want every product to fulfill a certain set of specifications and defined tolerances. No two pieces are going to be exactly alike. So, we need to measure what is the process capability, again do some pilots and those are manufacturing process quality oriented trials to determine process capability.

Now, we come to refrigeration, air conditioning, the subject that we are going to touch upon. So, within the subset of mechanical engineering design we have refrigeration and air conditioning, and when we look at air conditioning we could begin to think of where all are we interacting with one thing or another. So, all of us have interacted with the domestic refrigerator, right.

We have experienced an air conditioner, we have gone to malls where some of the commercial or large industrial chillers are used and all that. So, in our daily lives we have a lot of interaction with things to do with refrigeration and air conditioning.



Now, I want you to get a sense of the relative energy consumption of some common household appliances and see where the air conditioners sits within them, and there is a reason for that. So, do you more or less agree with what values I've put here? Now let us do a calculation. Some of you are carrying calculators? Phones can be used, right.



So, let us look at, first a TV and we make some assumptions. So, let us make an assumption that this is a one bedroom house where a couple is staying together, right. So, Why? Because then it will allow us to assume the number of lights, geysers and stuff like that. So, how long you think the TV will be used?

Student: not sure

Make a guess.

Student: 2 hours

So, 100 watts into (I'll be liberal) 3hours , and then let us make an assumption 365 days and this is more a representative calculation for you to get a sense. So, can someone give me the kilowatt hours here? 109.5.

Student: Yeah,

OK. Let us look at the refrigerator. So, we will then again take let us take 80 watts and we are going to use it.

Student: 24.

24 hours into 365 days.

Student: 700.8

How much?

Student: 700.8

700.8. Now, look at AC. So, we are going to use 1600 watts and for 1600 watts I am using 1.5 air conditioner right and we will make an assumption of how many air conditioners?

Student: 1, 2

2, right.

Student: one.

So, let us assume one, and let us assume one and at the same time we will factor in the number of hours that it is used, right. So, indirectly we will get that sense. So, I want to make an assumption here. While it may be used more than 8 hours, but the compressor may not run 8 hours. So, for purposes of averaging and just to get a sense we say 8 hours into 365 days.

Student: What about other AC?

No, we are saying let it be they are a very energy conscious couple and if they are in the bedroom then they will switch off the drawing room AC.

Student: ACs will be used in summers and not in Winters.

Let us make it half.

Student: 6 months

180 days.

Student: 4 month more like, 4, 3, 4 month not exactly.

I used to think like that when I was handling design and when I was doing some of these calculations, but I discovered then that people start using it in March and continue using it until end October.

Student: ACs can also be used for heating in winter season, right?

If you use it like a heat pump, yes. Let us let us factor it, let us make it half. Let us look at it you will use the AC in the months of April, May, June without doubt; April, May, June no one has the doubt, right..

July, August, September I have personal experience I can't do without using it.

So, 6 months are there, right. So, let us do this how much is it?

Student: 2336.

2336 and what are we left with right now, lighting?

See, given the emphasis on energy efficient LED lights, I would propose 12 watts and we can say 4 lights, right, and then how many hours?

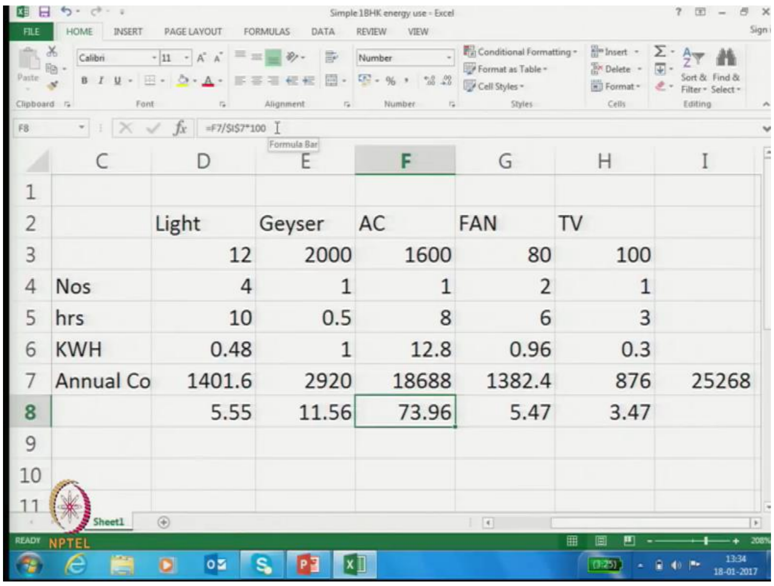
6 hours ok, 14,15 hours? I think it is too much.

Student: 10 hours.

OK, what do you want to say? We will put in that.

Student: 10 hours.

10 hours.



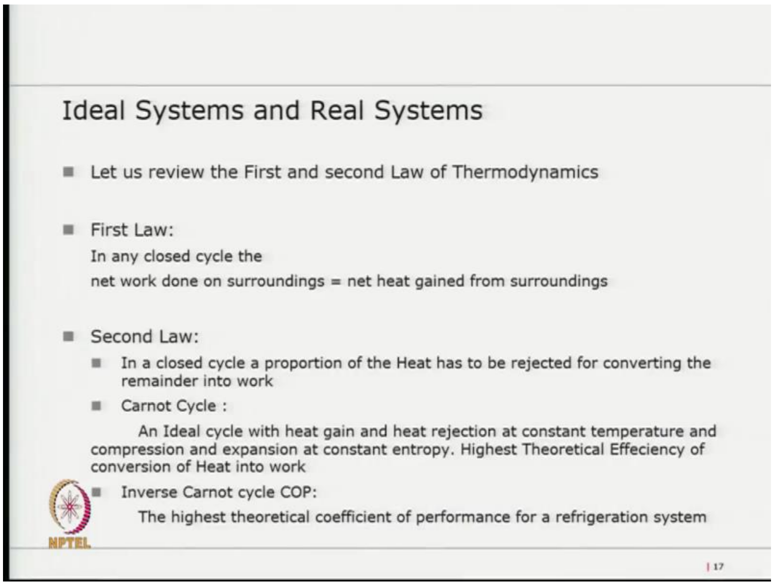
	C	D	E	F	G	H	I
1							
2		Light	Geyser	AC	FAN	TV	
3		12	2000	1600	80	100	
4	Nos	4	1	1	2	1	
5	hrs	10	0.5	8	6	3	
6	KWH	0.48	1	12.8	0.96	0.3	
7	Annual Co	1401.6	2920	18688	1382.4	876	25268
8		5.55	11.56	73.96	5.47	3.47	

So, what you can do is this is a simple excel sheet that most of you can do by yourself and you can develop some insights and come back next time. So, with whatever we did we have reduced from somewhere like 80 percent to 73, 74 percent the cost of energy 74 percent of the cost of energy is because of the air conditioner.

Student: Refrigerator is missing

And we have kept the refrigerator aside, I think we haven't taken that yet.

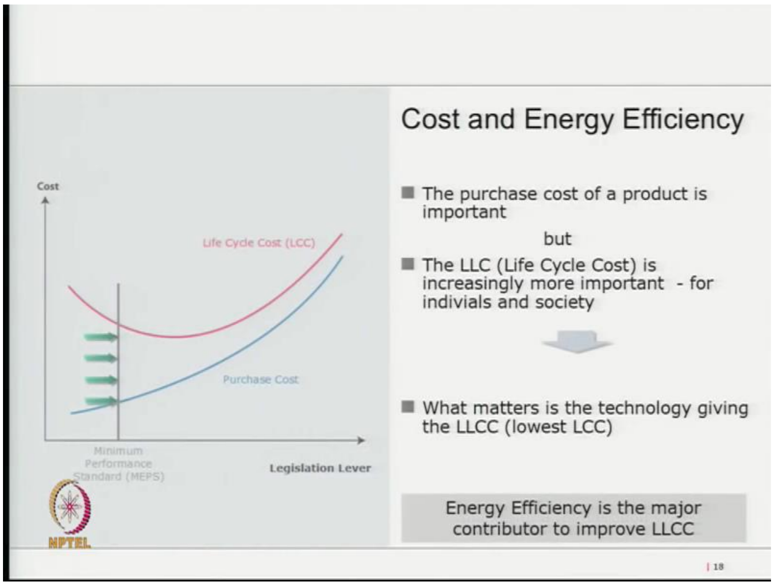
So, it is only going to increase. So, refrigeration air conditioning together contributes to a big part of the energy consumption and that is the reason why we see that air conditioners are the last home appliance to become popular. If you look at a trend chart people start buying refrigerators, buying TVs, but air conditioners come in last and that is because people already are aware of the high running cost of an air conditioner. So, we go back, I just want you to have this in mind Rs 20,000 approximately (annual energy cost) of a 1.5 tons split AC with a high energy efficiency rating. 1600 Watts of power consumption is not easy to get, the standard 3 star product will probably consume more power.



That was for you to have some context as to why we are going to look at system efficiencies and the impact on environment as you go forward on the slides. This background knowledge of the cost of running an air conditioner is important to appreciate the significance of energy efficiency for air conditioners. You know when Carnot wrote his first paper or first communication, he talked about the motive power of fire, it was a French article and it translated “Motive Power”. If you look at thermodynamics, the word Thermo (Heat) Dynamics (motion or movement). Start looking at these two and you will see that there is an interrelationship between heat and work.

The first law, essentially what it is saying is that when you move from one state point to another state point, there is always a relationship between heat transfer and work done in a reversible system: that is all that is. So, if you relate to it like that you will always be aware that there is a connect between heat (thermal) and movement (work). Now, what the first law never says is that you have to lose some heat before you can get some work, so that is where the second law of thermodynamic comes in.

So, if you had energy in the form of heat. Let us say you have some something at 600 degrees Kelvin and you want to convert all of it to work. The first law allows you to convert all of it to work, but the second law says that there is a penalty you’ll pay, you have to lose a part of that to a sink and only then can you generate flow which will lead to creating work and then we have a Carnot cycle which almost defines that penalty. The best system will never have an efficiency higher than the Carnot cycle efficiency for an engine, and when we come to refrigeration air conditioning we start looking at the inverse Carnot cycle.



Now, if we start looking at cost and energy efficiency then we need to appreciate what is the gap between the highest possible efficiency and the systems that are there today, I will come to that. Before that let us look at the purchase cost of a product. So, we make an air conditioner, air conditioners until a certain time were purely driven by marketing-features and price.

It was in the year 2005 we started an initiative with the bureau of energy efficiency about labeling, and we discovered that there was absolutely no regard for energy efficiency in terms of point of sale communications. Customers were not aware and there was no clear data. The catalogues were hazy on standard compliance. One manufacturer had a set of standards there he would use the lowest allowable performance by the Indian standard and design products to that. Another manufacturer would design products to true capacity. Both were being rated in the market in a very similar way, one and a half ton is one and a half ton. So, when we went through the process and we will cover it in one of the lectures how we went from the transition. From the consumer not knowing what he is buying in a very quantified and clear manner in terms of what matters to him to taking it to a point where it was mandatory to communicate this information (Cooling Capacity and Energy Efficiency). Today every air conditioner (residential) in the country is labeled.

So, I had some role to play when that was being done along with the manufacturers, stakeholders from other industries and all that and it will be a pleasure to go through it and one of the sessions that we have. Initial cost and therefore, price was driving it and then it is the combination today. Lowest life cycle cost : how do we get the concept of a life cycle cost? In the air purifier we are looking at the cost of replacing filters, in case of an air conditioner we just looked at how much it costs to run the air conditioner. So, we look at the total lifespan. What is, I mean when I ask you the price of a one and a half ton air conditioner what number comes to your mind?

Student: Rs 30,000.

30,000 somewhere around that, right and we found the running cost of how much.

Student: Rs 20,000

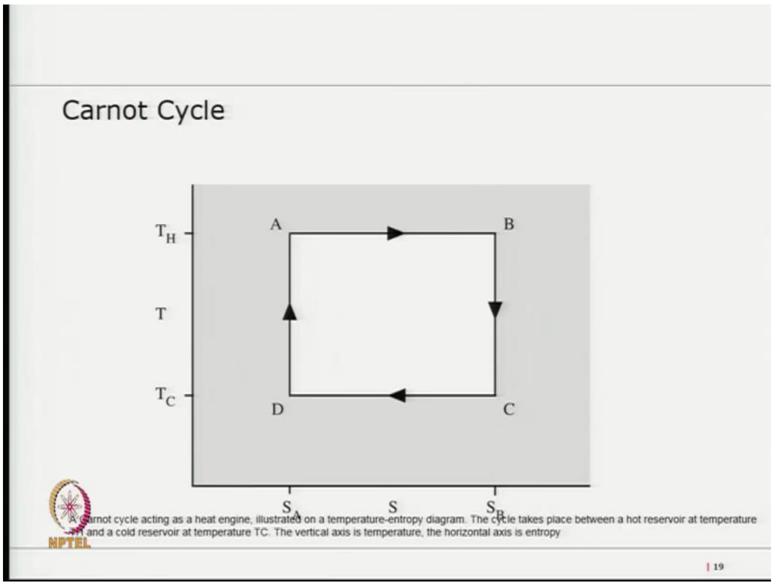
Now, you could actually contest and I want all of you to put your thinking caps on and contest the assumptions I made because I was trying to make a point. So, I would have exaggerated the number of hours and all that and maybe hidden something from you guys, right. You can always assume that and then try and come to a realistic understanding of what it is. So, what are the things you will use? You will say that the compressor cycles. So, one and a half ton air conditioner is running with the compressor on some part of the time and off some part of the time. So, you will factor that you will find out how much power the compressor will take and how much the fan will take and you can do all those sort of refinements, but you will not be able to go very far from the number we got. And therefore, we need to become appreciative of the concept of lifecycle cost for air conditioners more than other appliances. And when you start looking at that, then we start looking at technology which will give us the lower life cycle cost.

So, when people are paying more for high efficiency ACs maybe they are aware that over a period of 3 years, 5 years they will recover the premium they have paid because the energy cost of running the AC is going to be lower. That is what drives the inverter air conditioners and if we have the time we will include that also in our discussions in subsequent lectures. Now, why did I bring in energy efficiency and or touched upon the bureau of energy efficiency experience? Because if a market is left to itself then it does not by itself move in the direction of higher energy efficiency. So we need regulation, we need some kind of pressure. Someone was saying how can we make people adhere to law we need something like that.

So, once you say that this date onwards you cannot sell an appliance with efficiency lower than this number, you drive technology. It is just not true for India, even in California this has been found true. Many years back when I did my B.tech project I did some benchmarking. For refrigerators technology was stagnant, till one state in the US said that yes, we are going to mandate now that you need to have this energy efficiency for a refrigerator.

So, they went by defining, for this size you cannot consume more than this power and there was almost like a revolution. Most companies R and D budgets increased they hired more people and they have developed efficient systems. Before that there was no drive. So, legislation has a very important role and when there is legislation one has to also keep in mind that you cannot simply define a very high number. So, you want the best air conditioners take the best technology in Japan and say this is what you are going to do because then, you deprive a huge part of the population in their ability to satisfy their needs they want at an economical affordable value.

So, that is why we show this chart, where it is possible to look at a relationship between; are you able to read it. So, the legislation lever is defining the minimum acceptable performance of an air conditioner and the purchase cost we know will go up when we improve energy efficiency. The moment we start looking at lifecycle cost we will have an optimum, and that optimum could be the point which we could use from the legal/ legislative part.



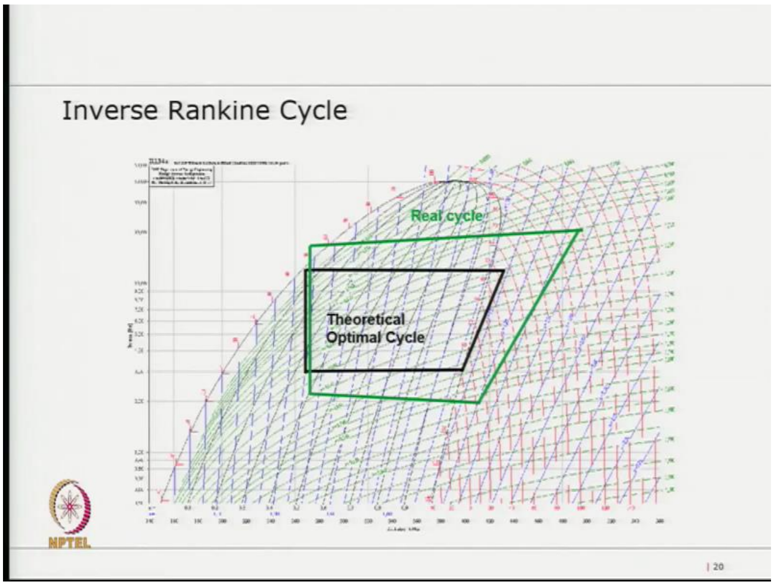
Now, we come to the Carnot cycle which all of you are familiar with and the key point here is that we have a reversible process for both taking heat from the source and throwing heat to the sink, and then we have isentropic compression and expansion. So, now, has anyone heard of any machine that works on the pure Carnot cycle? It is impossible, right, and how do we appreciate that it is impossible?

Student: Reversible systems are not real.

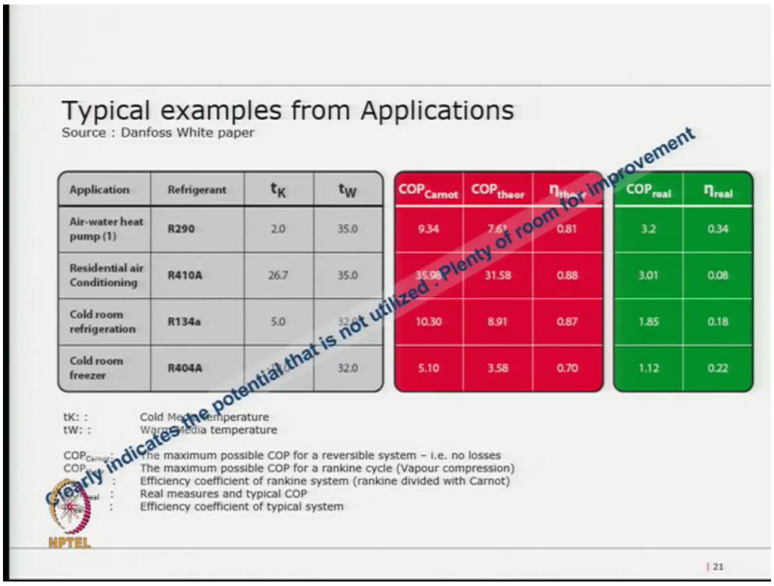
Right. So, it is a concept that has been created to define a limit, right. You will normally need a temperature difference if you want to, let us take an air conditioner you want to reject heat and the condenser the temperature of the refrigerant inside the condenser needs to be higher lower than the environment. What should it be?

Student: Higher.

It has to be higher, right for the condenser. Condenser is the part which rejects heat to the environment, so it has to be higher. So that delta is there, I mean as a necessity and then it is related to cost. So, you want a small delta you will have a large heat transfer surface area, but inherently because you are going to have a finite size of the heat exchanger you are going to have some part of irreversibility. Same thing goes for the evaporator and then we also know that we do not have compressors which will do isentropic compression. The closest is the expansion part which also follows in a capillary of fanno line, maybe in an expansion valve which might be isentropic, somewhat.

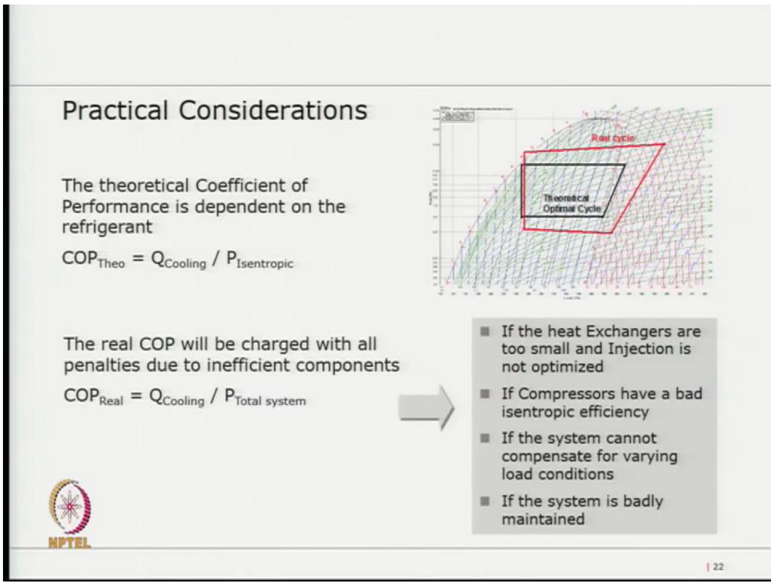


So, what we have in reality is: even if we look at it theoretically it will be the Inverse Rankine Cycle, and that is plotted on a pressure enthalpy diagram here. Now, there will always be a difference between the theoretical optimal cycle where we have taken care of adiabatic compression and we have factored in the two straight lines taking care of heat rejection and heat removal at constant temperature.



Now, before we go any further let us see how much is the opportunity in terms of our ability to improve systems? So, I have looked at air water heat pump using refrigerant R 290, and if we make an assumption of the differential temperatures of 2 degrees; so heat pump is basically something we look at you know environment like today. So, we want to pump heat from the environment to the room. And then we look at residential air conditioning with refrigerant 410A and we take a certain temperature inside and then a certain temperature outside.

So, you will notice that there is a major opportunity for improvement of energy efficiency in all these systems. So, we first related to the need as an economical as a commercial need and then we see the opportunity that is there in today’s systems and this is basically a design opportunity. So, if you want to look at pure air conditioning product design then here is an opportunity which are which is existing across the range of products.



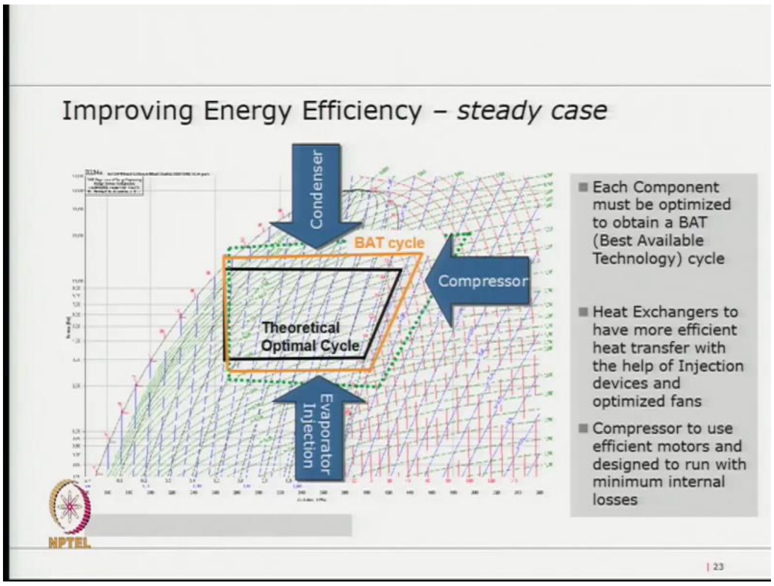
To appreciate the practical considerations that we have, so the practical consideration that we need to be aware of are like we talked about the temperature needs to be higher for the condenser, it needs to be lower for the evaporator for us to take heat away in case of a cooling application and we will always have a ratio of the two.

So, the penalties of all components inefficiency will be factored in the real COP. So, let us say that the gap. So, if you want to keep the room at 26 for comfort, can we really operate the cycle at 26 evaporating temperature on under those pressure enthalpy diagram? Yes, No? We will need to keep it lower, right. Now, how much lower and what would be another constraint that would determine how much lower? We also need to remove some moisture from the room we are all breathing. For comfort applications we will have a certain latent load. Put together the two will determine the evaporating temperature and in most comfort applies this is between 7 and 9 degree centigrade. So, you can notice how this evaporator which is a heat exchanger is going to introduce an inefficiency just because of the ΔT required to transfer heat and to have a reasonable size as well as remove moisture from the room.

Now, let us look at the condenser. There again we need a temperature difference. Before energy efficiency became a big thing driven by standards, products would be designed at $55^{O}C$ for an ambient of $35^{O}C$, so that is a big inefficiency. And what can we do? On the condenser there is no constraint about having to remove any moisture. We can play with the size. So, at a higher initial cost there may be opportunities for reducing the condensing Temperature and thereby reducing the overall lifecycle cost. What else can we do? The compressor will have an efficiency which is a function of how well we do the compression process and what motor is used. The motor will add to some inefficiency and there again there are compressor types. The next time we meet we are going to look at different compressor types and what are the advantages, disadvantages of those and how do they compare with each other on energy efficiency. And there is one thing which is pretty consistent with what you want, right the expansion process, which is a straight line on the Carnot cycle, on the Rankine cycle, inverse Rankine cycle and also in the practical cycle.

So, what is missing over there? We never recover work in the expansion process in all commercial systems. We simply expand the fluid. So, the inefficiency contributed there is because we have never recovered any work, whereas that opportunity exists just like we did work in the compressor to pump fluid from one temperature to another, when it drops down that opportunity was there. All right.

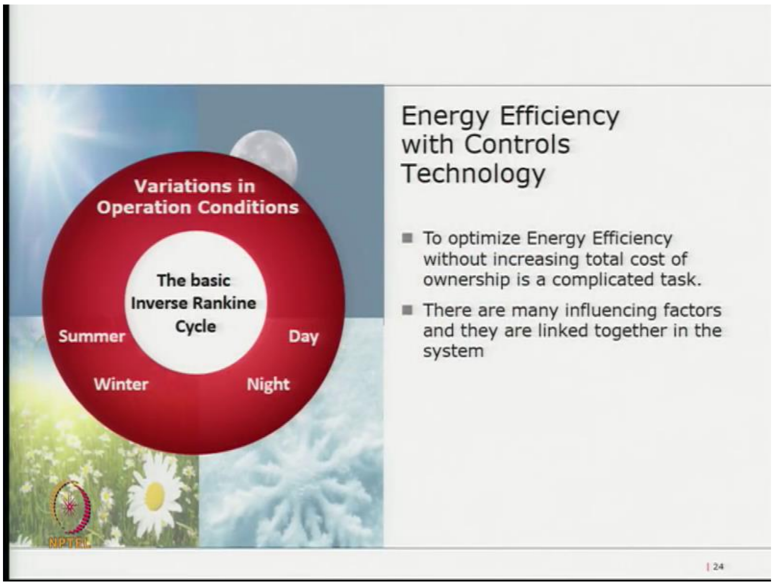
Now, we look at; see this is going to be a little tough because it is theoretical and you are not dealing with systems yet. So, you don’t have the hang and feel of all the variables, but look at an air conditioner we design it for let us say 35^{O}C because that is what our standard says that is what the international standard says, you design it for 35^{O}C. What happens in real life? We will have peak temperatures on a hot summer month say 46-47^{O}C during 2pm to 4pm, and then the temperature will come down and it might touch 31^{O}C at midnight.



Now, what happens to this cycle? It will keep varying because with the temperature, the theoretical cycle will also change and the practical cycle will also change. So, each component need just not be optimized for a particular defined condition, but needs to be able to handle the variation and now, it becomes an engineering problem which someone was purely there for the fun of it would say “No! It’s so complicated, maybe I will just not to get into it. I will do something else.” Or someone who is really interested will put together all these variables and see what it takes to optimize and design a system that will provide the best lifecycle cost over the varying conditions.

So, you know some of us can get excited about making simulation programs and putting in relationships that help us predict what is going to happen. So, one of the things that works in design is let us say 2 to 3 percent of the time you are going to experience high ambient air temperatures outside. So, 46 to 48 is going to be no more than 2 percent of the time in a year. We can define a weightage which is low for that condition, and allow for a relatively inefficient point of operation there. And then we look at what is the maximum number of hours. So, we find that the maximum number of hours are between 32 and 34. So, we start focusing our optimization efforts to get the best energy efficiency for that condition, and all the time we are keeping an eye on the lifecycle cost, not the initial cost.

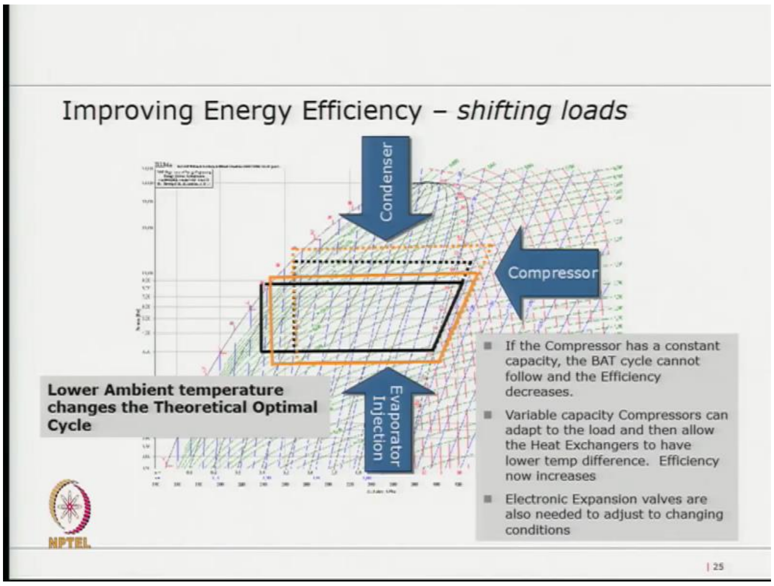
So, today the state of technology is that such systems are available; which have been optimized, but unfortunately they may not have been optimized for the climate of India. They may have been optimized for the conditions in Japan or for the conditions in the US wherever there has been a market large enough to appreciate the value of a low lifecycle cost that has been there. And the opportunity for India exists. We take our temperature conditions and it could sometimes mean tweaking the algorithms that drive the compressor, it could also mean choosing different compressors, different size of heat exchangers, all that and all this should lead you to start thinking what all goes into the product design when you are making an air conditioner for a specific need.



We looked at components, we can also look at some degree of control. The moment we bring in a compressor which can have varying capacity there is an opportunity to run the compressor faster slower depending on the need, the cooling need. The cooling need could be lowered at night, you could run the air conditioner all the time at a much higher point of efficiency, than cycle it on and off, and lose the energy efficiency opportunity when the compressor is off.

So, what happens is a conventional one and a half ton product will run at its capacity of 1.5 tons or whatever is the rated capacity with the change in conditions. So, 1.5 ton is at certain specified conditions. So, at night it would be a little more. So, it runs in and it stops runs and stops. Whereas, if we reduce the speed of the compressor we are running it just at the required load and then if you have a 0.5 ton compressor in a large system which is 1.5 ton you will get a much higher point of efficiency. You will have the condensing temperature come down, you might want to use the evaporating temperature go up for a certain duration and then you might address the humidity concern a very different way.

Whenever you find the humidity rising you lower the evaporating temperature and then bring it back up. So, then there is some algorithm sitting inside the control systems, working for the most optimum point of operation, all the time, and that means, we need to start thinking of computer programs and algorithms and sensors, so that again gets into components for air conditioner product design.



We have already covered it, but this slide kind of explains a little more clearly the shifting conditions for different components. The best available cycle for a particular set of conditions will not follow the cycle in varying conditions. But, if we have the ability to change the compressor capacity then it is possible to follow the best available cycle.

Alright so, I think this is the point at which we can close. So, this will be my concluding slide for the session today, and this is to bring in a perspective of climate and energy. When I have talked to you about different air conditioning considerations for components the one part we have not touched upon is refrigerant in any significant way except when you looked at the possible efficiencies. So, the refrigerants have been known to contribute to the ozone depletion and, therefore they are an environmental concern and there was an agreement, international agreement to phase out all those substances that deplete the ozone and that has been more or less implemented across the world. Having done that another concern that came up and that was global warming and that is the new issue. And some of it we will touch upon in our next class and we will also look at components for refrigeration and air conditioning product design.

So, the flavor of the next lecture is going to become a little more detailed around components, and we will pick up from here the global climate energy challenge and we will look at what are the ways to offset some of these threats to the environment, right. So, with that then I would like to conclude.