Energy Conservation and Waste Heat Recovery
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Lecture - 04
Introduction to waste heat recovery (Contd.)

Hello everyone. So, in the present lecture we like to see what gains we are having if we are having waste heat recovery system in an industry. We also like to see how waste heat recovery system is integrated with other energy issues of a particular industry or a particular society or in general the energy issues of a country of the state.

So, let us start with the gains by waste heat recovery. So, it is like this that there are number of ah gains when we adopt waste heat recovery. And some of these gains are primary grains and there are many secondary or auxiliary gains which commutates from the primary ones.

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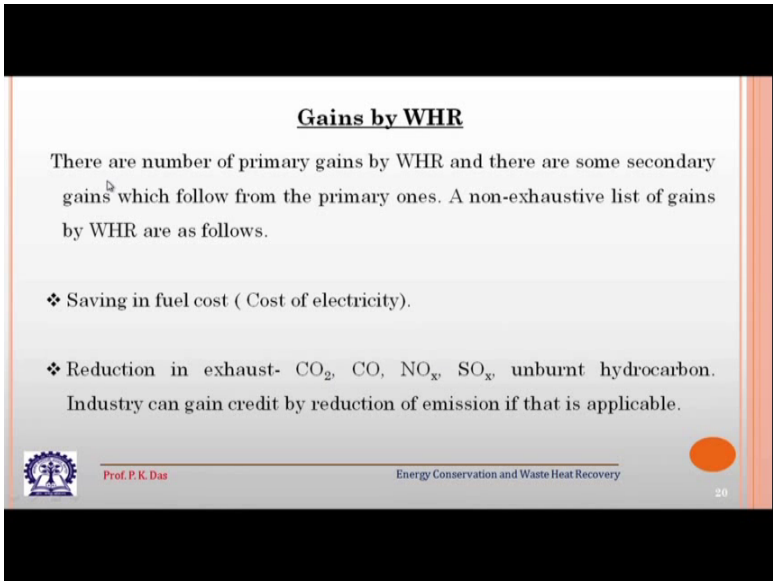

I am discussing some of them, but it may not be all exhaustive there could be some other gains also a state recovery depending on the specific application.

So, first thing is saving in fuel cost when we are having waste heat recovery; obviously, some of the plants need not I mean it is coming from the waste heat recovery and then the energy supply to the plant either in the form of fuel or from in the form of electricity

that can be reduced so, saving in fuel cost. And then when we are burning lesser amount of fuel we are generating lesser amount of exhaust. So, the exhaust gases like carbon dioxide, carbon monoxide, NO x, SO x everything will reduce and it has got tremendous effect. What are the effects? First thing is that; that environmental degradation that is arrested to some extent. We are having the same output, but we are not degrading the environment as much as we would have done, if there is no waste heat recovery device and second thing in many cases the legislations are very stringent.

So, there are legislation for restricting the emission and there are incentives also for having lesser emission. So, one industry can gain those incentive when the emission level is low.

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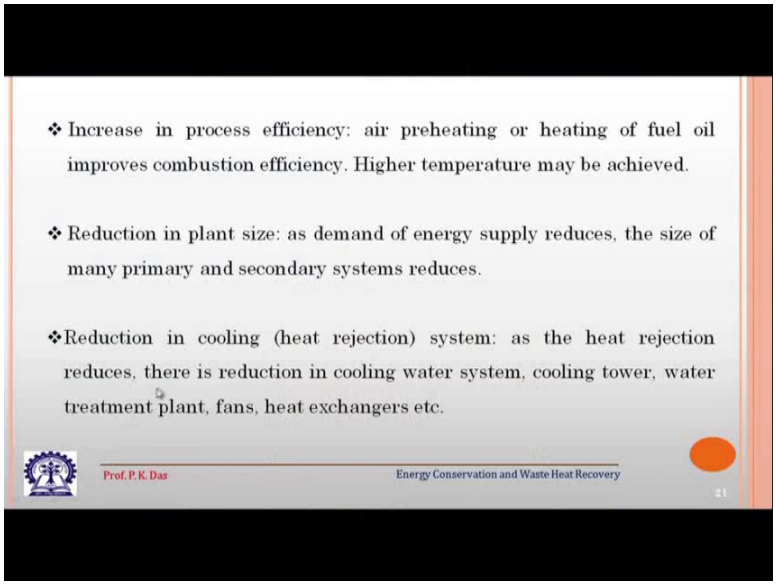

Then increase in process efficiency: increase in process efficiency waste heat whatever we are getting air preheating is a good option utilizing waste heat or one can even heat the fuel oil before it goes to the combustion chamber.

So, both preheating of air and preheating of fuel oil that will increase the combustion efficiency. Higher temperature may be obtained; if higher temperature is obtained then one can expect higher cycle efficiency, higher process efficiency. So, output that will increase with the help of waste heat recovery.

Reduction in plant size as demand of energy supply reduces, then the size of many primary and secondary system reduces. And we will have reduction in the plant size. The footprint of many equipment that will reduce. Reduction in the cooling system ultimately we reject heat to the ambient and there is some sort of a cooling system either it could be air cooling or it could be cooling by some sort of a circulating water and this cooling system will reduce, because now we are dumping lesser amount of heat to the environment. Cooling system reduces means there will be reduction in cooling water pipeline, cooling tower, water treatment, plant, fans, pumps, heat exchanger etcetera. So, it is; obviously, reducing the cost and reducing the plant size.

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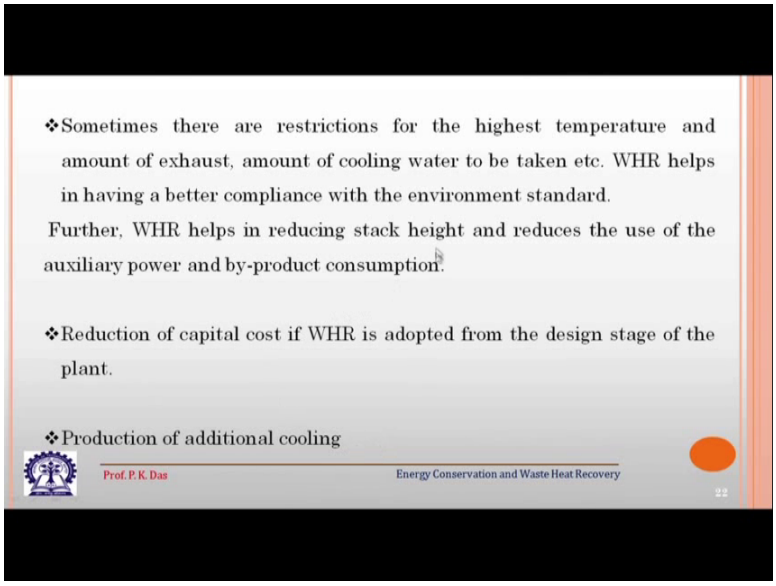

Sometimes there are restriction for the highest temperature and amount of exhaust, amount of cooling water to be taken etcetera. So, waste heat recovery helps in having a better compliance with the environmental standard. Further, waste heat recovery helps in reducing stack height, if we are having the exhaust gas at a lower temperature. So, generally stack height depends on the temperature of the exhaust gas. So, here it will help us in reducing the stack height. It reduces the use of auxiliary power and by-product consumption. So, this needs little bit of little bit of explanation what it is that in the in a plant we have to use palms, fans, etcetera and generally it is called suppose the plant is generating it is own energy, but this kind of pumps, fans are needed. So, generally the power needed by them is called auxiliary power.

So, when the waste heat recovery is utilized waste heat recovery is in place so; obviously, the demand for pump hand etcetera that will reduce and auxiliary power consumption that will reduce. By-product consumption; so in many chemical plant what happens the by-product which we obtain that is used as fuel, because energy is needed. If we use waste heat recovery principle, then what is happening that even without burning fuel we can get certain amount of energy; the by product that we that we do not have to consume. Now for the production of thermal energy and by-product are costly items that can be sold and revenue can be earned.

Reduction in capital cost if waste heat recovery is adapted from the design stage of the plant. So, this needs no explanation, because as our plant size is reducing as the equipment and subsystems are becoming smaller. So, if we are having it from the very beginning, then we will have a lesser capital cost for the plant. If we are having retrofitting in an existing plant if we are having waste heat recovery principles adopted then; obviously, there is a payback period and that economy we have to consider. Production of additional cooling; Now, already I have explained that by absorption cycle we can produce certain amount of cooling and waste heat can be utilized for producing some additional cooling.

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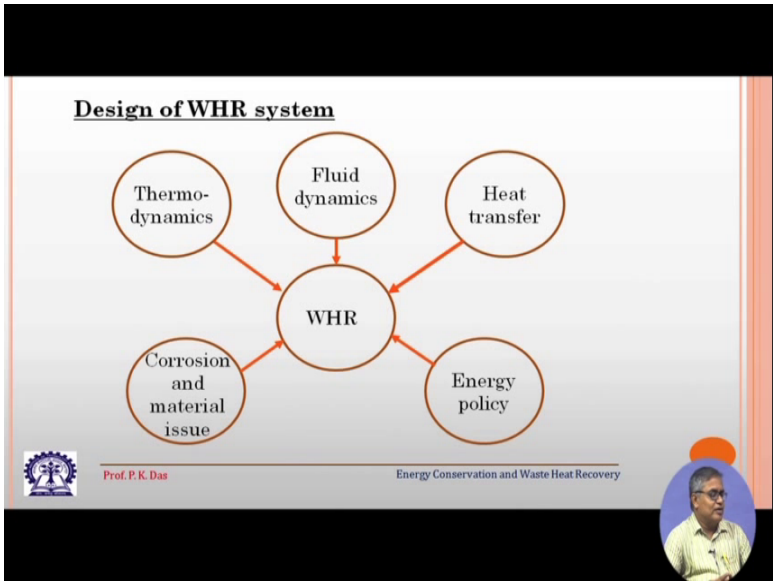

Then, we come to the design of waste heat recovery system. This is some sort of a schematic to explain how waste heat recovery system can be designed on which factor it

depends waste heat recovery; obviously, it is very much dependent on the thermodynamics. We cannot I mean we have to always keep in mind the thermodynamic principle, while designing selecting planning for waste heat recovery devices. And in many cases we have to handle running stream. So, fluid dynamics is very important we have to design systems where the benefit which we are getting from waste heat recovery is not written away by excessive pressure drop.

So, fluid dynamics is very important. Heat transfer; obviously, that needs no explanation no further explanation, as we are utilizing the heat thermal energy basically waste heat recovery is the utilization of the thermal energy. So, heat transfer becomes very important efficient and heat transfer efficient heat exchange devices heat transfer devices that we have to select to get a best a good waste heat recovery system.

Then, corrosion and material issues we generally handle with exhaust gases. So, that often it is corrosive and with high temperature when this corrosive nature of the gas is present, then material selection becomes an issue and one has to keep some sort of care one has to give some sort of care for this issue.

Then ultimately energy policy, what is energy policy? Now, no industrial activity can be complete or can be perfect without economy. Economy of the waste heat recovery device; obviously, it is dependent on the available technologies it is dependent on the innovative design, but at the same time it depends on policy.

So, what is the energy policy of the deep of the country itself? So, if there is incentive; if there is tax benefit for adopting waste heat recovery so; obviously, it gives some sort of encouraged impetus for having waste heat recovery devices in the plant and in many cases the initiative for having the waste heat recovery devices that comes from the energy policy which is existing in this state.

So, in a Nutshell based on all these one has to select a waste heat recovery device. Based on all these factors one has to select the waste heat recovery device here; obviously, we will not be able to give much attention to energy policy and material issues time to time we may discuss, but we cannot we will not go much into it. So, waste heat recovery device basically from the thermal design point of view and thermodynamic principle point of view we would like to discuss and that is what we like to deliver in this particular course.

We had towards the end of our introduction to waste heat recover. The last topic which I like to touch upon is that, what is the position of energy recovery activity in the perspective of energy activities?

Now, energy is a very broad terminology, it has got lot of significance particularly with our development with the industrialization energy is almost synonymous and energy cannot be looked into in a compartmental with a compartmental view. The total perspective of energy has to be looked into and; obviously, waste heat recovery is a part of it. So, I like to discuss, how in the perspective of total energy policy waste heat recovery is important?

Let us see both the top down and the bottom up process where energy bottom up process for this energy activity and where exactly waste heat recovery feeds and what is it is relationship with other activities of the energy principle in general.

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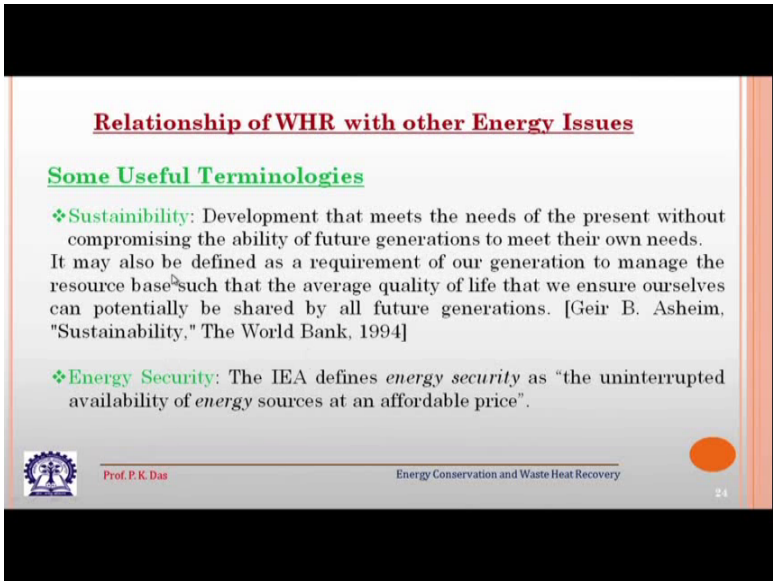

So, what I would like to do in this case? I like to first describe certain terminologies and then we can see where exactly waste heat recovery feeds. As we had till as we were discussing that the issue is the development of the humankind and development of a society or state and this development it is not a local or it is not a very instantaneous phenomena. The development should take place all over, development should prolong with time continuing with time.

So, in this regard there is a terminology or there is a term which is very often used that is sustainability. So, development that meets the needs of the present without compromising the ability of future generation to meet their own needs that is called sustainability. We have to have development so, that now we are comfortable, that is good, but that is not good enough the way we are comfortable the future generation should be also comfortable in the same way. And it encompasses many issues energy is only one of them, it could be water usage of water, it could be usage of land, it could be usage of mineral, it could be usage of forest products etcetera.

So, it may also be defined as the requirement of our generation to manage the resource base such that the average quality of life that we ensure ourselves can potentially be shared by all future generation and; obviously, if the quality of life that depends on energy. So, when we talk about sustainability energy is very important. Then we come in the next level let us discuss what is energy security.

The international energy agency defines energy security as the uninterrupted availability of energy sources at an affordable price. So, there are energy sources renewable, non-renewable there should be planning for recovering waste heat it should be done in such a way. So, that in future the energy sources are not in such a condition. So, that people cannot approve this either it is not available or it is having exorbitant for a price that should not be the usage pattern that should not be the pattern of harnessing energy. So, this is called energy security.

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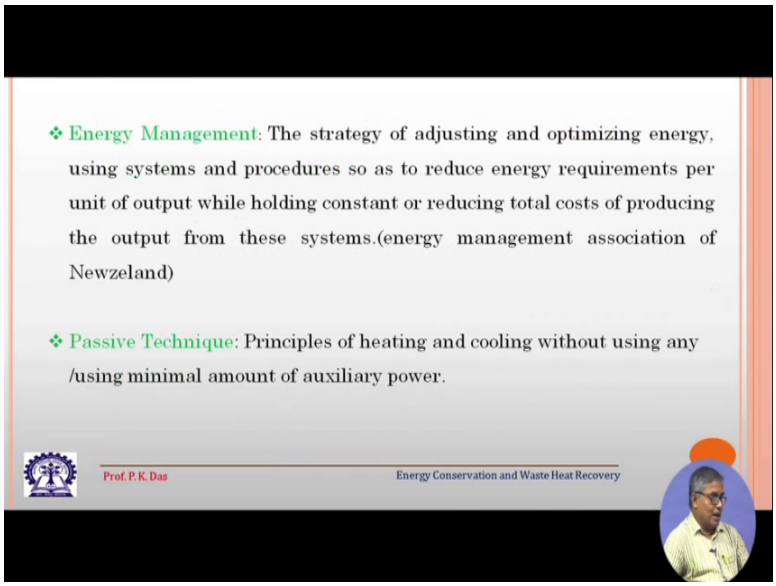

Now, energy security that is; obviously, is a concern of a state sustainability that is; obviously, a concern of a state. Energy management; energy management could be the concern of a system which is not as big a state it could be the concern of a factory or industrial.

This strategy of adjusting and optimizing energy, using systems and procedure so as to reduce energy requirements per unit of output while holding constant or reducing cost of production or of producing the output from this system that is your energy management. So, for a system or for an industry one has to go for energy management. And then some more topic, I like to discuss one is your passive technique, what is a passive technique? Passive technique it is another useful energy activity and mainly it is associated with renewable the principles of heating and cooling without using or using minimal amount of auxiliary power that is your passive technique.

So, you see for energy management or energy security, it is a very useful practice or useful principle. If we see in the perspective of waste heat recovery it is some sort of supplementary it is some sort of parallel kind of principle for waste heat recovery, where we are using some sort of natural energy, energy from natural resources for heating and cooling. One example is trombe wall. What is the trombe wall?

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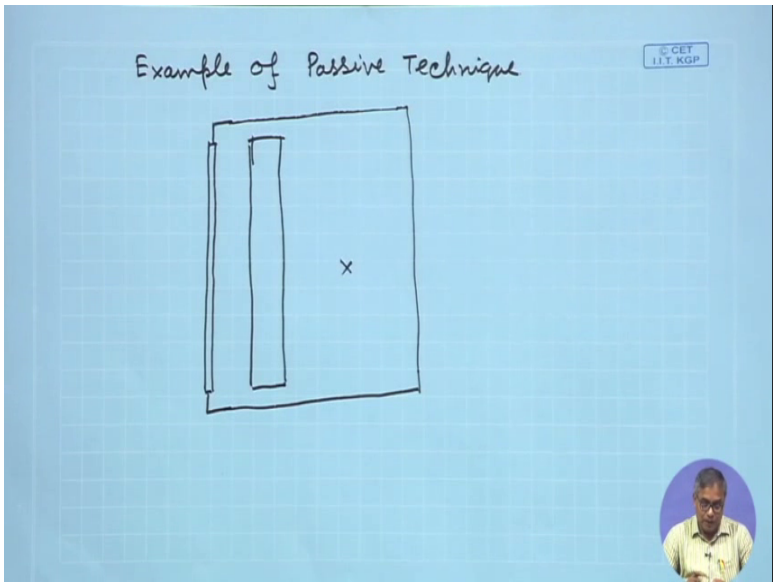

So, trombe wall; let me explain it example of passive technique.

So, let us say we are considering space comfort space heating and space cooling. Now what one can have one can use solar energy for that. So, let us say what I have drawn that is some sort of transparent wall or fenestration and below behind that there is some sort of a massive wall during day time it can store energy, it can store energy and during night time when there is there is low temperature in the in the living space. So, this is the living space this is the living space. So, what one can do one can have this energy either radiated or due to convection it can be utilized for heating of the living space.

Now, the with some sort of a change of the design, what one can do? That this is heated during daytime; during night time I can make the air flow with the help of this heated wall in such a way that the air is taken away from the living space and some cold air is entering in the living space.

So, this can be utilized even for cooling to some extent it can be used even for cooling. So, this is an example of a passive technique and it goes hand in hand with the waste heat recovery or the energy conservation principle; obviously, in our present course we do not have much scope of discussing or describing this kind of system, but at the beginning when we like to see waste heat recovery in it is full perspective. So, it is important to know there are passive techniques and in the total energy principle one should also consider them.

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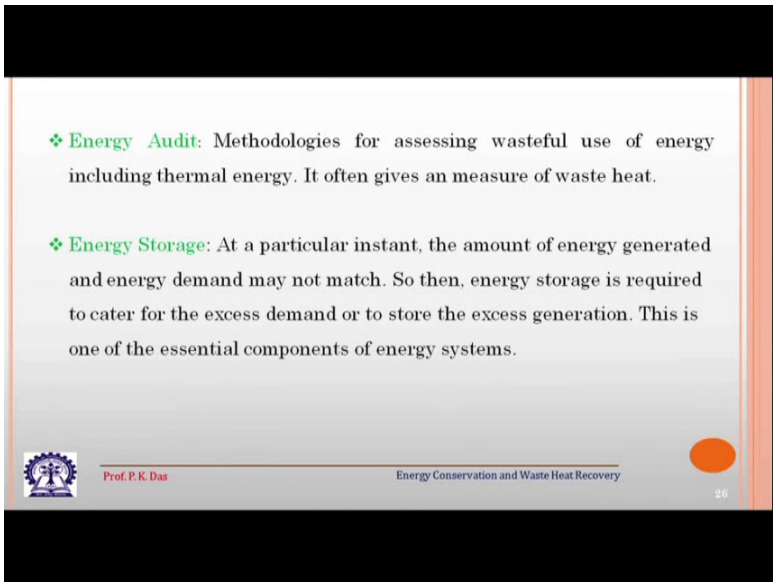

Energy audit; energy audit actually a methodology the methodology this methodology can encompass, calculations, estimation, measurement, and by this by combination of all these one can assess the wasteful use of energy including thermal energy. It could be everything, but thermal energy plays a very important part, because we can assess where there is wasteful use of thermal energy and it go often gives an measure of waste heat or possibility of recovering waste heat. Along with other benefit is so energy audit that is also very important. Particularly, for an existing factory if we want to know how much waste heat is there how much of heat can be recovered, so energy audit could be a very useful tool.

Then energy storage; energy storage as such it is a very important aspect of energy conservation and in the present course the other instructor is going to spend good amount of time on energy storage. So, at a particular instant the amount of energy generated and the energy demand that may not be equal. Let us say in an energy system we are having renewables also we are having also fossil fuels. So, during day time solar energy is available so; obviously, we generate more energy during day time.

But this demand may not be that high. So, that energy has to be stored. So, that it can be used when it is required. And there are different devices, different methodologies for storing this excess generation. The energy has to be stored in such a way so that the losses during storage that is less and when we are storing during storage period the loss

is less, when we are storing that there is minimal loss, when again we are extracting energy there is minimal loss.

Let me give you a; give one example. let us say we are having some sort of thermal energy and at present we do not have any usage of heat we have to store it and that thermal energy is utilized for producing power, let us say running a turbine or some such thing generating steam. So, how can you store it? We can store it in the form of electricity. So, from thermal energy we have to convert it into electricity and then again we have to convert it when it is needed into thermal energy, because we want to run a turbine or we can store it in the form of thermal energy itself.

In the first case two times we have to convert the energy; once from thermal to electrical and then from electrical to thermal again. So, really one has to consider what are the losses during this conversion. So, energy storage is another important aspect which we are going to deal in this particular course.

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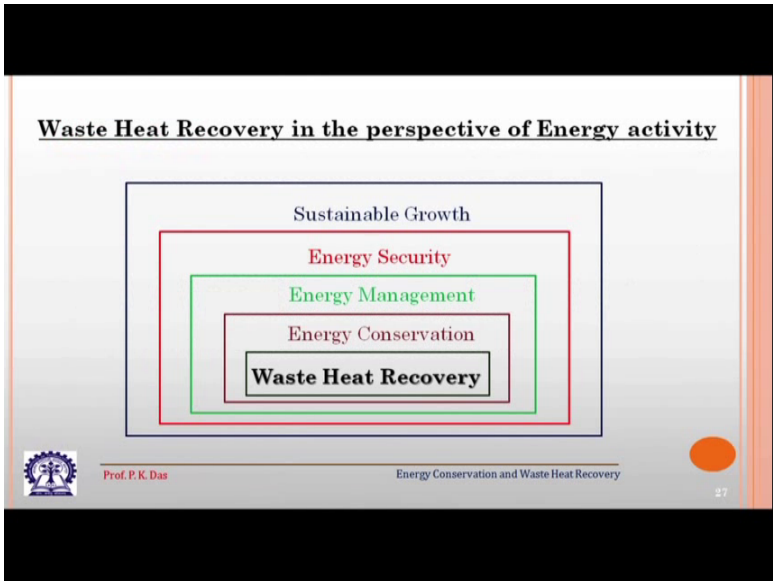

Then lastly, waste heat recovery in the perspective of energy activity. So, this diagram is very important, let us spend some time on this diagram. At the outer layer we are having sustainable growth. So, this is important for a state for a society even for the entire world sustainable growth is important. There are many aspects like land, water, food, environment, forest and of course energy, then if we want to go towards our goal, then there is energy security. This is again globally important, but it is very important for a

state. So, the state has to ensure the energy security how energy supply will be there in future days, what will be energy usage pattern, how much of it will be renewable, how much of it should come from waste heat recovery that is very important.

Next level if we go, then we are having energy management. This energy management is the outlook or is the policy adopted by a particular organization or industry. So, what does it mean? At what price it will purchase energy from which sources it will purchase energy? How much of it is funding for energy will go for waste heat recovery? How much for renewable etcetera and then the next layer is energy conservation.

Now, energy management that cannot be successful if there is no good principle of energy conservation and energy conservation already I have discussed. So, energy conservation it again constitutes different activities. Let us say we are considering one big industrial establishment where there is large plant for hvac heating ventilation and air conditioning.

So, energy conservation principle dictates that wherever there is built environment wherever this heating or cooling off space is used those spaces are to be well insulated. Those places are to be designed in such a way so that there is less amount of infiltration. So, this is one of the activities of energy conservation. If there is any pipeline for hot gases it has to be insulated. So, that there is lesser amount of loss, but these are not enough. So, there should be some sort of waste heat recovery devices also if possibilities exist. So, there it comes the waste heat recovery. So, this is the inner layer of energy one of the inner layers of energy conservation. So, waste heat recovery we can take as some sort of a subset of this set called energy conservation, where there are many activities and this is how they are very closely related.

So, our main focus of this course will be waste heat recovery, time-to-time we will go to the outer layer that is your energy conservation, because waste heat recovery is also one energy conservation principle and some other aspects of energy conservation also we will see with this I come to an end of these ah four lectures I have taken which constitute some sort of a background of waste heat recovery.

Now, from the next lecture I will switch over to some thermodynamic principles. Principles of power generation which serves as the background of waste heat recovery. So, thank you if you have got any query you can contact the teaching assistants details

have been given the instructors details have been given. So, you can contact and then some of your doubts we will your doubts we will try our best to clarify your doubts.

Thank you.