SUSTAINABLE MINING AND GEOINFORMATION

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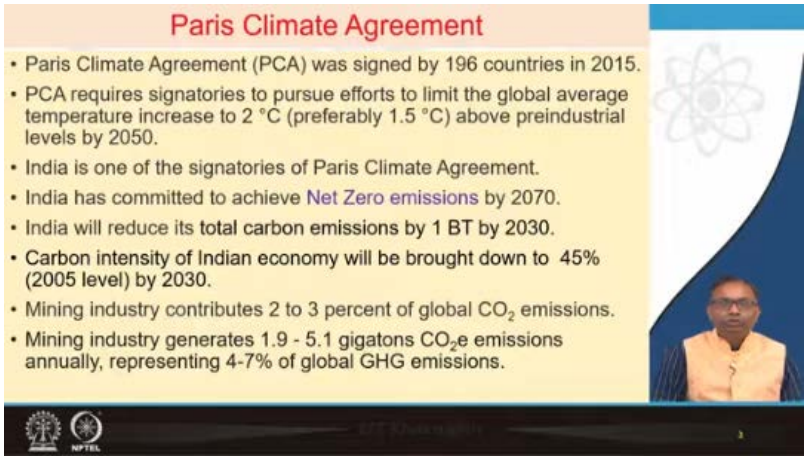
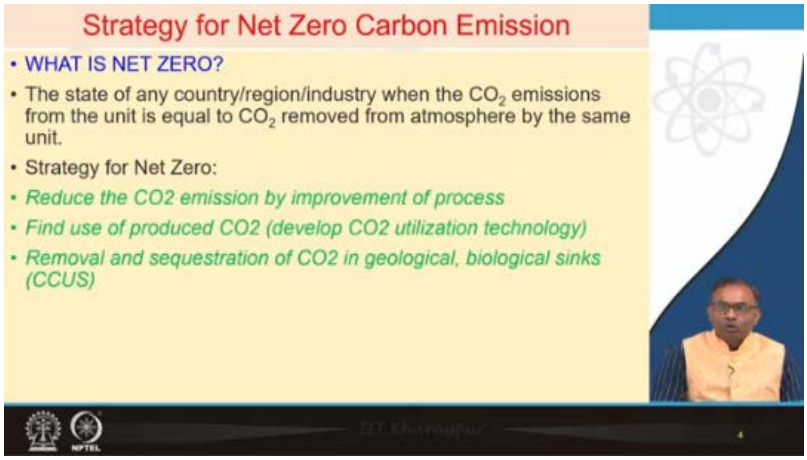
Week – 11

Lecture 55: Net Zero and Decarbonisation of Mining Industry

Welcome, students, to our NPTEL course on Sustainable Mining and Geoinformation. Today we are taking lecture number 55, and the topic of today's lecture is 'Net zero and decarbonization for the mining industry.' In this class, we will discuss what net zero is and what the strategies are to achieve net zero for the mining industry. We will talk about emissions and sources of emissions from mines or the mining industry, and what possible decarbonization measures can be taken for the mining industry. Then, what are the drivers for implementing decarbonization, and what are the barriers to decarbonization? So, these are the few salient points that we will discuss in today's lecture. Now, we come to the topic. If you are following climate change, you must have heard about the Paris Climate Agreement. This was by the United Nations Framework Convention on Climate Change (UNFCCC). The United Nations Climate Conference took place in Paris in the year 2015, and in this, they agreed on what is called the Paris Climate Agreement. It was signed by 196 countries in the year 2015. As per this agreement, the signatories, member nations, have to pursue efforts to limit the global average temperature increase to 2 degrees centigrade above the pre-industrial level.



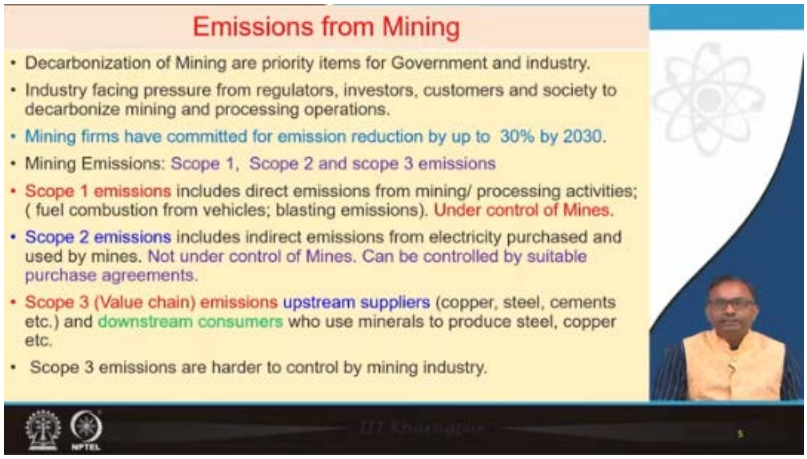
And they will strive hard to limit the rise of temperature to preferably 1.5 degrees centigrade above the pre-industrial levels, and the timeframe available is by 2050. Now, as you might know, India is one of the signatories of the Paris Climate Agreement. India has committed to achieving net-zero carbon emissions by 2070. So, for this, there are what we call the NDCs, and India has committed that it will reduce its total carbon emissions by 1 billion tons by 2030, and the carbon intensity of the Indian economy will be brought down to 45% compared to that of the 2005 level by 2030. So, this is about the Paris Climate Agreement and India's commitment. Now, once the country agrees to the reduction of carbon emissions, it will come to different sectors. So, every sector contributing to carbon dioxide emissions will also commit to reducing CO_2 emissions. So, for the mining industry, if you look at the global mining industry, it contributes to 2 to 3 percent of global CO_2 emissions. The mining industry generates about 1.9 to 5.1 gigatons of carbon dioxide equivalent emissions annually, which represents 4 to 7 percent of global greenhouse gas emissions. The range that you are seeing is actually coming from different climate change models. Now, with respect to CO_2 emissions, member countries are committing to achieving net-zero carbon emissions. So, what is net zero? Net zero is the state of any country, region, company, or industry



when the CO_2 emissions from this particular unit are equal to the CO_2 removed from the atmosphere by the same unit. So, for example, if the mining industry is emitting 1 gigaton of CO_2 and, during the same time, it is removing 1 gigaton of CO_2, then we can say that the industry has achieved net zero carbon emissions. This is the same for a country, a state, or any industrial sector. What are the strategies to achieve net zero? So, there are basically three main pathways for achieving net zero. One is that you reduce your CO_2 emissions through process improvement, research, and development. You develop improved technology so that CO_2 emissions are reduced. So, that will help in reducing your CO_2 emissions. The second thing is, whatever CO_2 emissions you are producing, if you develop some CO_2 utilization technology or develop some product that uses CO_2, then what you can do is capture the CO_2 you are emitting and use it to develop some process or product utilizing that CO_2. So, that is also one way the CO_2 will not be released into the atmosphere. The third and last option is that, whatever CO_2 you are releasing into the atmosphere, you capture the CO_2, remove it, and sequester it—isolate it in some geological sink, biological sink, aquifers, oceans, or similar.

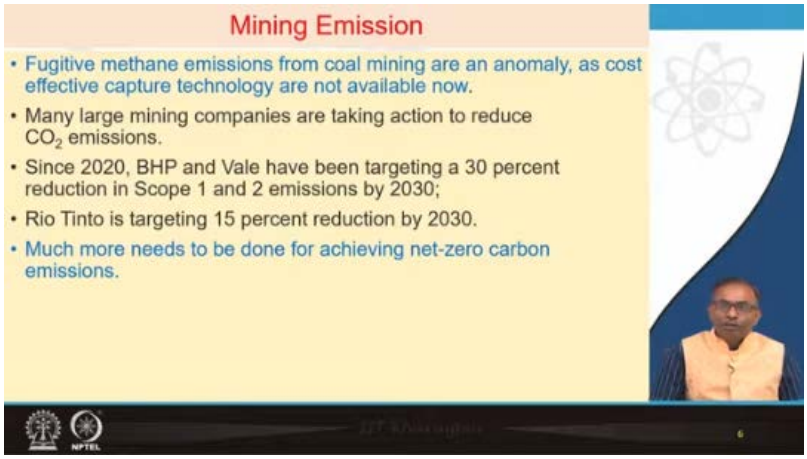
So, that is called CO_2 sequestration. It is also called carbon capture, utilization, and storage. These are the three means by which we can help reduce our CO_2 emissions and achieve net-zero carbon emissions. Now, coming to mining, the decarbonization of mining or sustainable mining is a priority agenda item for the government and the industry. The industry, particularly the mining industry, is facing pressure from regulators, investors, customers, and civil society to decarbonize mining and processing operations. The industry is facing a lot of pressure from different stakeholders to reduce CO_2 emissions. Now, big mining companies have committed to reducing CO_2 emissions by up to 30% by the year 2030. The emissions from mining—there are three different types of emissions. If you look at the UNFCCC reporting guidelines, we have what we

call Scope 1 emissions, Scope 2 emissions, and Scope 3 emissions. Scope 1 emissions include direct emissions from mining or mineral processing activities. That is, when you burn some fuel—say, heavy earth-moving machinery uses diesel—combustion takes place, and CO_2 is emitted. That is called Scope 1 emission. These processes can be improved to reduce CO_2 emissions. Scope 1 emissions are under the control of the mines or the mining industry.



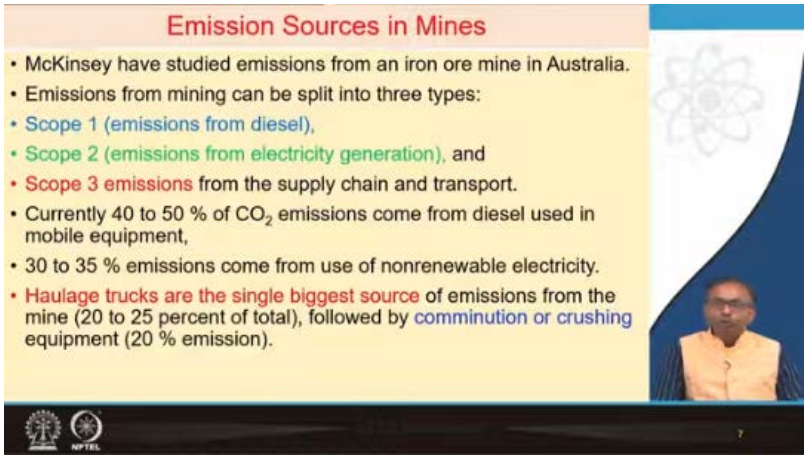
Now, there are Scope 2 emissions, which are indirect emissions. The mining industry uses a lot of electricity. In many cases, the mining industry does not produce the electricity; it buys electricity from NTPC or other power producers. But the power producers also emit a lot of CO_2 while producing power. That is the Scope 2 emission, and it is not directly under the control of the mines. However, mines can try to control Scope 2 emissions by negotiating with power producers. By making suitable changes in the power purchase agreement, they can pressure the power-generating company. This can lead to reduced CO_2 emissions through the use of clean combustion technology. The third type of CO_2 emission is known as Scope 3 or value chain emissions. These are emissions that occur in the upstream suppliers of the mines and the downstream consumers. The upstream suppliers of the mines procure products like steel, cement, lime, and iron rods from different companies. Where these products are produced, CO_2 is emitted. That is the Scope 3 emission. Then, minerals—after production—are supplied to, for example, a steel plant in the case of iron ore, or coal is supplied to a power plant, where it is used and processed. Emissions occur in the power plant. In downstream consumers, where the mineral is used, CO_2 is emitted—this is known as Scope 3 emission. Mines have direct control over Scope 1 emissions; with process improvements, they can reduce Scope 1 emissions. Mines can influence Scope 2 emissions through agreements, but they have little control over Scope 3 emissions. Fugitive methane

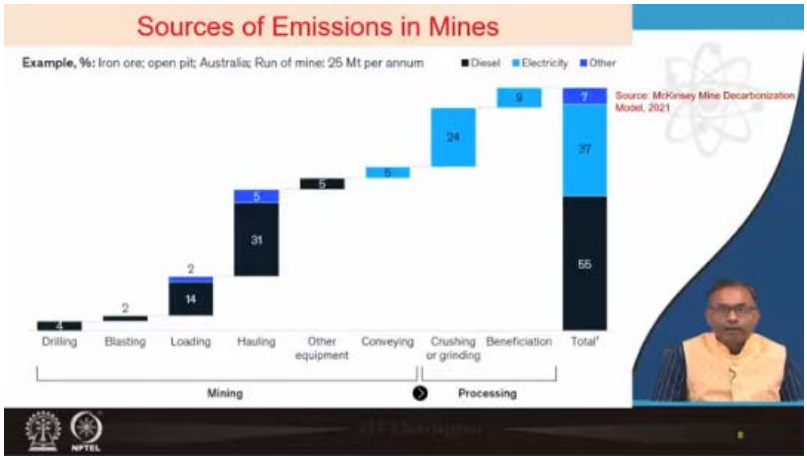
emissions from coal mining are a major source of CO_2 emissions. Unfortunately, cost-effective methane capture technology for open-cast mines is not yet available. However, many large mining companies are taking initiatives to reduce CO_2 emissions. For example, since 2020, BHP and Vale have targeted a 30% reduction in Scope 1 and Scope 2 emissions by 2030. Rio Tinto is targeting a 15% reduction by 2030. Mining companies are taking measures to reduce Scope 1 and Scope 2 emissions to become more carbon-efficient and move toward net-zero emission targets. But much more needs to be done. What has been done so far is insufficient, and further action is required—not only by mines but also by upstream industries, downstream industries, and the supply chain.



So, a coordinated effort is required to achieve net zero. Now, McKinsey has studied carbon emissions from an iron ore mine in Australia. And as per them, you know, as I have already told you that emissions are scope 1, scope 2, and scope 3 emissions. So, currently they have studied the emission from the mines and they have seen currently 40 to 50 percent of CO_2 emissions are coming from the diesel used in the heavy earth moving machinery and 30 to 35 percent emissions are coming from the electricity that is used by the mines and in most of the cases these are the non-renewable electricity. So, haulage trucks are the single biggest source of emissions, because they use diesel or fossil fuel for combustion. So, 20-25 percent of the emissions are coming from the haulage truck. The next largest emitter is the communition, or crushing, which is responsible for 20 percent of emissions. You can see this diagram. It is the iron ore mines from Australia. You can see that there are different unit processes: drilling, blasting, loading, hauling, other equipment used in the mines, conveying, crushing, beneficiation, etc. You can see that there are two types of sources of emissions: diesel and electricity. Emission from diesel is the scope 1 emissions, emissions from electricity are the scope 2 emissions. You can see that this hauling is contributing to 36 percent of the emissions. followed by

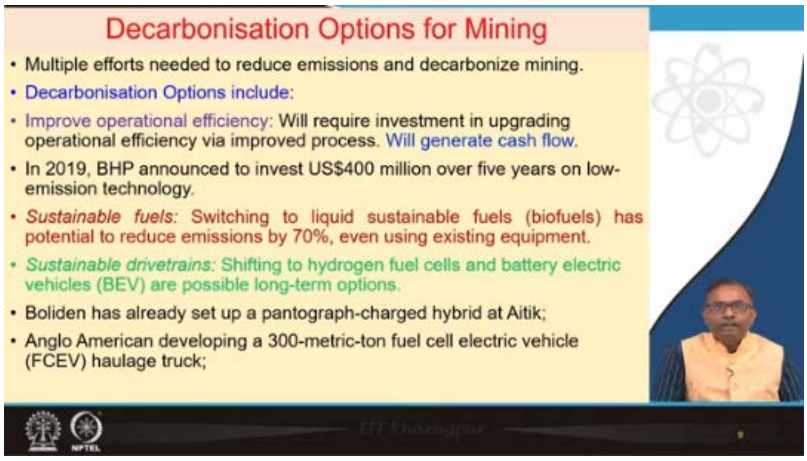
crushing, which contributes 24 percent of the emissions, and that is the scope 2 emission. You can see from the fuel-wise, diesel is contributing to 55 percent, and electricity is contributing to 37 percent of the emissions. These are the status of the emission.





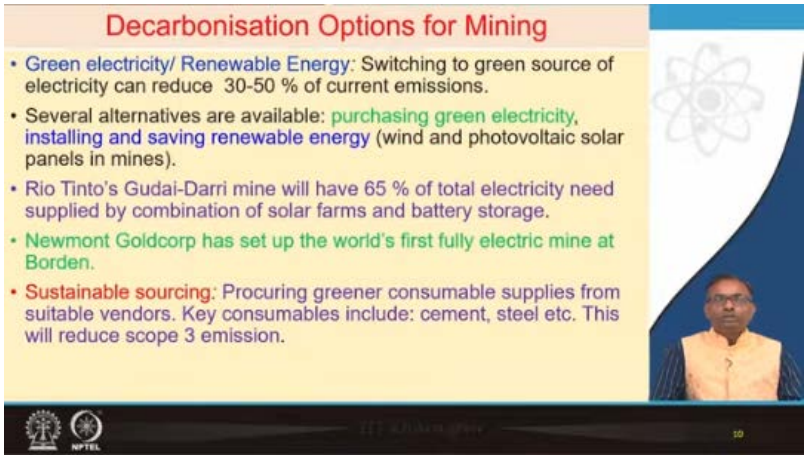
Now, we will talk about the decarbonization options for the mining industry. So, as I told you, multiple and coordinated efforts are required to reduce emissions from the mines and also to decarbonize mining. The decarbonization options will include number one, improve operational efficiency. So, operational efficiency, if you want to improve, you have to invest in upgrading your equipment, upgrading the technology. So, that will require certain investment; but once you invest in the upgradation technology, and there you come up with better processes, better equipment, then once they are in use, your efficiency will increase, CO_2 emission will decrease, and since efficiency will increase, you will generate cash flow also. So, this operational efficiency cannot be done overnight. It will require some time and some investment, but once it is done, it will be highly beneficial to the company. In 2019, BHP announced it would invest 400 million USD over five years in low-emission technology. The second strategy is sustainable fuel,

because you are using the fossil fuel diesel. Now, switching to sustainable fuels like biofuels has the potential to reduce emissions by 70 percent, even using the existing equipment. So this is also one way, and the third option is a sustainable drive train shifting to Hydrogen fuel cells and battery electric vehicles (BEV) are also possible long-term options. So, now many companies have already invested in developing electric vehicles. So, this Boliden company has already set up a pantograph charge hybrid vehicle at the Aitik mines.

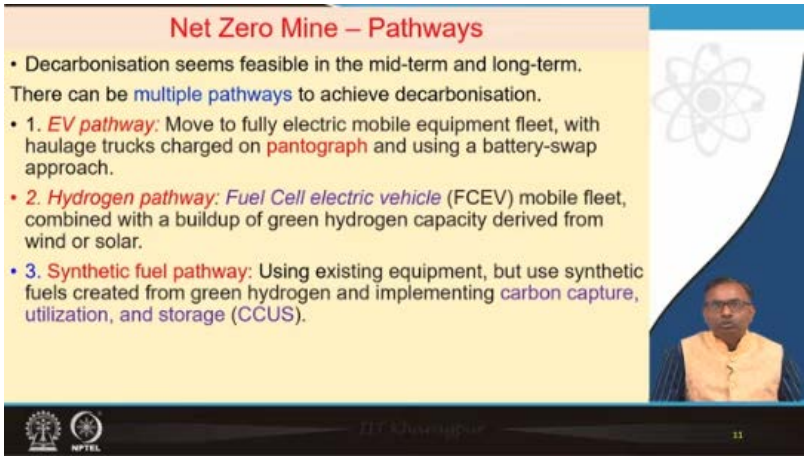


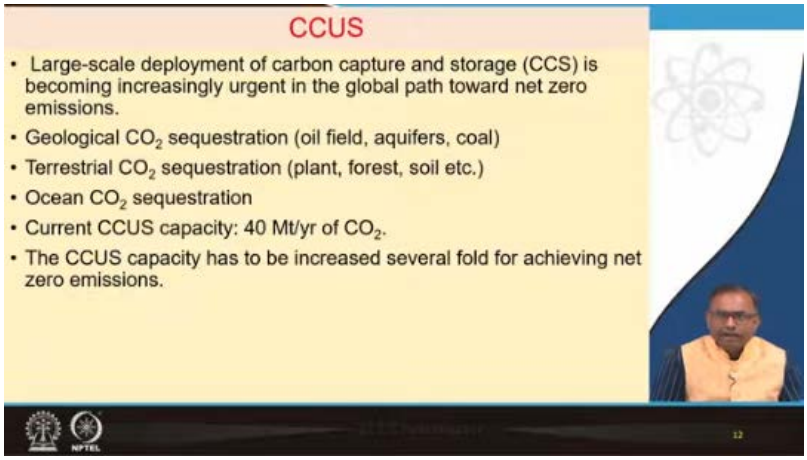
An Anglo-American company is developing a 300 metric ton fuel cell electric vehicle, FCEV, in Hollister. So, switching or transitioning to Renewables, because mostly now in India, particularly we are using the non-renewable energy, particularly fossil fuel, coal based power, we are using. So if we can transition to green electricity, or renewable energy, switching to a green source of electricity can reduce 30 to 50 percent of the current emissions. Now, several alternatives are available for how you can switch to green electricity. You can purchase green electricity from green electricity generators that use wind or solar. You can purchase from them, or you can install renewable energy systems, particularly wind and photovoltaic solar panels, in mines. In mines, you have large areas that are open. There, you can install wind panels or a photovoltaic solar panel, and the green power can be used in the mines. So, for example, Rio Tinto's Gudai Darri mine will have 65 percent of the total electricity needed of the mine supplied by a combination of a solar farm and battery storage. Similarly, Newmont Goldcorp has set up the world's first fully electric mine at Borden. Sustainable sourcing is another strategy. Sustainable sourcing means we are procuring greener consumable supplies from suitable vendors. The mine procures many consumable items like cement, steel, lime, and steel supports. So, if these items are procured from sustainable sources, then the emissions,

that is, the scope 3 emissions, will be reduced. So, now we come to the net-zero mine pathways.



So, the decarbonization, if you think about it, overnight, there cannot be any decarbonization. But the decarbonization can be planned in the mid-term and also in the long-term period. There are multiple pathways that are possible to achieve decarbonization. The first alternative, the first pathway, is the electric vehicle pathway. So, we move from diesel-operated vehicles to an electric mobile equipment fleet, with haulage trucks charged on a pantograph and using a battery swap approach. So, basically, from diesel you are switching to electric vehicles. The second is the hydrogen pathway. As you know, hydrogen is a very clean fuel, and the CO_2 emission is almost zero. During the process of generating electricity, there are no recorded direct CO_2 emissions. So, a fuel cell electric vehicle using the hydrogen mobile fleet combined with the buildup of green hydrogen capacity derived from wind or solar. So, if you are using a fuel cell electric vehicle combined with green hydrogen, that will reduce your CO_2 emissions significantly. The third alternative is the synthetic fuel pathway. This is the mid-term. So, using the existing equipment, you can change the fuel. You can use the synthetic fuel. And whatever CO_2 emission will take place, you can couple it with the synthetic fuel, you remove the CO_2, and implement the carbon capture, utilization, and storage technology. So, these three different pathways are available to achieve decarbonization. So, now, the last concept that we have discussed is the CCUS, carbon capture, utilization, and storage. Large-scale deployment of carbon capture and storage is becoming increasingly urgent in the global path towards net-zero emissions.

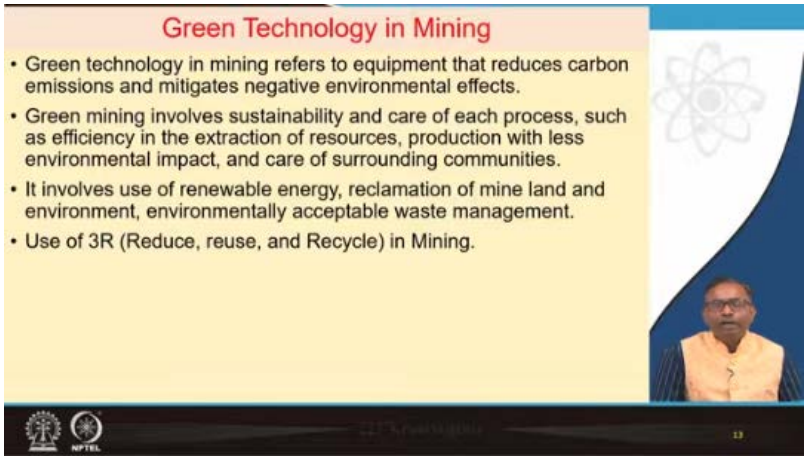




Now, with the CO_2 capture from the different energy systems, we can capture CO_2 from the energy systems and we can isolate it, sequester it in different forms, different sinks. There are different alternatives of CO_2 sequestration, like geological CO_2 sequestration, terrestrial CO_2 sequestration, and ocean CO_2 sequestration. So, in the geological CO_2 sequestration, the CO_2, separated CO_2, captured CO_2 is injected into an oil field, an oil formation, or an aquifer or shell deposit where the CO_2 will be isolated and it will not be allowed to mix with the atmosphere. It will be separated and it will be locked there. In terrestrial CO_2 sequestration, you go for a plantation. Trees have the capacity to bind CO_2 through photosynthesis. When the tree plantation takes place, the tree grows, and it binds the CO_2. So you go for a plantation, create the forest, and it will result in terrestrial CO_2 sequestration. In the soil, also, by using microbes, the carbon dioxide can be converted to organic carbon, soil organic carbon. That is also termed as terrestrial CO_2 sequestration. The third option is the CO_2 sequestration in the ocean. A lot of CO_2 can be sequestered in the ocean. And of course, in all these cases, their feasibility, what is the environmental effect, that we have to study the risks of the CO_2 emissions coming back to the

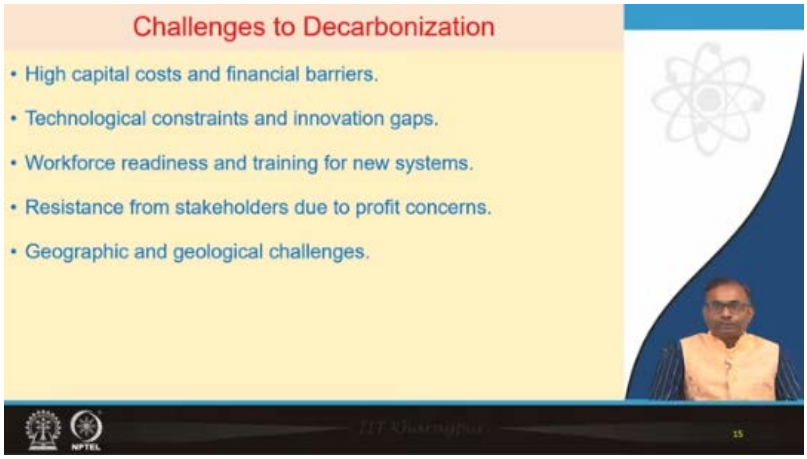
atmosphere. Everything has to be properly studied, particularly the safety and risk analysis has to be done. Currently, the CCUS capacity is 40 million tons per year, and at a global level, if we want to achieve net zero, not only for the mining industry, but for the countries.

For net-zero emissions at the global level, the CCUS capacity has to be increased by 40 times, 50 times, or 100 times. So, now we come to the green technology in mining, using renewable energy, or when you are doing the process improvement, so that the CO_2 emission is reduced, or whatever CO_2 emission is taking place from the mine, if you are sequestering. So, all these technologies together will be referred to as green technology or green mining technology. So, using green technology, we can reduce our CO_2 emissions, and it will mitigate the environmental effects. Green mining involves sustainability and care of each process, such as efficiency in the extraction of resources, production with less environmental impact, care of surrounding communities, and care of flora and fauna. So, it involves the use of renewable energy, reclamation of mine land, remediation of the environment, and environmentally acceptable waste management and flora and fauna management. Particularly, if we use the 3R techniques that reduce, reuse, and recycle in mining. Altogether, these are called the green mining or sustainable mining technology. So, this is the concept of decarbonization. Now, drivers to decarbonization: Why decarbonize? Mining companies should make an effort to decarbonize because of regulatory pressure. The regulation may come now, since the nation has committed to decarbonization at global platforms. So, the nation will transfer this, it will allocate CO_2 emissions to different industries, and the circular economy may come that you have to reduce your CO_2 emissions. So, if the regulation comes from the ministry, the mining industry has to take measures to go for decarbonization. Pressures from investors, government, and society. Now investors who are giving money to the mining company can make a condition that, you know, if you are using decarbonization, then the capital will be available at a lower interest rate. So, then you have to go for decarbonization to reduce your CO_2 emissions.



Similarly, governments, civil society, and environmental groups can put pressure on the mining industry to adopt cleaner mining technologies to reduce CO_2 emissions. When you reduce CO_2 emissions and take environmental measures, it will also help you obtain a social license to operate, as you will benefit from it. Your image will improve, and your credibility in society will strengthen, making it easier to secure the social license to operate. The company's reputation will increase. Companies will receive financial incentives, such as capital at lower interest rates. Conversely, if you do not decarbonize, investors may leave, and consumers may avoid your products. The fear of losing market share is also a driver for decarbonization. Now, what are the challenges to decarbonization? Decarbonization cannot happen overnight or with the status quo. You must change the technology, implement numerous measures, and shift people's attitudes. Training is required for employees to adapt to new processes. This entails high capital costs and financial barriers. Technological constraints and innovation gaps exist. Existing machinery and equipment will not reduce emissions; advanced equipment and innovation are necessary. Workforce readiness and training for new systems are also critical. You

must train your workforce to learn new technologies and operate new equipment. Resistance from stakeholders due to profit concerns may arise. Since investing in new technologies and innovations may reduce profit margins, investors may hesitate due to potential profit losses. Geographical and geological challenges also play a role. It depends on where your mine is located and whether CO_2 sequestration is feasible. Geological CO_2 sequestration may not be technically possible in all locations. Suitable sequestration sites may be far from your mine, raising logistical and cost concerns. The expense of sequestration could be very high, and only certain geological locations may be suitable.



Some locations may not be suitable for sequestration. Depending on geographic and geological challenges, these factors could pose barriers or challenges to decarbonization. To summarize, we discussed the net-zero concept, its definition, emission sources in mining, decarbonization measures, pathways for mining, and finally, the drivers and barriers to decarbonization. These references were used to prepare this lecture material. You can review them for more detailed information. This concludes today's lecture, Lecture 55, on the net-zero concept and decarbonization in the mining industry. Thank you for your attention.

SUMMARY

- Net Zero.
- Emissions from mine
- Decarbonisation measures for mining
- Drivers for decarbonisation
- Barriers to decarbonisation