Course Name: Architectural Approaches to Decarbonization of Buildings

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Lecture 02

Strategies to reduce GHG in Building Industry

Dear students, In the last class, we saw what are greenhouse gases, what is the impact of greenhouse gases on the environment and what are the major sectors that are contributing. In a very brief manner, we saw that. But then the significance of greenhouse gases to this course is what we saw. In this segment, we will look at strategies to reduce greenhouse gas emissions. So, what does greenhouse gas do as a phenomena and how do we reduce it? So, this lecture will cover the basics of greenhouse gas emissions, what are the factors that influence the greenhouse gas emissions, global and Indian scenario, strategies for reduction, relevant policies, what are the impactful case studies and the broader impact, challenges and future trends within the building industry. So, the emphasis will be largely on building industries because most of you are architects, designers, civil engineers and planners belonging to the building industry.

It will emphasize on collaborative efforts, international initiatives and specific measures like energy efficiency. The summary underscores the critical need to address greenhouse gas emissions for a sustainable and low carbon future in the building sector. So let us look at the strategies for how we can reduce the greenhouse gases. So the first strategy that we will look at is through bio-climatic design.

We have already seen in our previous classes that the building sector has you know it consumes a lot of energy, the building sector is a large contributor to GHG emissions and therefore, there is a need to strategize you know reduction in greenhouse gases through our design of buildings. Now, bioclimatic architecture is defined by sustainable design and it results in significant reduction in GHG emissions. So, bioclimatic buildings minimize reliance on artificial heating and cooling. We have seen that energy consumption by buildings is very high and one reason for that is how buildings indoor is made either warm or cool depending on the requirement. But bioclimatic buildings themselves are designed in such a way that the internal temperature or internal thermal performance is very good.

And therefore, reliance on artificial heating and cooling is significantly reduced. So, reducing energy consumption and associated GHG emissions also gets reduced. What are the features that can be incorporated in a bioclimatic design to ensure that the indoors are

very cool? One is optimal building orientation. All this we will look at in greater detail later. Natural ventilation - suppose a building needs, now, let us take the case of this building.

If you look at the bioclimatic feature I have not really projected the orientation, but let us assume that the building is oriented, if this is the building and then if this is the north, then you can see in this building, the western side is very short compared to the north and the south. And we all are aware that the western radiation is very high, radiation along the west is very high. So, if a building is oriented properly, that is what I mean by optimal orientation with provision for natural ventilation. Here in this building you can see that there is provision for not only natural ventilation, but different ways in which the ventilation can happen. You have the ventilation along this, you have a shaft, shaft ventilation and so on.

Then for energy efficient envelope, the design of the envelope itself should be such that the building consumes less energy by virtue of making the indoors comfortable. This approach utilizes many features. One can be orientation, natural ventilation, envelope design to decrease the load on artificial heating and cooling, thereby lowering energy consumption and thereby lowering greenhouse gas emission. Additionally, integration of renewable energy sources like solar panels and wind turbines and other sources of renewable energy, a focus on natural lighting and water conservation practices also enhances the overall environmental sustainability of bioclimatic buildings. In essence, the principle of bioclimatic architecture offers a holistic strategy to create structures that not only prioritize energy efficiency, but also contribute substantially to the reduction of greenhouse gas emission.

Now, another strategy that can be used is renewable energy integration. Now, integration of renewable energy can happen in two ways. It can be on-site or off-site. So, renewable energy integration in the building industry involves incorporating sustainable energy sources to power the structure efficiently. Now, renewable energy integration entails efficient powering of structures by incorporating sustainable sources.

What are the sustainable renewable sources? Solar is one, especially in a tropical country like India, solar energy is the way to go, solar panels. We have abundant resources for wind turbines. There are many places in the country where there have been sustained efforts to tap the potential of wind energy. The on-site clean energy generation reduces reliance on traditional power grids, cutting carbon emissions and promoting environmentally sustainable buildings. The shift not only contributes to a greener and a more sustainable energy mix, but it also aligns itself with global initiatives to combat climate change.

Incidentally, that happens. Relying on natural resources and harnessing the natural resources, buildings can reduce their reliance on power grids, thereby lowering carbon emissions because we already saw in last class the humongous amount of carbon emission because of the reliance on conventional heating strategies. And it leads to environmental sustainability by reduction in GHG emissions. The integration of renewable energy in the building industry not only contributes to a greener and more sustainable energy mix, but

also aligns with the global efforts to mitigate climate change. So, how all can we have this integration? We can have this integration by having solar PVs integrated in the buildings itself.

The building itself can host it or it can be offsite. Offsite meaning there can be solar panels which are not on the site -which are off site and the energy that comes from this can be given to the grid and that energy can be used here in the building. That energy can come back here or it can remain with the grid also. That's up to you. Again wind energy can be off site.

Normally wind energy is off site only it is very difficult to have wind energy on site. So, these are the larger strategies. Another strategy is trying to get green building certification. There are a number of green building certifications in every country. For India, we follow LEED India or we also follow what is called as GRIHA.

So, right now we are having two major certifications. The third could come which is called as the EDGE certification. So, these are largely Indian certification, LEED India. At this time, in this class, we are not going to talk of certification and therefore, I am not speaking more on this. But we could have LEED India, GRIHA, EDGE.

These are Indian based. All the other things that I am quoting here like BREAM, CASBEE are all foreign. There is Passive House. They are all for the adapted in Europe and the US. So, of all the categories, in all of these green building certifications, consumption of energy, the amount of points -that is, every building has to score certain points in some of the or many of the criteria.

So, what happens is, almost 30 to 35 percent of the points that are found in any of the rating system is attributed to energy efficiency. So, it is found that energy efficiency consists of 30 to 35, normally we will keep it as 32, of all the points available on an average for the rating systems that is adopted globally. As a result, it can be said that energy efficiency is one of the most important aspect of green buildings. So, adhering to green building certifications like LEED India or GRIHA is essential for environmentally responsible construction. By virtue of having to go for the certification, you end up designing buildings - climate conscious buildings because the consumption of energy is automatically reduced because of the way the building is designed consciously for the certification.

So, you prioritize energy efficiency when you try to go for certification. So, this highlights the pivotal role of energy efficiency as the most crucial aspect of green building practices, emphasizing its significance for achieving sustainability and thereby reducing GHG emissions. Now, let us come to one of the main focus of this course, which, is trying to adapt low carbon materials. To minimize GHG emissions in construction, various strategies can be implemented, including utilization of low carbon, neutral or carbon storing materials. Notably, carbon storing materials are essential.

They are like wood or hemp or straw or bamboo, algae. Now these are all derived from plants that sequester carbon during growth and it serves as environmentally friendly building options. What do you mean by sequester? We will look at it in the forthcoming class. Incorporating recycled or reclaimed materials further diminishes emissions linked to new material production. Adopting sustainable low carbon building materials like recycled or locally sourced material, this emerges as a very important approach or a key approach to significantly reduce the carbon footprint in construction projects.

Now, here we will look at the various strategies. Now, if you see The best thing where you are not going to damage the environment is by building nothing. So, what do you mean by building nothing? By building nothing it means whatever is existing you repurpose it, refurbish it, you know sort of make small changes in it and then you use that. How is that possible? Because the family grows, then how can you do that? So one way of doing that is at the early design stage itself, you should start designing flexible and adaptable structures. which means a house which was all right for a family of two adults and two small children must also become flexible to accommodate two adults and two adolescents and later on two elderly and two adults.

How is that possible? Only if we start focusing on designing flexible and adaptable structures. How to do that is a task for another day. The next strategy is we should build less. What do you mean by build less? Build only whatever is needed. Why would a family of say two adults and two children need 5000 meter square of a house? That's a question every architect, designer or anyone who is in the construction industry must try to create an awareness in the client by telling them to build less or I would say build appropriate.

Need not be very frugal. Being frugal is very good when it comes to the GHG emissions, but if not frugal, at least be sensible. Build clever. Next strategy I mean what else can we say after the build nothing build less you can build clever. What do you mean by build clever? Build clever is this is what is our main focus area. Build clever means 'Try to reuse as much materials as possible'.

Salvage as much material as possible rather than trying to bring in new materials every time. Because what happens is every building material, everything that is added to a house or a building has a carbon component in it. We will look at it in greater detail later and what happens is when you build clever and you start reusing the materials, you tend to use low carbon materials and products and that is very very important for the nature. Next is you build efficiently. What do you mean by build efficiently? We have already seen 'use bioclimatic principles', 'use principles of climate sensitive architecture' in order to minimize design loads, 'use efficient forms and grids' and 'maximize material utilization'.

So, this will result in building efficiently. Not only that, it will also result in consumption of low carbon materials or the building itself will have less carbon footprint. And last is

'minimize waste'. So, when you build, please use appropriate building construction technologies which will result in minimizing waste. For example, using conventional ways of plastering.

What happens is, sometimes it results in a lot of waste of cement. and as we have already seen cement, steel - they generate a lot of.

... their production generates a lot of GHG gases. If we can minimize waste on these carbon-intensive or energy-intensive materials, automatically we are going to do our small part in reducing GHG emissions. What are the ways of doing this, - minimizing waste through construction technology? We can go for prefabrication. Prefabrication means, the parts have already been manufactured somewhere else off site and the components are brought on to the site for erection. Improve construction practices and utilize or reuse or recycling streams.

For example, doors of a house can be recycled. Suppose a house is undergoing demolition. For a newer construction, a number of elements can be recycled and reused from the existing house itself and it can be refurbished. We are not saying that you should use it in its state. You can refurbish and use it because by doing this you can reduce GHG emissions.

Other strategies in general is, we can optimize the concrete mix. By optimizing concrete mix there can be a reduction of up to 30 percent of GHG emissions. Next is 'rebar'. That is, use high recycled content rebars, because steel is a very energy intensive industry and that can result in about 4 to 10 percent reduction in GHG gases. Insulation- So, we can select low or no embodied carbon insulating products.

So, insulation in a country where we have varying climate types, there are certain climates where insulation is not even a criteria, but in cold places it is a very important criteria and there we have to select low or no embodied carbon insulating products. that can result up to 16 percent reduction in you know GHGs. Glazing-select low embodied carbon glazing products. This can cause a reduction of even up to 3 percent. Finish materials- so select low or no embodied carbon materials on finish materials.

The kind of carpet, what do you use for carpet? If you are going to have more of organic elements on the carpet, it is going to be low carb, if you are low carbon. And if you are going to have synthetic materials, the embodied carbon is going to be very high. More embodied carbon, more GHG emission. The next strategy is the measurement of GHGs impact- This is determined through global warming potential as we already discussed and it is expressed in carbon dioxide equivalent -that also we have already seen. Assessing a product's embodied carbon involves a life cycle assessment.

What is life cycle assessment? We are going to look at it in very great detail but then this life cycle carbon assessment analyzes environmental impacts at each stage of the product's

lifestyle. The disclosure of LCA which is life cycle assessment results through environmental product declaration which are called as EPDs and it offers consumers valuable insights into the environmental footprint of the building products which is called as RMI. Conducting lifestyle assessment also helps us in evaluating a building's environmental impact from the cradle of the building to its demolition and it considers factors like materials, energy, end of life disposal. So, you are not looking at building as a momentary product. You are looking at the consumption of carbon or the emission of GHG right from the raw material production phase which is nothing but how do you extract the raw material for a particular product and what all carbon emissions happen at that time? How do you extract it? How do you load it onto the transport system? What is the mode of transport that you use? What is the manufacturing technology that you use? How do you know during the construction phase? How do you transport it to the site for installation? For example, The production phase can consume up to 85 percent - between 65 to 85 percent of the total embodied carbon emission can happen at the production phase itself.

Now reserve the word embodied carbon emission because we are going to look at it in greater detail in the forthcoming classes. Just understand that embodied carbon emission has got a direct relationship to greenhouse gas emission. So, it means sometimes up to 85 percent emission can happen at this stage itself and about 6 to 10 or I would even say 15 percent can happen at this stage also, the stage of construction. Use and maintenance phase is another. There again 8 to 15 percent of embodied carbon can get emitted.

Then 3 to 15 percent can be during its demolition phase. So, all this comprises of the phases of construction and at each of these phases there is going to be a carbon emission. So, Anyways, we can just go through what is carbon equivalent. So, carbon is calculated as a global warming potential which we already saw last class. It is called GWP and it is expressed as carbon dioxide equivalent units, CO_2e, because you will come across this word quite frequently in the subsequent classes.

To quantify a product's embodied carbon an analysis called life cycle assessment is used to assess the environmental impacts associated with each stage of the product. We will look at it in greater detail in the forthcoming classes and we will not hurry up for it now. The next strategy is to reduce in order to reduce greenhouse gas emission we can use energy efficient technologies. The building industry is increasingly integrated energy efficient technology to enhance sustainability and reduce environmental impact, but the percentage of buildings is still very less. We need to incorporate it in a very accelerated manner and at a fast pace.

These technologies encompass a range of innovations including advanced insulation materials, Smart building management. You know having sensors when somebody enters the room the lights will get switched on. So there is no reduction in consumption of electricity because when somebody is not occupying the room the lights are not on and the electricity required to fuel the light is also not there. So smart building management systems, energy efficient lighting solutions and high performance windows and doors.

Smart sensors and automation play a pivotal role optimizing energy usage by adjusting heating, cooling and lighting based on real-time occupancy and environmental conditions.

So, these advancements not only enhance energy efficiency, but they can significantly cause mitigation in climate change by reducing the emissions in the building sector. So, if we look at the strategies to reduce greenhouse gas emissions, we can see that we can have energy saving technology. What are the energy saving technologies? We can have accessories which can consume less energy and therefore they save energy. We can have green construction technology. That can be one of the major, what shall I say, motivation for all this can come from green building certification because these become very important components there.

So, green construction technology right from the way materials are sourced, right from the way the building is constructed, right from the way the building is maintained. Water supply and drainage technology, sound environment guarantee technology, acoustically better environment, air environment assurance technology. How do you maintain good indoor air quality? Then you can have good building material technology, you can have intelligent technology, environmental greening and green design technology, waste treatment technology, hot and humid environment protection technology. We can either have it as an advanced passive technology or we can use it with energy efficient contraptions.

Optical environment protection technology. All these if we incorporate, the building will become, internally it will become a very comfortable place and therefore, we will not need extra contraptions which are energy consuming. Ultimately the aim is to reduce the consumption of energy. When I mean energy, I mean the electrical energy. The source can be anything, it could be either fossil fuel which is worse or it could also be green energy in the form of solar and wind turbines. Ultimate aim that the strategies that we are looking on, they aim to reduce the consumption of energy and therefore, reduce the emission of GHG gases. More of this we will continue.