Course Name: Architectural Approaches to Decarbonization of Buildings

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Lecture 04

Operational Energy and Operational Carbon - Part 2

Welcome back to our class and to the next segment of this course. Last class we had discussed about operational carbon. We had discussed about operational energy consumption. What does that mean? What is the operational energy consumption pattern in rural India and urban India? What is the global scenario and projection for operational energy use globally and what are the projections in India for 2050? in the urban areas and rural areas. Now today we will look at operational carbon versus embodied carbon. All the activities associated with the use of buildings during their lifetime are included in operational emission.

So the energy needed to run appliances like lights, ventilation, air conditioning, heating, cooking, cooling systems, etc. is known as operational energy. Embodied energy is independent of occupancy, but operational energy consumption is dependent on the inhabitants. Rather, energy is integrated into the materials and is mostly determined by the kind of materials utilized, the main energy sources and the effectiveness of the conversion process that produce the products and construction materials.

Over the building's useful life, operational emissions might be affected and accumulate over time. However, nearly all embedded emissions occur just once. And when does that occur? When the material is embedded in the building. When is the material embedded in the building? At the time of construction. So, during a building's original construction phase, the remaining emissions occur during maintenance and repair.

That also goes into embodied energy only, which we have already seen in the previous week. For example, a tap. I had given the same example and to make it easily recollect for you, I am quoting the same example. If you have a tap, there is an embodied energy to it. Maintenance of the tap using another washer replacing another washer is a retrofit or a maintenance and repair yet that gets added.

That gets added to the embodied energy. Now energy efficient appliances, renewable

energy technologies and enhanced insulation materials in a cold area. which are more widely available can help achieve operational energy conservation more effectively. Now, here if you look at what all constitutes operational energy versus embodied energy. We have already seen this for the sake of recollection and for the sake of better clarity and understanding.

I would like to repeat that. Embodied energy of a product happens when you extract the raw material, transport the raw material to the factory and when you manufacture the raw material. I had given an example of comparing two different materials. One was brick, another was aluminum for you to understand what goes into the embodied energy of a particular product. Then you have embodied energy during construction where the product is transported to the site when there is construction of the building using that particular product.

Then embodied also comprises of maintenance, repair, replacement. It can be anything. It could be say flooring. Flooring needs to be replaced. So, if flooring is replaced, it is going to consume more energy.

Then you have refurbishment, you add on, you add on a carpet. Say you repair when it comes to flooring, let us look at this. Maintenance of the flooring could be anything, polishing from time to time. repair of the flooring, add-ons in different places, replacement, say the flooring is replaced and here carpeting. I am taking just one example to tell you how embodied energy can increase due to maintenance issues of a particular component.

You could apply this to any component. Then comes the operational. In operational, we are focusing more on energy use and when we look at energy use in the operational segment, we are looking at all the energy consumption, all the energy consumption due to operation of a, due to operating appliances primarily. and we could make a list of appliances that we operate in a different type of buildings and you will realize how much of energy is consumed by the appliances and therefore, how much is the emission due to that operational energy. As we said, as we have seen in the last class, in the Indian scenario, 90 percent approximately, 90 percent of the energy used in a building is attributed to operational energy.

90 percent is operational energy and there is and we have also seen in the last class that we can reduce the operational energy By how much? By how much can we reduce the operational energy? 50 percent. By 50 percent we can reduce. What are the strategies? We will look at that in a little detail in the forthcoming class, next class. Now let us look at the factors influencing operational energy. Operational energy consumption in

buildings is intricately influenced by several key factors.

The type of building. Now if it is a residential building, list down all the contraptions you need to run the residence or run the house. For commercial, it is completely different. A small example I will give you. In a residential building, energy is consumed, more energy is consumed in certain areas.

They could be a geyser or a refrigerator because it runs through the day. Lighting. And then smaller amounts go into a coffee maker or a washing machine because we assume that the washing machine is not going to be run every day. So, maybe once a week or twice a week. But when it comes to commercial, just imagine where the energy goes into, energy consumption goes into.

You have large sewage treatment plants. You have huge monster size laundries also in some of the commercial centers. Some of the commercial complexes, if they have hotels or service apartments, laundry service takes. If it is a hospital, it is a completely different energy consumption thing with appliances, which we will not delve into because most of them are necessary. And compromises cannot be made on most of those energy consumption.

Then industrial. Now industrial buildings depending on the industry the energy consumption is very very high. So these dictates unique energy demands based on specific functionalities and equipment used. Like I said, hospitals, it is very unique, it is very different. You have the ICU, the surgical theatre where there has to be no continuous electricity supply has to be there not even for a second. The electricity supply can be stopped or paused.

And therefore, depending on the unique functions in every building, the energy requirement happens. But in some of the buildings the way the energy is consumed can be changed especially because of what an architect or a designer does. So we should not forget that also. Additionally geographic location it plays a pivotal role because we have varied climatic conditions necessitating different heating loads or cooling loads and ventilation needs. For example, if you look at a place like Shimla or Manali, you would need heating as a primary contraption for energy consumption.

Whereas, if you look at a place which is hot and dry, an arid place, air conditioners are needed there. If you look at warm humid places or hot humid places, you need air conditioners. You can't even use coolers because already the air is moist in a warm humid climate and having further air coolers is going to make the air even more moist and it can result in fungal and algal deposits. causing health hazards. So, depending on the varied

climate of the country and India is blessed that way with all kinds of climate here.

We have places where it snows, we have places which are deserts, we have forests and so on and so forth. So, the magnitude of occupancy in a space also directly impacts energy uses as higher numbers of occupants elevate the demand for lighting, heating, ventilation, air conditioning and other utilities. Moreover, Now, occupants individual preferences and behaviors regarding comfort, lighting and appliance usage also affects the overall energy consumption. Effective building design, encompassing elements like insulation, natural lighting and ventilation, I mean using natural ventilation, it optimizes energy performance. Simultaneously, efficient use, maintenance practices and proper facilities management also ensure the operational system operate at peak efficiency.

For example, how many of us care to clean the air conditioning filter regularly? Only when we sense a dip in its efficiency, we make that effort. But that also increases the load on the air conditioner. I am not talking about the impact it has on the indoor air quality. So, maintenance of equipment is also a very important criteria. Only then we will get its peak efficiency.

All these collectively contribute to reducing the building's energy footprint. Understanding and addressing these multifaceted factors are essential in implementing strategies to enhance energy efficiency and reduce operational energy consumption in buildings. What are the ways and what are the factors? Let us look at the factors which influence energy use a little in detail. Let us look at the human factor. Now, if you look at human factor, it is a very personalized factor.

By personalized factor what I mean is people have personal preferences for what is comfortable for them. So, we have these are personalized factors where somebody may wear a jacket saying they are feeling cold for some other person they may not feel it that cold. And hence it's a very subjective term.

Occupancy requirements. Yes. How many people live in that particular room? Management and maintenance. I have already talked to you about management and maintenance. In the form of the example I gave about air conditioning equipment. Then activity levels.

Imagine there is a space. probably even a residence and there you have a treadmill. So you are going to feel, a person who uses the treadmill is going to feel warmer than a person who is sedentary. The activity level matters. So can you imagine what happens in a gym compared to another space where a sedentary activity takes place? And then access to control. Yes, if you have a facility to use air conditioner, you are going to use air

conditioner in a warm place.

So, these are all the human factors. Then you have the building design factors which I am noting as a building envelope because it's through the envelope that heat enters in or it's like the skin of a building which protects the inhabitant. So, the size of the building matters, the built form matters, the shape of the building matters, building material used. The ventilation building material used contributes in two ways. One is how much heat it is allowing to come inside and what is the energy required even in the manufacture of that material which is the embodied energy. Then the location whether it is on a coastal place, coastal, hilly, all these are going to matter.

Material, use of say a material with no thermal mass. Its thermal mass is less or more. Ventilation, whether there is provision for cross ventilation or it is a completely sealed room. Orientation, whether the room or the building is facing west side or say east side, I would say any other. We will look at these in greater details in the rest of the classes, etc.

So, there are many such factors which influence. Then you have building services. What is the type of system? What is the size of system? How do you control that plant? What is the efficiency of the plant? What is the operating regime? So, all these factor in, you have to factor in all of these to understand the energy use in a building. So, the building type matters whether it is a hospital I am just quoting a few examples.

I will just take three examples. Hospital, office and residence. Number of occupants in a hospital, it is going to be a floating population. In a office, you will have a determined number almost. In a residence also, you will have a determined number.

So, determined number or floating population. Why it matters? In a room, if there are 10 people and in a room where in the same room if there is 1 person. The person, each individual also radiates heat and that can increase the temperature inside the room and therefore that can increase the, that will increase the load on air conditioner based on the number of occupants. Efficient building use, how can that happen? By factoring in all of these, all of these factors. Location and climate based on whether it is located in a hot dry climate in which case you can use desert coolers or air conditioners to make the indoors comfortable if the building is not designed to do it. You can have a hot humid climate where air conditioners I am talking only of contraptions I am not talking of bioclimatic strategies at this stage.

In hot humid climate you need air conditioners and in cold climate you need heaters. So, based on the location in climate and the psychological traits which is subjective individual traits. Based on a person's metabolism, based on a person's gender, based on a

person's age, that person will feel warm or cool in the same environment, same weather, same climate. Facility maintenance. How do you maintain the facility? So, all of these add up and contribute to the operational energy.

These are all the factors. Now let us look at the strategies to reduce operational energy. Reducing operational energy in buildings, it involves implementing various strategies which are aimed at improving energy efficiency and minimizing overall consumption of electricity. Some effective approaches include energy efficient building, operational HVAC systems, smart lighting solutions and so on. In this class, I am going to touch upon a few of these aspects and carry forward this same class next time.

So, we will continue this next class. For now I will just give a small introduction about the strategies to reduce operational energy. So, we can reduce operational energy in many many ways and using more strategies the building is going to become more energy efficient. So, energy efficient building operational HVAC systems, heating ventilation and air conditioning system, smart lighting solutions, building envelope improvements, building management system, renewable energy integration, behavioral changes and education, creating an awareness amongst the users, energy efficient appliances and energy audits with no specific benchmarking. So we will now look at it in a brief and continue it in the next class. So in the next class what we will see is where are the opportunities for us as architects to implement the strategies to reduce operational energy and we will also see whole system level strategies for operational energy reduction at a city level.

So, at a slightly broader level we will see and we will bog down to only what is there in the building level specifically or with greater focus. So we will stop the class here and continue in the next class with the strategies to reduce operational energy.