Energy Economics and Policy
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Week - 05
Energy Supply - Part II
Lecture - 02
Economics of Renewable Energy Supply

In the second lecture on Renewable Energy, we are going to discuss the policy structure that is in place to promote renewable energy.

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Before we begin with the policy and the structure of the policies let us start with the question on why government support and policies are important in the context of renewable energy? There is a large volume of literature on sustainability transition, where the engineers and sociologist mainly and other social scientists work together to understand the uptake of different technology at various points of time. They also analyze the economy, the policy, the social barriers that are there in the uptake of technology and this kind of studies frequently points out that, if they are not looked after in the initial phase and left to market selection alone, the radical innovations delivering the sustainability gain, emerging as niches might lose momentum and die out.

This happens because there is always some kind of an incumbent technology and in our context that is the fossil fuel-based power generation and we have also seen that many of the technologies associated with renewable energies are yet to be matured. If these technologies do not get government support in order to upscale and embed in the whole technological domain, then it might face a severe challenge at the initial phase and there lies the importance of government policies and support. Oftentimes this kind of new technology where the commercial viability is yet to be established also faces the challenge in the form of market failure.

If you think about renewable energy there are two types of market failure that we come across. The first one is because of the absence of internalization of all externality that is being raised by the production of power through non-renewable or fossil fuel-based resources. If these kinds of externalities are not internalized, then the cost that is there in the market that is the cost of output of fossil fuel-based power generation does not reflect all the costs that the power generation sector has to take into account.

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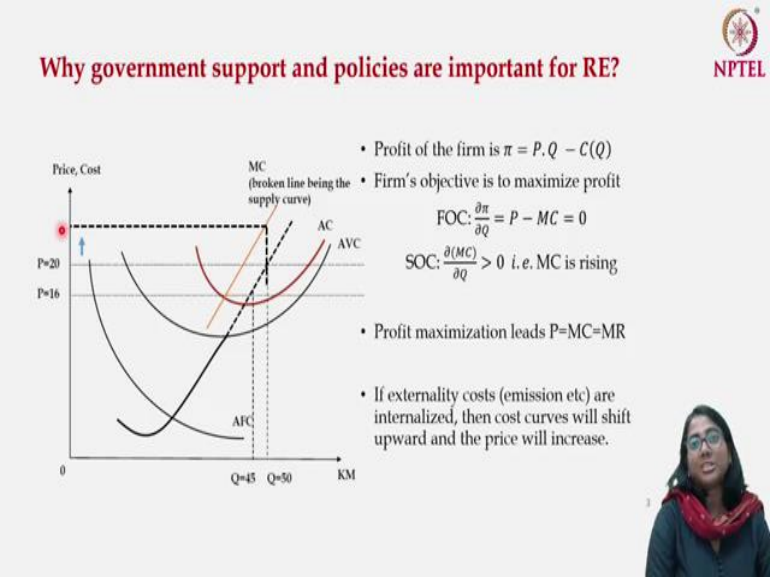

Let us have a quick look at the theory in order to understand, what do we mean by the internalization of externality? We have already come across this concept in our previous lectures where we showed that if you think about the production the prime objective of the producer is to maximize the profit which is $\pi = P.Q - C(Q)$ that is the difference between

the revenue and the cost and $C = C(Q)$. That is cost is a function of Q that is the output produced which in turn is a function of the input that is used in the production process.

The profit indirectly is a function of the amount of input that you are putting in the production and the price of those inputs. The firm's profit maximization objective actually led us to the condition where we found that P that is the market price has to be equal to the marginal cost of the firm which is equal to the marginal revenue that is $P = MC = MR$.

In the diagram, the upward rising part of the marginal cost curve of the firm was the supply curve of the firm. If this is the supply curve as well as the marginal cost curve, then if the firm has to supply quantity equal to 50, it can charge the price equal to 20. The marginal cost curve or any other cost curves actually do not capture all the costs that the firm should have taken into account. For example, if you think about Q as the output being produced, what are the inputs that are taken into consideration? In case of power generation, the inputs that are taken into consideration are capital that is the machinery, labour, energy is the fuel for example coal or oil or gas and there are service sector inputs and other material used.

What is not taken into account is the cost of the environment? The component of environment does not enter into the production function as an input but when the output is being produced that is when the power is generated in a coal fired power plant it is also using some atmospheric space as the input because it's dumping the greenhouse gas or the other pollutant that is being emitted as a by-product of the process in the atmosphere. However, the firm is not paying anything for use of that atmospheric space.

Some inputs are omitted from the production function. As a result, some costs are omitted from the cost function. This is called the ignorance of the external cost, the externality that the firm is generating. However, if this plant wants to internalize the external cost that it is generating in terms of probably environmental degradation or greenhouse gas effect the variety of input that one needs to take into account to construct the production function goes up. We have to incorporate the environment as an input in the production function that is to incorporate the cost of the environment in the cost function. The cost is going to go up and as cost goes up the dashed line is no longer its marginal cost curve, the marginal cost curve shifts up. When there is a shift from black dashed marginal cost curve to orange continuous marginal cost curve then to produce a particular quantity more cost needs to be incurred by the firm. The dashed curve was representing the cost of the firm. The new cost curve takes into account the external costs

as well. If the firm now wants to produce quantity which is equal to 50 which was being produced at price $P = 20$ on the broken MC curve, it will no longer be able to do that.

If the firm has to produce $Q = 50$ and supply that in the market, then the price needs to go up from $P = 20$ to the given point. As a result, if all the external costs are internalized by the firm, then all the cost curves will actually shift upward leading to a situation where the price of output in the market rises. There is a gap between the price of output produced from renewable energy and the non-renewable or fossil fuel-based energy. The cost of production of power through renewable is generally much higher as compared to the cost of production of power through conventional sources that is by the use of fossil fuel. Although, the market price signals but we also know that the market price is an underestimation of the true price of power that is being generated through non-renewable sources. We come back to the point that in the absence of internalization of all external costs the cost of energy generation from renewable remains high as compared to fossil fuel and is one reason for market failure attached to renewable energy.

The second point is about the time of benefit. If the firms underestimate the future benefit of investment into renewable innovation, they will not be willing to invest too much money from a macroeconomic perspective and there will be some under investment. This is because the alternative to renewable energy is fossil fuel which is depletable in nature. As we keep on using fossil fuel and reach closer to the end of the stock of fossil fuel it will become more and more expensive and probably at that point of time the return from renewable investment will be much higher but that is not going to happen today or tomorrow.

Oftentimes people do not understand the future stream of value that can be generated by investing in renewable energy today. This is the other reason behind market failure. Although these kinds of challenges are there but we have already seen that the investment in renewable is rising continuously and the cost is coming down. This is a good sign. Although, there are a number of technologies which are still to experience maturity. To understand whether these technologies can deliver some sustainable development goals it is important that renewable technology should have policy and other support from the government and here lies the role of the government.

However, you need to take into consideration the fact that there is not a single policy that can fit all sizes. There is no such blanket policy available for the promotion of renewable energy.

The policies that are required for the promotion of renewable energy may vary from technology to technology. The policy support that is required for solar may not be similar to what is required for wind or may be very different from what is required for geothermal. Also, it may vary based on the location. The kind of policy that you need in India may be very different as compared to the kind of policies needed in New Zealand. There can be an umbrella policy at the national level however, there can be sub policies at the state levels as well depending upon the structure of the country. There is a lot of complexity which is involved with renewable power generation. Although it is very important to shift from non-renewable to renewable power generation, it is important to understand that there are practical challenges associated with the production of power with renewable energy. It requires space and certain resources which may not be available all the time and renewable energy generation is also associated with intermittency as you cannot expect to generate the same amount of power from a solar backed energy supply system because the amount of sunlight will vary not only during the day but also during the year.

There is some kind of intermittency associated with renewable based energy and to give support to this intermittency fossil fuel-based energy is required. The shift to renewable energy should not be looked at as the only panacea of the whole problem. This is one of the medicines that we can have but there are other things which need to go hand in hand for example energy efficiency.

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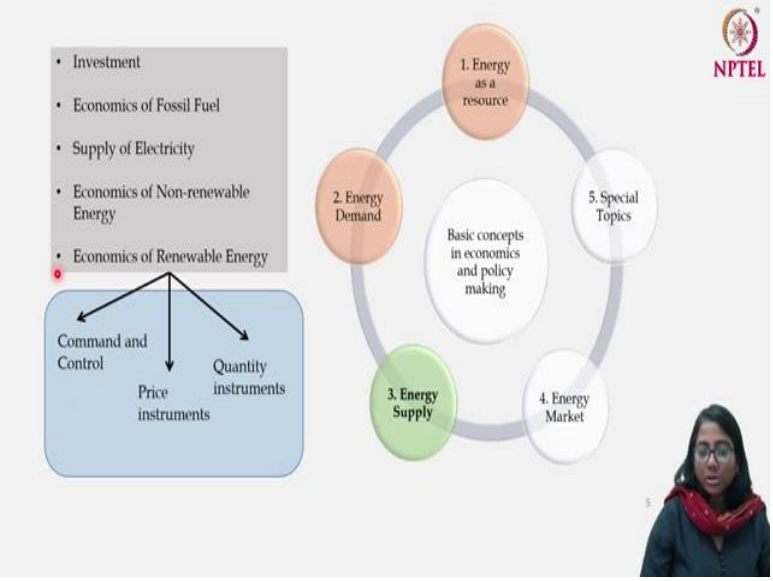

Let us look at the type of policies that we are going to discuss in this lecture. We are going to talk about three types of policies; one is called command and control, the second one is the price instruments and the third one is the quantity instruments.

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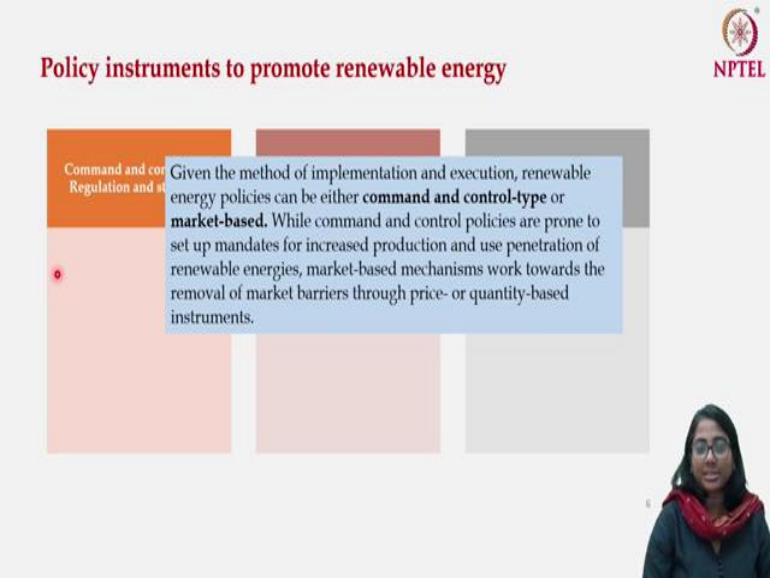

Although, they look like different policies but if you look closely the genesis is two types of policies; one is the command and control and the other is market based. Given the method of implementation and execution these renewable energy policies can be categorized.

What does the command and control policy do? This is more like a mandate driven policy. Some mandates will come from the state or from the regulatory authority and if the entity who is supposed to comply with that mandate fails, they have to pay a penalty. There is a penalty structure associated with that whereby either you comply and don't pay the penalty or you don't comply and end up paying a penalty.

The other is the market-based mechanism. In that case there is no hard and fast rule or there is no sort of penalty structure which is created. It creates a sort of market incentive so the producers and the users of renewable energy automatically go for increased supply and increased demand for renewable energy. Under the market-based policies there can be two varieties; one is the quantity-based policies and the other is the price-based policies. We start with the command and control policy.

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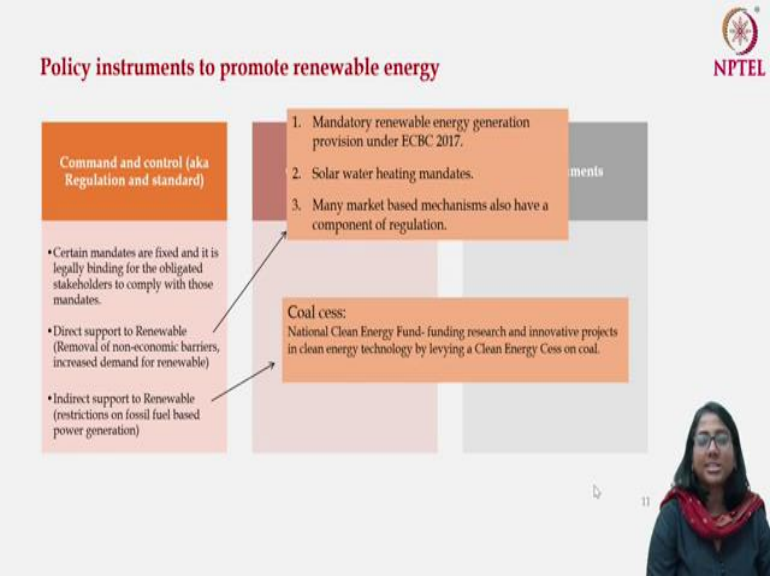

There are certain mandates that are fixed and it's legally binding for the obligated stakeholders to comply with that kind of mandate. Then we can come across a lot of policies that try to promote renewable are of command and control type. There are two types of policies under the command and control. The first one is those policies, which provide direct support to renewable energy. It leads to removal of all non-economic barriers and increases the demand for renewable energy, the examples are as follows. The energy policies to promote renewable energy, can span from all India level to the state level, to even sub state level. We are going to discuss a national policy, which is a mandatory renewable energy generation policy under Energy Conservation Building Code (ECBC) 2007.

We are also going to look at some of the state policies regarding the solar hot water mandates. Although the command and control policy, the price instrument and the quantity instrument look like disjoint policies actually they are not, usually these policies have more than one common component. The policies that we are discussing under the quantity instrument has a mandatory component as well. Oftentimes the policies are a mix of one or two domains.

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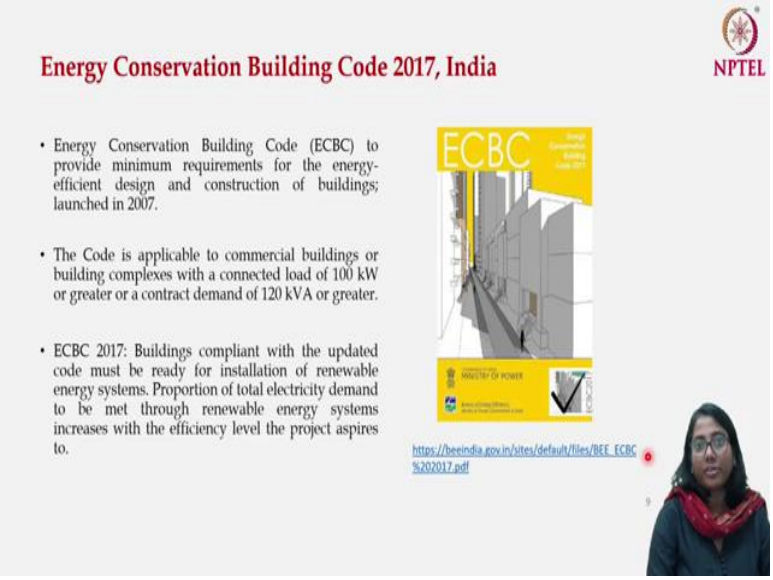

We start with the mandatory renewable energy generation provision under the ECBC 2007. The Energy Conservation Building Code (ECBC) was designed to provide the minimum requirement for the energy efficient design and construction of buildings in India. It was introduced in 2007 and many changes and updates have come up as new knowledge has been gained. This code is usually applicable to the commercial buildings or the building complexes with a connected load of 100 kilo Watt or greater or a contract demand of 120 kVA or greater.

These kinds of building codes are applicable in the context of big commercial buildings like hospitals or hotels or commercial areas. It is yet to be implemented in the context of the residential sector. As per ECBC 2007 the new buildings that are coming up which are of a particular format, size and a particular level of energy consumption have to comply with the code and have to have a provision of generation of renewable electricity in the building.

It does not say that you start generating renewable energy in the building but it mandates having the provision of it in the future. There comes the mandatory part where if they do not have future facilities then they do not comply with the Energy Conservation Building Code 2007 in India. The implementing agency of this program is the Bureau of Energy Efficiency under the Ministry of Power and this is one of the nodal agencies when we start discussing energy efficiency or in some cases also about renewable power. If you want to know more about this program, visit the BEE website through the link provided here. The Energy Conservation Building Codes are designed to promote energy efficiency.

Although it may seem that promotion of renewable energy is a different agenda as compared to energy efficiency, it is not so. All the energy policies come under the umbrella energy policy of a nation and they go hand in hand.

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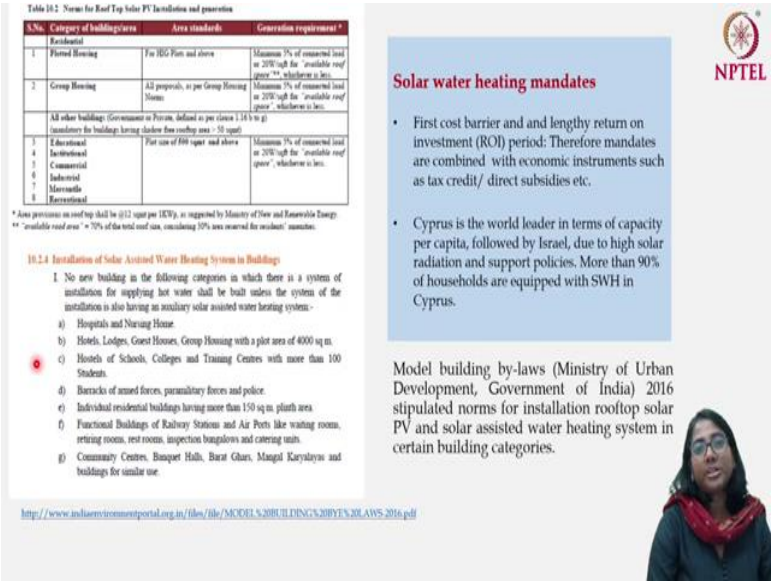

This is actually an excerpt from the model building by-law by the Ministry of Urban Development, Government of India, which was published in 2006. Point number 10.2.4 lays down the points related to installation of solar assisted water heating systems in the building and from point a to g different types of building are defined.

For example, hospitals, nursing homes, hotels, lodges, hostels, barracks, community centre etcetera and so on. For these kinds of buildings which have a particular area and particular load, have to mandatorily install solar assisted water heating systems for future use. Again, they do not have to immediately start but over a period of time it is mandatory that they start using the solar water heating system. What are the problems with the solar water heating system? Why is it so important to have a policy in place not only for solar but for other technologies as well?

The concept of return on investment, has been discussed which is net cash flow of the company divided by the investment multiplied by 100. It actually gave us the number of years that are required in order to recover the investment in a very crude manner. If the return on investment time period is very long, it actually shows that if I invest my money today, I might get some benefit but it will take years to recover that investment. Therefore, there is no general inertia

from the part of private investment to come for solar water heating systems and there comes the role of the government.

It can either make it mandatory or can create a certain kind of incentive. The solar water heating mandates in different countries or different states although is a mandatory policy, it comes along with some kind of economic instruments like tax credit or direct subsidies etcetera. Cyprus is the world leader in terms of capacity of solar water heating system per capita followed by Israel. This is not only because of the fact that they get direct sunlight and radiation for a very significant time but it is also because of the fact that they have a very favorable policy regime and economic incentives in order to promote solar water heating. More than 90 % households are equipped with the solar water heating system in Cyprus.

The next policy that we are going to look at is the indirect support for renewable. This is generated by putting some sort of a restriction on fossil fuel-based power generation and one classic example is the coal cess in India which was launched in the year of 2010. India has a fund which is called the National Clean Energy Fund whose objective is to fund the research and innovative projects in clean energy technology by levying a clean energy cess on coal.

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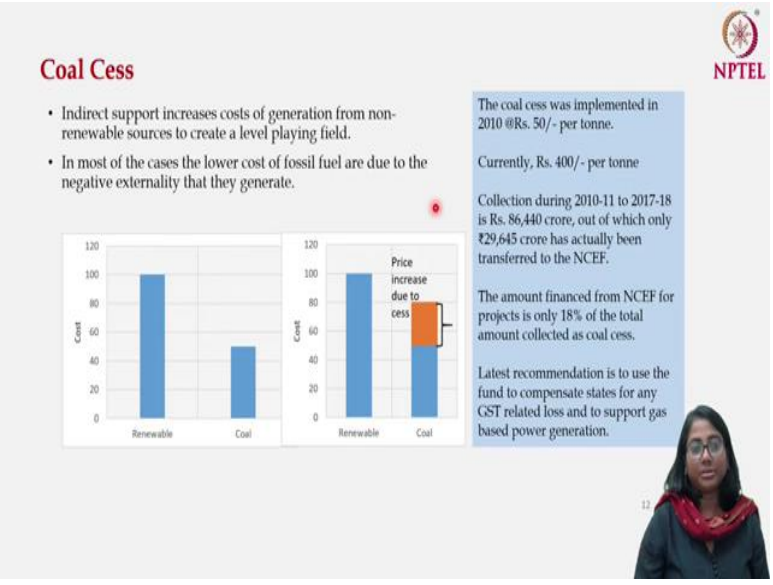

The indirect support that you get increases the cost of generation from non-renewable sources and it tries to create a level playing field between the renewable and non-renewable sources. The coal cess is increasing the price of coal, which is the primary input of the power generation in the thermal power station. If the input price goes up, the cost is going to go up and therefore,

the price of electricity that is generated out of coal is also going to go up. Therefore, it is not doing anything directly to renewable energy but is reducing the gap between the price of renewable and non-renewable energy.

Why is it so important to have this kind of structure in place? This can be legitimized in terms of the following argument that we have seen in most of the cases, the lower cost of fossil fuel-based power is due to the fact that they do not internalize the negative externality that they are creating. Cess is actually the price that was missing from the cost structure of the firm. The coal producer is paying cess because this is the price for emission generated from the production process of power from coal which is going to use atmosphere space. This diagram graphically shows the cost of power generated from renewable and from coal fired power plants with and without cess.

The price that we are getting for the power generated out of renewable energy is almost double than coal. Once the coal cess is in place the price of coal is going to go up. As a result, although nothing is happening to the renewable energy, the gap between the price of the electricity produced through the renewable and fossil fuel-based energy is going to be decreased.

The coal cess in India was implemented in the year 2010 at rupees 50 per tonne however, overtime it has increased to rupees 400 per tonne. During the period of 2010-11 to 2017-18 the total collection out of this coal cess is rupees 86,440 crore, out of which less than 30,000 crores has been transferred to National Clean Energy Fund. The amount financed from the National Clean Energy Fund for the projects is only 18 % of the total amount that is collected as a coal cess. Rest of the fund is actually somewhat idle or has not been used for the proper purpose. There is also the latest recommendation from the expert committee which suggested the use of a fund which is available with the National Clean Energy Fund in order to compensate the states for any GST related loss and also to support gas-based power generation in the country.

The argument for gas-based power generation is that gas may not be as clean as renewable but is much cleaner as compared to coal because it has a low carbon content. There is a large capacity of gas-based power plants, which is idle in the country, where the investment is sitting unproductive due to non-availability of domestic gas. The money from the Clean Energy Fund can be used to import gas from other countries and revive these gas-based power generation. This is the ongoing debate with arguments in favor and against this and is one of the proposals that has been put forward.

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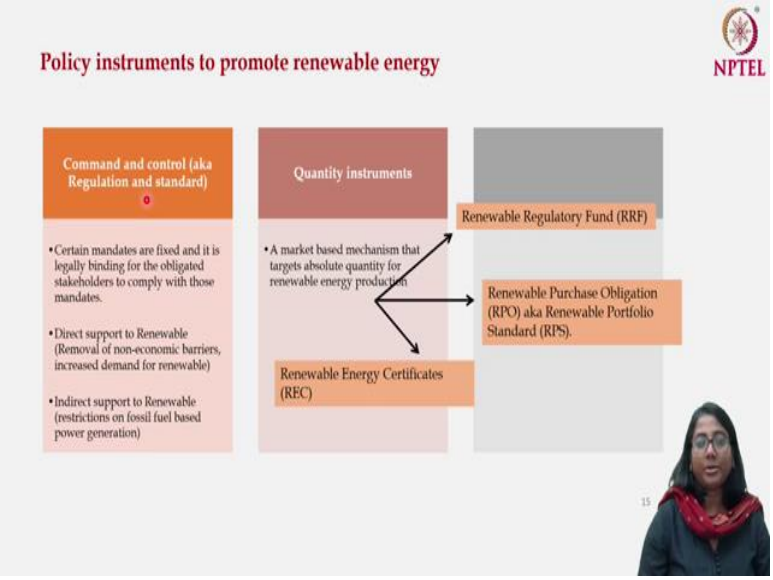

Next is the quantity-based instrument. As already mentioned quantity-based instruments and the price-based instrument both are market instruments.

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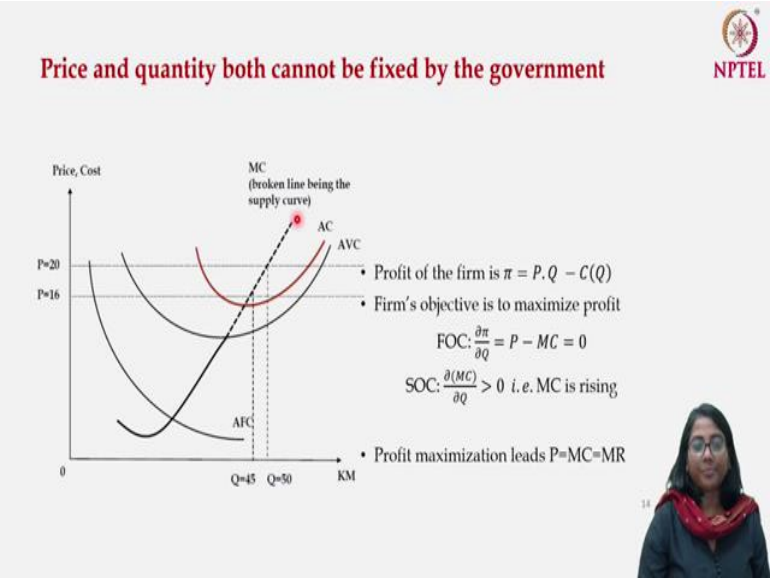

Let us have a quick look why price and quantity-based instruments cannot be implemented together. That is either the government fixes the price and let the market decide the quantity of renewable energy that is being generated or fixes the quantity or mandates the quantity and let the market come up with the price.

Now, the question is why the government cannot mandate both price and quantity? Again, we go back to the previous diagram where the upward rising part of the broken line is the marginal cost curve of the firm as well as the supply curve of the firm. If we assume that this is the supply of the renewable energy of the firm, then if the government fixes the price of renewable energy or fixes the electricity produced from renewable energy at rupees 20 then given the supply curve the firm will produce and supply quantity equal to 50 measured in suitable units.

However, the government cannot simultaneously decide some price equal to 20 and some quantity which is other than 50. Then, the firm has to deviate from its supply curve which will actually violate their profit maximization condition and that's not quite an optimum situation for them. Therefore, the government's interest is that it fixes the prince at 20 and let the market discover the quantity, which is eventually going to be equal to 50 or it can also say that at the end of the day I want to produce renewable power which is equal to 50 in some suitable units and let the market discover the price and given the supply curve the market discovered price will be P equal to 20.

In quantity-based instruments the targets are in terms of absolute quantity of the renewable energy production. Here, we are going to discuss three types of policy instruments, the first one is called the Renewable Purchase Obligation RPO. This is also known as Renewable Portfolio Standards or RPS depending on the geographical location of the countries. Usually the Renewable Purchase Obligation or the RPS is implemented along with another instrument which is called the Renewable Energy Certificates or REC. The third kind of policy is called the Renewable Regulatory Fund, this is not exactly the same as quantity instrument but it also addresses the quality issue of power supply.

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The Renewable Purchase Obligation is one of the major renewable energy policy instruments that are implemented in India. This is sometimes called the backbone of the policy instruments of Indian renewable energy system. It basically mandates the introduction of a certain percentage of absolute quantity of renewable energy capacity or generation at some unspecified price.

Therefore, it may or may not be technology specific. It says that a certain percentage of absolute quantity of renewable energy has to come from solar or from wind or sometimes it has to come from renewable energy. It means for example, 20% of renewable standard or 20% of Solar Purchase Obligation implies that all energy suppliers have to provide power to grid to meet such standard in order to ensure that whatever power they are supplying to grid, 20 % of it is coming from the green sources that is 20 % of it is coming either from the solar in case of Solar Purchase Obligation or from any renewable sources in case of Renewable Purchase Obligations.

If all energy suppliers have to comply with this kind of a policy it looks more like a command and control policy because there is no market element. They have to probably set up a small solar plant somewhere and produce the solar energy and supply it to the grid but it might be very expensive for them. As a result, this kind of inflexibility which is a typical feature of the command and control policy leads to certain kinds of inefficiency in the whole system if RPOs are implemented as the stand-alone instrument. The source of inefficiency arises out of the fact

that this policy if operated alone has less flexibility and Renewable Energy Certificate is the complimentary instrument that is provided or implemented along with RPO to get rid of this kind of inflexibility of the system.

The following are the features of renewable energy certificates. One Renewable Energy Certificate means production of 1 unit that is 1 megawatt hour of electricity generated using renewable energy. This is a non-tangible and non-tradable commodity at the first place. For the production of renewable energy, the producer is going to get Renewable Energy Certificate from the authority. The Renewable Energy Certificate has two attributes, one is that 1 megaWatt power has been generated and the other attribute is that it has been generated from renewable energy. These two attributes can be bought and sold together or they can be bought and sold separately. If I am producing 1 unit of energy with the help of renewable technology, then I can sell some of the DISCOMS both these attributes together.

The DISCOM has to comply with the target of 20% renewable purchase obligation. Both the attribute that is 1 megawatt of power as well as the renewability attribute can be sold to the DISCOM. However, it might also be the case that the DISCOM doesn't want to buy the electricity but what it wants to buy is only the renewability attribute. Only the renewable attribute can be sold to the DISCOM and the power that I have generated can be sold to the grid or to some other consumers. This kind of disjointment is possible. This kind of a policy whereby Renewable Energy Certificates are introduced along with the RPO gives flexibility in the system and it sort of ensures that the same target has been achieved at the least cost possible.

Here we can pause and think about the policy that has been discussed with respect to industries, which is the Perform Achieve and Trade (PAT). Under PAT there are government mandated specific energy consumption targets for the industries and the industries have to achieve those specific energy consumption targets. This is more like a mandatory policy without any market instrument, which resembles the functioning of RPO.

Here also the energy suppliers have to achieve some target of 20% of power from the renewable sources. However, PAT was not only about achieving a particular threshold of specific energy consumption it was also about a certain kind of market mechanism. If you recall the discussion, we said that if a particular industry fails to achieve the target of specific energy consumption, which may happen when the industry finds it very costly to upgrade the technology in a more energy efficient manner but cost effective to buy the certificates from the overachievers under

the Perform Achieve and Trade. Exactly the same thing is happening here. Although the target is to supply 20% of renewable energy, it is not mandatory to produce this amount of renewable energy yourself. It is discretionary to produce or not to produce oneself depending on cost effectiveness. If you find it cost effective you can produce it yourself or if you don't find it very cost effective then you can buy it from somebody else as well through the Renewable Energy Certificates. The Renewable Energy Certificate, the ECERs have sort of a similar property. It kind of gives the flexibility and cost effectiveness in a mandatory policy.

This is the combination, in a way you can say that RPO is a command and control policy but RPO along with REC, this is the combination and when implemented together this renewable purchase obligation and REC is a mix of command and control policy and the market driven policy.

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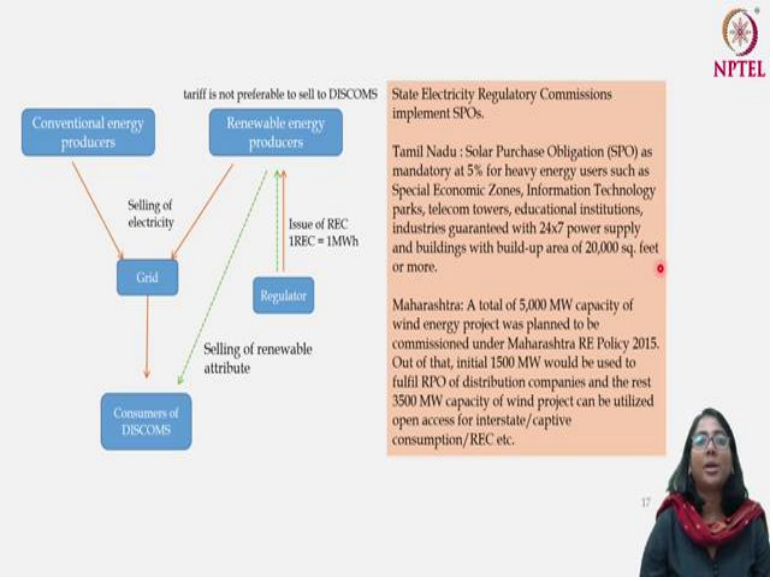

Let us have a quick look to understand in more details, how the Renewable Energy Certificate works? There are 5 stakeholders; one is the conventional energy producer, the second is the renewable energy producer. Both of them can provide electricity to the grid. There is a regulator who is actually issuing the energy, the RECs that are Renewable Energy Certificates and there are customers of the DISCOMS. How does the function of Renewable Energy Certificate happen? Once, the renewable energy producer produces electricity, the regulator issues Renewable Energy Certificates. REC has two attributes; the orange line actually represents the

attribute of electricity and the green line reflects the attribute of renewability. These two attributes are bundled and given to the renewable energy producer.

The renewable energy producer along with the conventional energy producer can supply the power to the grid. The renewable producer can also supply the power directly to the customers but this is the one of the examples. The DISCOMS actually sell power to the customer from the grid. The renewable energy producers, once they have sold the power to the grid, they are left with the renewability attribute. They have multiple options to sell the renewability attribute depending upon the exact design of the policy.

If the conventional producers are forced to show that a part is being produced from renewable sources, then they can sell it to the conventional energy producer, which is often not the case. In other cases, the DISCOMS may be under obligation to show that 20% or 25% of what they are selling is coming from renewable energy. They can sell the renewable attribute directly to the DISCOMS or they can sell directly to the consumer who wants to comply with such a mandate. Once, the renewables and the power component are sold, that is the time where the Renewable Energy Certificate actually retires. It is no longer in existence when both the attributes are sold in the market.

Let us have a quick look at two of the policies related to RPO and REC. In India State Electricity Regulatory Commissions usually implement SPO which are the Solar Purchase Obligation. Instead of calling it RPO we are calling it SPO because this is specific to a technology. The obligation is that 20% has to come from solar power. For the state of Tamil Nadu, the Solar Purchase Obligation that is SPO is mandatory at 5% for heavy energy users such as the Special Economic Zones, the information technology park, the telecom towers, the educational institutions, the industries who are guaranteed with 24*7 power supply and the buildings which are much bigger with the built up area of 20,000 square feet or more. All these entities who are bigger energy consumers have to comply with the mandatory target that 5% of their energy has to come from Solar Purchase Obligation.

In case of Maharashtra Renewable Energy Policy 2015, a total of 5,000 megaWatt capacity of wind energy project was planned to be commissioned. Out of that, it was decided that initially 1500 megaWatt hour would be used to fulfill the Renewable Purchase Obligation of distribution companies and the rest of 3500 mega Watt capacity of wind projects can be utilized for open access for interstate or captive consumption or for REC as well. So, once the power

is produced by the wind mills, the initial 1500 will actually go to fulfill the Renewable Purchase Obligation.

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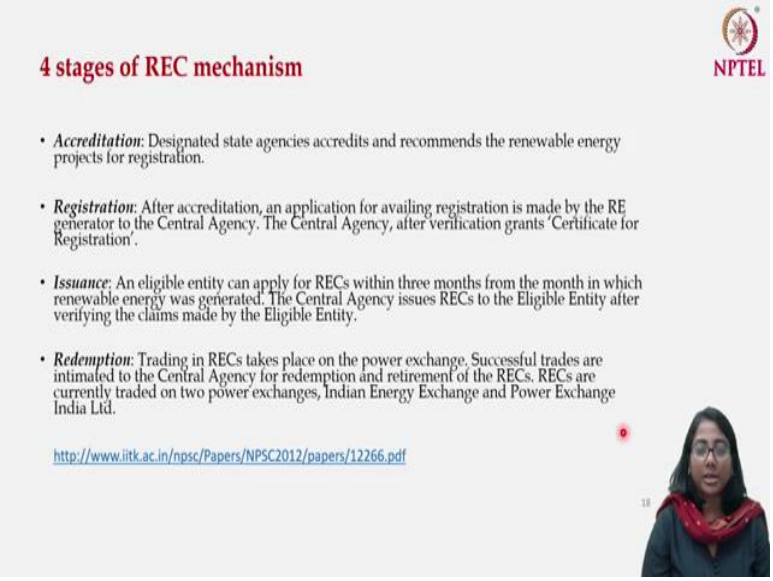

There are four stages of this Renewable Energy Certificate mechanism, the accreditation, the registration, the issuance and the redemption. The designated state agencies have to accredit and recommend the renewable energy project for registration. Once they get the recommendation, they go for registration after verification of all the documents and the central agency registers these renewable energy projects. Once, they are registered and once they produce the renewable energy within 3 months duration of the production of renewable energy, they are eligible to apply for the Renewable Energy Certificates. The same central agency will issue the Renewable Energy Certificate to these eligible entities, after verifying the claims made by them. The final stage is redemption where they can sell these two attributes as we have discussed, the electricity as well as the renewability attribute. This usually takes place on the power exchanges. These are the same power exchanges that dealt with the buying and selling of ECerts in the context of PAT. The Indian Energy Exchange and the Power Exchange India Limited. These are the four stages and everything goes on online and the system is being made more and more customer friendly as we move on.

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The final instrument is the Renewable Regulatory Fund. This is not directly associated with the RPO or REC obligation, this is a different kind of policy instrument that is often implemented. This is basically a penalty and incentive structure, which is created in order to ensure the stability of power supply through the renewable sources. This is especially applicable in the context of wind and solar power projects in India.

When we talk about renewable energy it comes with a certain amount of intermittency and there is uncertainty with regard to how much energy will be supplied by these renewable energy projects on a day to day basis. But this is very important information that the DISCOMS need to know, how much power will be there in the grid? Under RRF the bigger wind and solar generators are mandated to undertake the forecasting and give a schedule of their generation one day ahead. They are responsible for forecasting with an accuracy of at least 70%. Whatever they forecast if they are within a 30% limit of that up and down then there is no penalty applied. The forecast is assumed to be pretty much accurate. However, if their forecast goes beyond the deviation of plus minus 30% of the schedule a penalty structure is applicable.

Renewable Regulatory Fund provides the kind of stability to the power supply system in order to achieve the quantity targets. If you want to know more about this Renewable Regulatory Fund, I will encourage you to go to the given website and check content.