Power Plant Engineering

Prof. Ravi Kumar
Department of Mechanical & Industrial Engineering
Indian Institute of Technology, Roorkee

Lecture – 01
Energy Scenario and Basic Concepts

Hello, I welcome you all in this course on Power Plant Engineering. Today in the first lecture we will discuss about the Energy Scenario and Basic Concepts. Now topic to topics to be covered in today's lectures are first, we will start with the introduction of power plant engineering.

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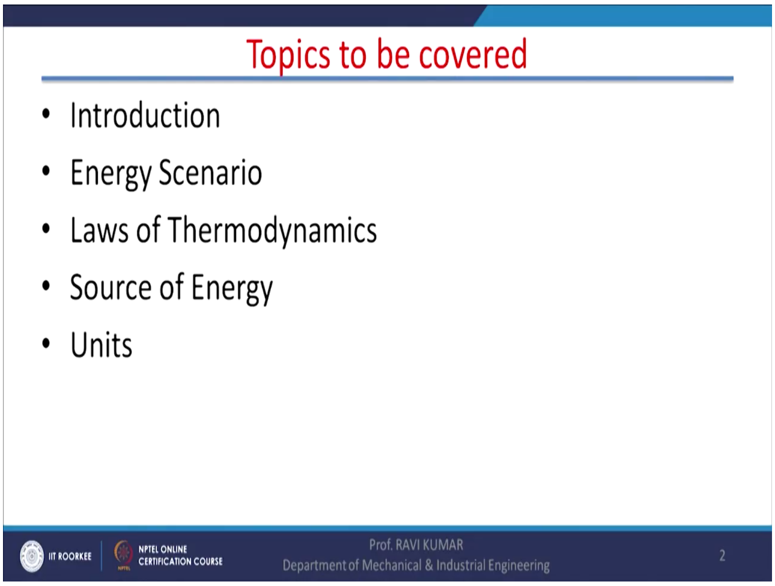

Then we will discuss a little about the Energy Scenario, then some basics that is Laws of Thermodynamics because laws of thermodynamics are important because they are the basics for the power generation or conversion of heat into the useful work. Then Source of Energy because when we want to generate power, source of energy is also required. So, we will discuss about the source of energy also and at last the Units of power generation.

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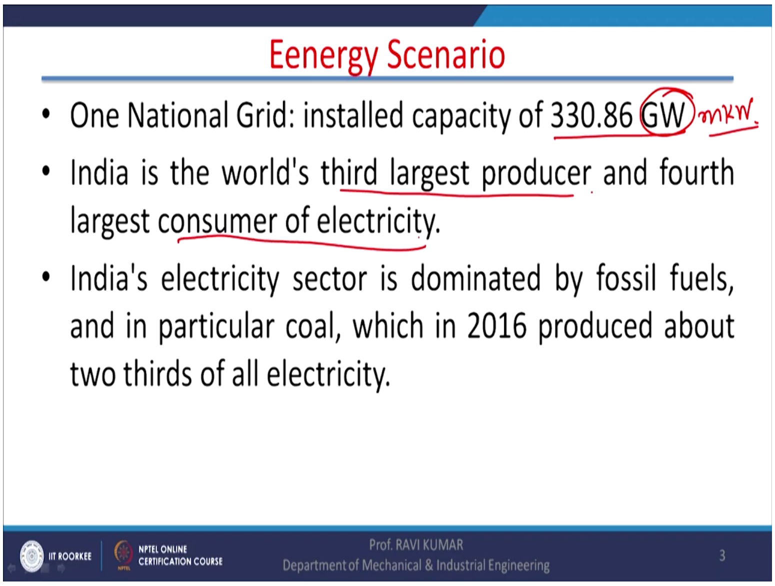

First of all I like to discuss the Energy Scenario in India. We have one National Grid and this National Grid this National Grid is has a capacity of 330.86 giga Watt of power generation. If you want to convert this into million kilo Watts, so Giga Watt can be replaced by million kilo Watt because we are very much converse with the unit kilowatt.

So, it is 330.86 million kilo Watt and we are the third largest producer of an energy and the fourth largest consumer of electricity and electricity is the part of, we cannot imagine life without electricity. It has become part of our life. In fact, in any civilized society we cannot imagine life without electricity and electricity is generated in principle it is generated by with the help of mechanical work in most of the power plants in most of the power plants.

This electrical work sorry, this mechanical work is again generated with the help of heat that is where the laws of thermodynamics comes into the picture where we can convert available heat into the useful work. So, all these we will discuss in the in this lecture. Normally power generation in India is dominated by the fossil fuels. We have thermal power plants and two-third of the power is generated with the help of fossil fuels.

So, it has some environment related issues also, but as the time goes by the technology has developed and now a days the thermal power plants have lesser impact on the surrounding environment.

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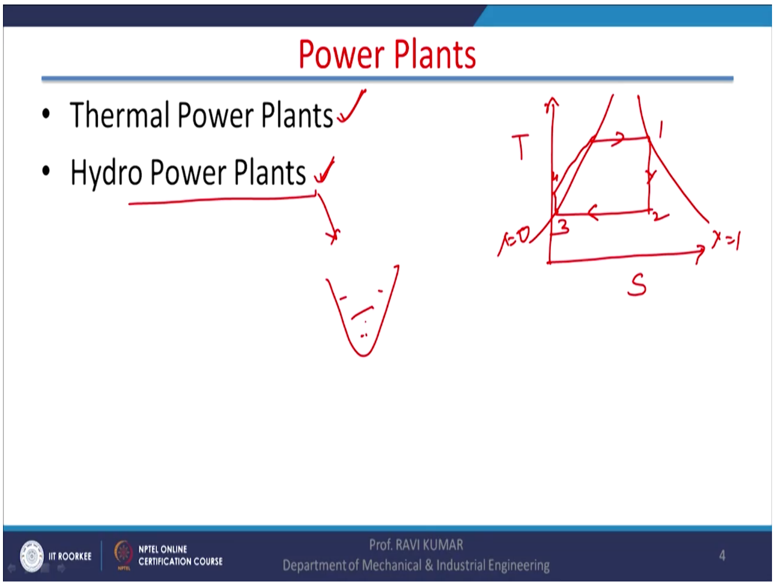

Regarding the power plants mainly the energy is generated in thermal power plants and hydropower plants. In thermal power plants the fossil fuel normally fossil fuel is burned because our most of the power generation in thermal power plants in India is through fossil fuel. And this fossil fuel, this heat this heat of fossil fuel generates steam and that steam enters the turbine and the turbine gives the output in the shaft in the form of shaft work and the steam which is coming out of the turbine goes through the condenser.

As you know in a rankine cycle if you look at the rankine cycle if on temperature entropy scale. So, this is x is equal to 0 this is x is equal to 1. So, if you look at the rankine cycle the expansion of a steam takes place in process 1 to 2, then there is condensation of a steal process 2 to 3 and in after process 3 that is water only, it is pumped the pressure is raised and the water is sent to the boiler and where the heat is added to the water.

So, this is basic working principle of any fossil fuel based thermal power plant. However in the case of hydro power plants the kinetic energy and the potential energy of running water is converted into the useful work and it is a type of renewable source of energy. Water is a renewable source of energy because with as the time passes by the energy is replenished.

So, that is the benefit of hydro power plants. They also have an impact on the surrounding environment because whether you have to build the dams and dams are normally build in the valleys right and this has environment impact.

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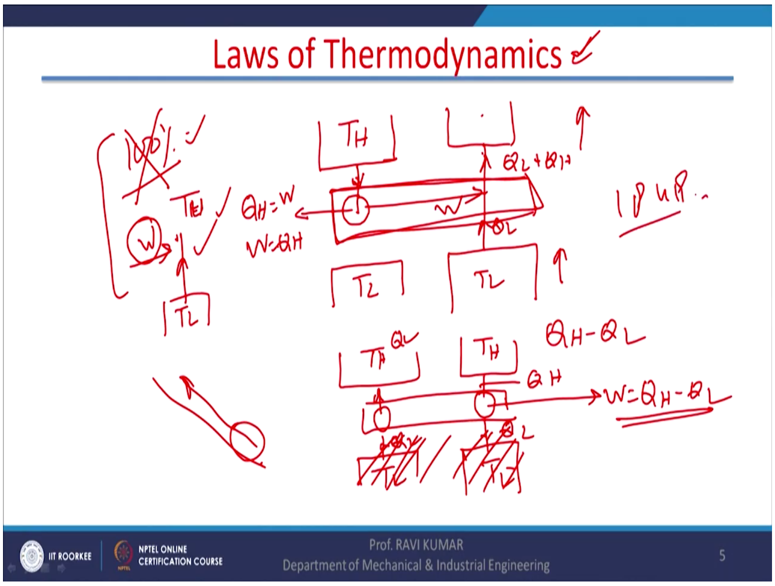

Now, before we start with the with the power production let us refresh our knowledge on the laws of thermodynamics. As all of us know there are 4 laws of thermodynamics. I will start with the II nd law of thermodynamics because II nd law of thermodynamics is important because it tells us that we cannot have engine efficiency engine of efficiency 100 percent or any cycle cannot have efficiency more than the efficiency of a current cycle.

So, the laws of thermodynamics have state, two statements. One is Clausius statement; another is Planks statement, because Plank said that it is not possible to convert entire available heat energy into the useful work right. So, an engine cannot have 100 percent efficiency. It is not possible at all.

Now, Clausius said that the heat cannot flow from lower temperature to higher temperature; higher temperature by its own. So, work has to be required. For example, we cannot take any object from low elevation to high elevation, right. If you want to take any object from low elevation to high elevation, so work has to be done.

Same is the case here. If heat has to flow from lower temperature to higher temperature some external work is required, but these two statements actually they mean the same. They mean the same if you violate one statement, another statement is automatically violated. For example for example, I will give you an example. For example, let us say there is a machine which violates the Kelvin statement. So, temperature, high temperature to low temperature right and we find a heat engine which converts all heat coming from higher temperature into the work. So, QH is equal to work or work is equal to QH.

So, whatever heat is drawn from here is converted into the work and there is no heat rejection at lower temperature. Suppose this device is invented. Now if this device is invented, then look at the scenario where we have to pump QL at lower temperature. Now, if we combine this these two then work will come here and this will be QL plus QH and this heat will be rejected here.

Now part of this heat can be used again for pumping the heat from lower temperature to higher temperature or we can say if we consider this as a system, then heat is flowing from lower temperature to higher temperature without any external work. So, such type of arrangement is not possible. Now if we consider that there is a violation of Clausius statement, the Clausius said that heat by its own cannot flow from lower temperature to higher temperature.

Now we make a device. This is higher temperature and this is lower temperature right and there is a device which make this happen. I mean heat is flowing from lower temperature to higher temperature without any external work right. Suppose there is QL is going to here is going here and now we have an engine which takes heat from higher temperature QH and reject some part at lower temperature QL, this is TL and does some work. So, work is let us say work is QH minus QL.

Now here in this case if we combine these; if we combine these, then QL is entering at lower temperature, QL is leaving the lower temperature and this part of the system can also be eliminated. So, we will get a heat engine which draws QH minus QL right, heat form the source and does equal amount of work.

So, here we can say we can see that violation of Clausius statement will automatically lead to the violation of Kelvin's statement and violation of Kelvin's statement will automatically lead to the violation of Clausius statement. In fact, the Lord Kelvin was the person who coined this word thermodynamics in 1848. Before that this word was not existing at all.

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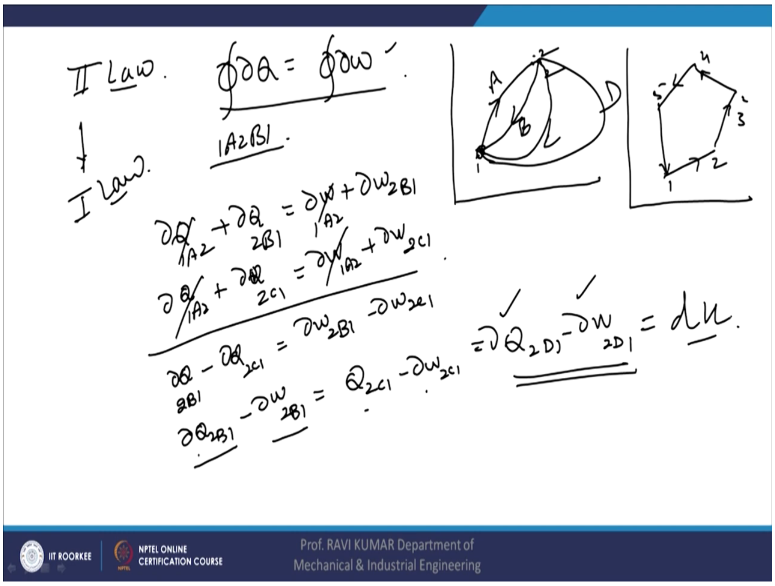

So, we have discussed the II nd law of thermodynamics II nd law. Now before we discuss the II nd law I mean after the discussion of II nd law we have come to know that heat can be converted into the work right. So, now comes Ist law into the picture I st Law states that heat can be converted into the useful work.

So, the exact definition of the I st Law is in a cyclic process. The net heat given to the system is the net work done by the system right. So, in a cyclic process, cyclic process means their number of processes starting from 1 to 2 let us say 2 to 3, 3 to 4 and let us say 4 to 5 and 5 to again 1. So, these are the cyclic processes.

So, in the cyclic process net heat given to the system it means cyclic integral of heat is equal to cyclic integral of work, that is I st law of thermodynamics. I st law of thermodynamics is silent about the internal energy right. The internal energy is the derivative of the I st law of thermodynamics. I will show you how.

For example, you have to go from one point to point 2, state 1 to state 2. Now, while moving from state 1 to state 2 you can take path A right. Now you want to come back to state 1, then you can take path B or you can come by path C also. Now we will apply I st law of thermodynamics.

So, here now in this process 1A 2B 1 cyclic integral of heat transfer. Cyclic integral of heat transfer means del Q 1A 2 plus del Q 2B 1 is equal to cyclic integral of work that is del W 1A 2 1A 2 1A 2 plus del W 2 B 1. This is one cyclic process 1A 2 B 1. Let us take another cyclic process that is 2. See there is 1 A 2 C 1. So, if we take another cyclic process 1 A 2 C 1, then del Q 1 A 2 plus del del Q 2 C 1 is equal to del W 1 A 2 plus del W 2 C 1.

Now, we take difference of these two. So, this will be cancelled out and this will also be cancelled out. So, del Q 2 B 1 minus del Q 2 C 1 is equal to del W 2 B 1 minus del W 2 C 1. We can see further rearrange this equation as we can take del Q 2 B 1 minus del W 2 B 1 is equal to Q 2 C 1 minus del W 2 C 1 right.

So, here we can see that if we take any process like 2 to 1 the difference of heat interaction and work interaction is equal to the heat difference of heat interaction and work interaction if we choose another path. So, it is independent of path right. We can have another path like D like D here.

So, we can have Q 2 D 1 minus sorry del del W 2 D 1 so on. We can have N number of paths for written and the difference between heat interaction and work interaction is going to be the same. It means there exist a property the there are characteristics of a Thermodynamic property is that it is independent of the path how it is achieved the state independent of the path how the state is achieved.

So, we are going from state 2 to state 1 and the difference of these two is constant and it is independent of the path and that is how the internal energy has come into the picture in I st law of thermodynamics. So, I st law of thermodynamics tells us about the heat and the work interaction.

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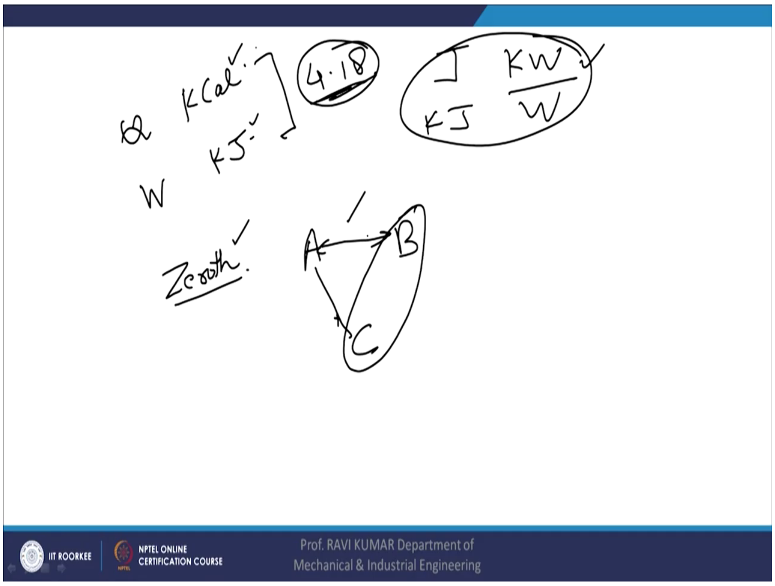

Now a days in old days the unit of heat transfer was kilocalorie for heat and for work it was kilo Joules or Joules, right and there was a conversion factor also 4.18 which was 4.18 right which through which we could convert kilo calorie into the kilo Joules right. But now a days in si system all energy is expressed in terms of Joules and kilo Watts or kilo Joules or Watts, right. So, energy is expressed in so that because they are mutually converted convertible and one form of energy is heat, another form of energy is work right. So, that is why both are having the same unit.

Now, after this II nd law of thermodynamics one more law is remaining that is zeroth law. It is the youngest law. It is the latest law because now we have discussed that heat can be converted into the work right and here the temperature is important. So, the concept of temperature has been given by the zeroth law of thermodynamics. Now, zeroth law of thermodynamics states that if there are three bodies A B and C A is in thermal equilibrium. Thermal equilibrium means there is no heat transfer between A and B. There are two types of equilibrium in thermodynamics; thermal equilibrium and thermodynamic equilibrium.

In thermodynamic equilibrium it has to be there has to be a chemical equilibrium. Thermal equilibrium there should not be any net force working on the system, but however in the case of thermal equilibrium we focus only on the heat interaction. There should not be any heat transfer between A and B.

So, if there is A and B are in contact and if there is no heat transfer between A and B, we will say that they are in thermal equilibrium. Now A is also in thermal equilibrium with C, right. So, in that case B and C shall also be in thermal equilibrium. So, this is zeroth law of thermodynamics. It is law of equivalence and it gives the concept of temperature measurement or the temperature.

So, IV law of thermodynamics is not much of engineering importance, but the III rd law states that at absolute 0 temperature the net energy of the system is going to net entropy of the system is 0. So, these three laws of thermodynamics zeroth law, I st law and II nd law are of engineering importance right.

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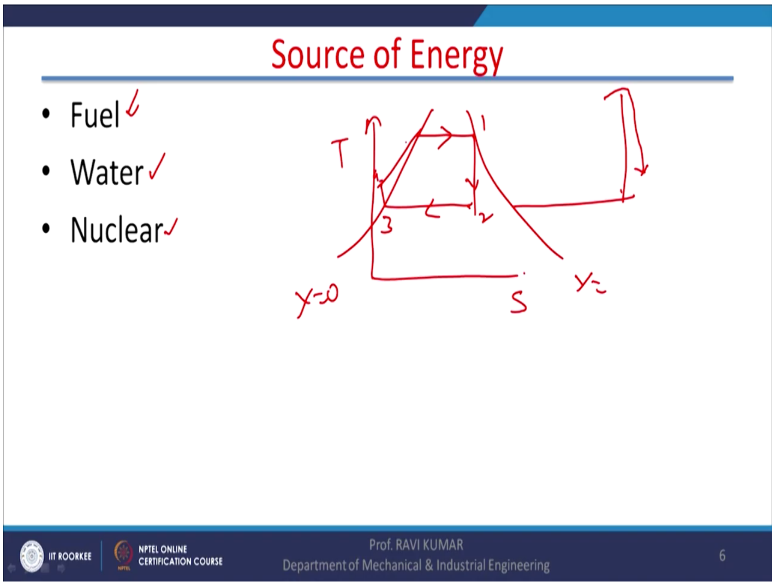

After these laws we will take up Source of Energy. Now, source of energy for electricity generation is fossil fuel. Fuel means fossil fuel the fossil fuel is burned and the heat is generated in like in thermal power plants. Water is also very good source of energy because the flowing water or run of water has a lot of energy. It carries a lot of energy, kinetic energy and this kinetic energy can be used for power generation and water falls they have potential energy. This potential energy is also used for the power generation. That is why dams are made for hydroelectric power plants.

In these dams the water is stored and the these high potential and high velocity water when it falls on the turbine, it makes the turbine rotate and power is generated and the 3rd one is nuclear power plants. Nuclear power plants they do work on, nuclear power plants also they also work on rankine cycle in, but in the rankine cycle there is certain modifications. Suppose this is temperature and entropy.

So, in a rankine cycle, so what nuclear power plants they do have turbines, they there are with the steams. So, they have steam turbines, they have condensers, however they have pumps also to pressurize the waste. However, where the heat is added from process 4 to process 1, this heat addition in normal thermal power plants it takes place inside a boiler.

Now, in nuclear power plants this heat addition takes place inside a nuclear reactor where fission of fuel takes place during fission a lot of energy is generated. This energy converts water into the steam right. So, they are three main sources of energy, however in our country the contribution of nuclear power plant is only approximately 2 percent majority of the energy is produced by a fossil fuel and it has contribution of two-third of our energy production.

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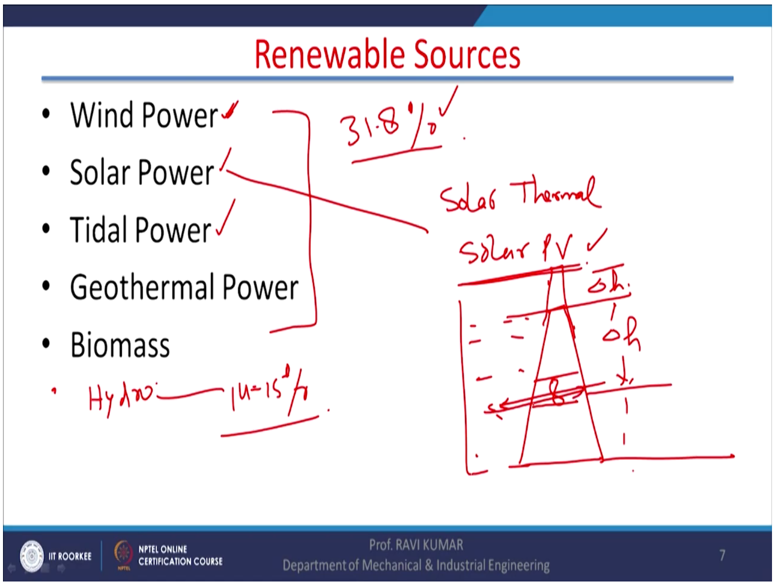

We have renewable sources also for energy and renewable sources of energy they contribute approximately 31.8 percent of our power production because in renewable sources we consider hydroelectric power as a renewable source.

So, hydro when we consider hydroelectric power also as a renewable source hydro power, then the contribution of the power generation contribution in the power generation by a renewable sources shoots up to 31.8 percent, but normally this is only 15 percent, 14 into 15 percent 14 to 15 percent of total power generation by hydro and remaining 14 to 15 percent is by these renewable sources.

In renewable sources mainly it is wind power, but wind power requires a lot of space and these mostly these systems are costly systems. Wind power requires a lot of space right and certainly is also not there I mean and it can be applied only a fixed terrain. I mean terrain I mean the geography of the place is very important when we apply the wind power. Wind power cannot be applied everywhere.

So, there is a threshold value for the wind speed below which wind power is not effective or it cannot be applied. Wind turbines are not effective. Solar power nowadays I mean we have I mean solar power solar power can be divided into two parts now; solar thermal and solar PV. Solar Photo Voltaic it is solar photo voltex. So, solar photo voltaic is used for nowadays for power generation and solar energy is converted into the direct current and that direct current is again converted into the AC and it is used beyond the solar power.

There are tidal powers. Tidal power is also there. In tidal power there is a suppose there is a dam and in this side of dam is has a reservoir and there is a through tunnel where turbines are fixed or a turbine is fixed. On the sea side when there is a high tide, when there is a high tide, then suppose height of the dam is this much.

When there is a high tide, then there is a difference in hand and the water will flow in this direction and power will be generated. When there is a low tide, then this is the head and water will flow in this direction and power will be generated. So, this is how the power is generated in tidal power plants.

Now geothermal power if we go down the earth, below the earth at a certain depth we will get sufficient temperature which is which will get sufficient temperature for the generation of a steam and suppose the places you must have seen that the hot steam is coming out of the; out of the earth right, so in those places the temperature at a particular height is depth is quite high to generate a steam.

So, geothermal energy is used for generation of a steam. Rest of the power generation is by the rankine cycle right, but geothermal power in geothermal power, the geothermal energy is used for generation of a steam biomass has not very significant contribution in the power generation.

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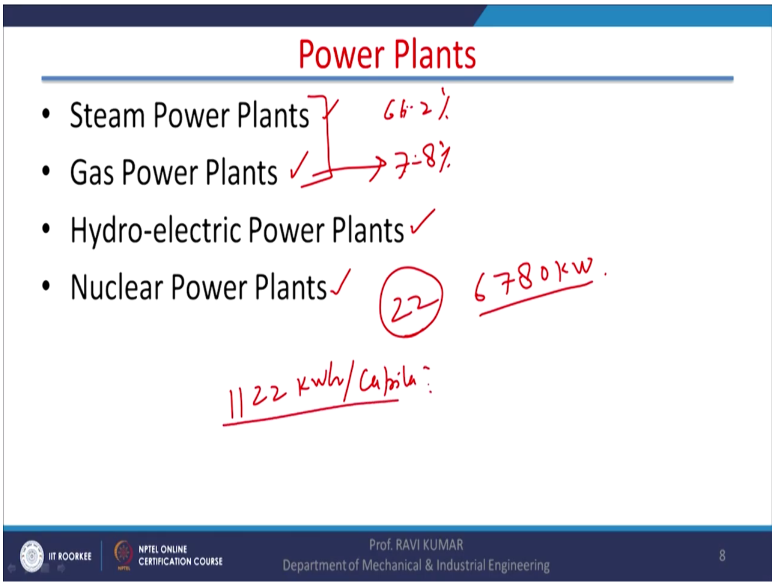

Now, we have in India we have Steam Power Plants which are running with the fossil fuel, we have gas power plants. So, as I said earlier steam power plants the or the fossil fuel based it has 66.2 percent of energy production, we have gas power plants also. This is they are together they make thermal power plants.

So, gas power plants they their contribution is between 7 to 8 percent and it is clubbed with this 66.2. So, 7.7 to 8 percent is part of the 62 66.2 percent. Then we have hydroelectric power plants. As I have said earlier 14 to 15 percent energy requirement is made by hydroelectric power plants, we have nuclear power plants which meet the requirement approximately 2 percent of our requirement.

Now, India has 25 22 reactors and these reactors are producing 6780 kilo Watts. The total capacity of these 22 reactors is 6780 kilo Watts. We have in average energy consumption is in India is 1122 kilo Watt hour that is units per capita. 1.22 kilo Watt hour per capita is the average energy consumption in India. Transmission losses are high in our country. The transmission losses are high if you look at the energy consumption pattern if you look at the energy consumption pattern.

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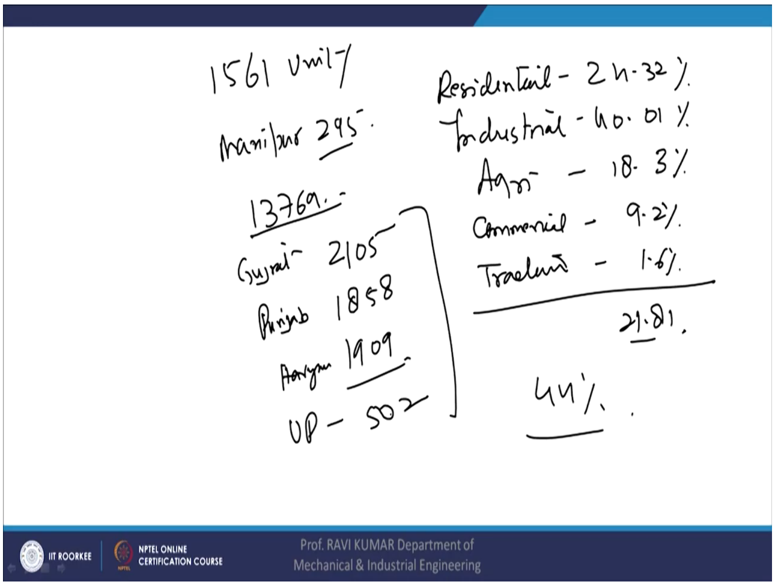

Then residential is 24.32 percent, industrial energy consumption is 40.01 percent. Agriculture approximately 18.3 percent Commercial it is 9.2 percent and traction it is traction it is 1.6 percent and losses are 21.81 percent. So, losses are quite transmission losses are quite a high in India and this total power generation in India 44 percent is generated by the power sector.

If you look at the per capita state wise all if you look at the per capita power consumption by the states, then Delhi is 15.61 units per person and Manipur has the lowest it has 295 units per person and the highest per capita power consumption is 13769 it is in Dadarnagar Haveli perhaps due to number of industries there.

There per capita power consumption is 13 769 kilo Watt hour per units per person. Gujarat has 2105, Punjab has power consumption per capita 1858 and Haryana 1909, UP has up has 502. This is Haryana, this is Punjab and this is Gujarat. So, industrial development or the property of state also depends upon the per capita power consumption. So, this fact cannot be cannot be denied while judging the prosperity of an individual state fundamental units of power. Normally as I said earlier there were Watts and Kilo Watts, sorry Kilo Calories and Joules normally.

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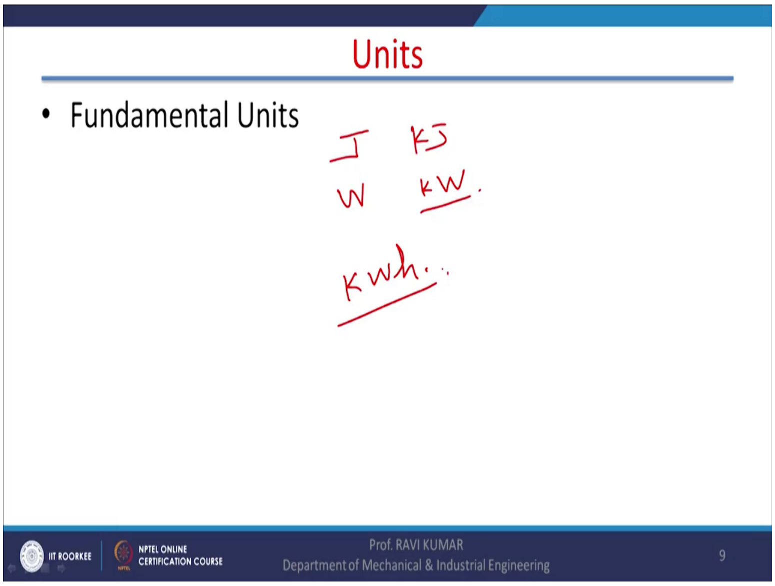

Now, a days for energy we use Joules or kilo Joules or Watts for power Watts or kilo Watts and for unit of electricity consumption it is expressed in terms of energy or kilo Watt hours. So, 1 kilo Watt hour is 1 unit of power. That is all for today.

Thank you very much.