[SQUEAKING]

[RUSTLING]

[CLICKING]

SIQI ZHENG: So today is our second lecture on the economics of green buildings. So last session, we talked about the first lecture. Remember, recap-- very, very quick recap. So last session, we talked about these green buildings.

So we had this structural way that we talk how the market may work and how the market may not work. Remember, this market-- and we have that cash flow. We have that chain of the developer and investor and also tenants.

So sometimes it works, and then you have the incentive from the tenant side, from the user side. You have a higher willingness to pay for rent. And then the owners, they can get higher revenue from the green buildings. If they have higher revenue for the green buildings, they are willing to pay higher price to purchase the green building. And that will incentivize the developers to build green building. So that's market work.

And then we talk about how the market may not work-- so the market failure. We talk about several reasons of the market failure, for example, information asymmetry. Then we talk a little bit about how to solve this information asymmetry, which is the certificate, like the LEED, to solve this information problem, and also because externality and because other issues, the market may not work. So that's last session.

So today, we continue our journey on the green buildings and the economics. And we have another way-- I have another way to organize today's session, which will be technology versus people-- technology versus people.

We will look at some green building technology. We have so many technologies. Here is MIT, Massachusetts Institute of Technology. So we are not in short of all kinds of technologies.

And we will talk mainly about two technologies. One is this passive house, and the other is the heat pump. So this is a very popular two technologies nowadays. Maybe you already heard of some of this from the media and from other people. So that's technology.

But I will argue we cannot just look at technology and say, oh, this is so fancy, so advanced technology. But the technology may not work at all. And we also need to consider people. So that's the people side.

People are those who are making decisions. We need to understand the people's incentives and behaviors so that we can make sure the technology can be used in the right way that can generate the right incentive. So that's today's session.

So after today's session, if you understand this logic of technology versus people, you already got the point. So start from this building decarbonization. So this always show up. I already showed this in our intro session, session 0, is this-- real estate sector, we are responsible for 30% to 40% of the carbon and energy use. That's why we are always the target, the target when the country leaders, the city leaders-- is that OK?

The country leaders, the city leaders, the mayors, they want to make sure their city can become net zero in which year. So they say, OK, look at this pie. We must-- we must target this-- where is the pointer? Oh, here?

OK, when we look at this pie, they say, OK, if I want my city to become net zero in 2040, we must target this, the building sector. So that's why all the real estate stakeholders, they are under big pressure to decarbonize. This is just not about US story. It's about the global story.

So there's some headlines in the media say "European Green Deal," renovate-- it's a renovation wave that they say, OK we will invest a lot to renovate those buildings and decarbonize those buildings. And Mumbai, Asia, Mexico City, and the US, we have this Inflation Reduction Act and just inject a lot of capital into this sector to decarbonize this sector. So that's basically all what's going on for decarbonization.

And think about this. Decarbonize the building sector-- we first need to understand, what is carbon about for the building sector? We show this, the building's carbon footprint.

So we know that in general, two major categories-- one is embodied carbon. That's in the concrete, in the cement, and in the production supply chain that you just gather all the materials and then you build. That's embodied carbon. All those are embodied carbon.

And the other category is operational carbon. Operational carbon means building is already there. And then you operate the building, some very durable asset, 50 years, 100 years. And for each year you operate, then you have the operational carbon. So that's the idea.

So now, when they are talking about this decarbonization, many of those policies, they first look at this operational carbon. They have not got the chance to look at the embodied carbon. Now, some of them, they try to look into this. But first, they say, decarbonize the buildings. They are talking about operational carbon. So that's basically the energy you are using-- the gas, all your electricity in the building.

So think about now. We also make our life easier. Now let's put this embodied carbon aside, and we only think about the operational carbon. And for operational carbon, there are several strategies that can help to decarbonize the buildings. Do you have any idea of these strategies of the decarbonization? Look at operational carbon. Any thoughts? Please.

AUDIENCE: Electrify the building?

SIQI ZHENG: Electrifying the building. Yeah, that's good. That's one of the major topics we are going to talk about. But first, think about the high level. What are the ways that we can decarbonize the building? Yeah?

AUDIENCE: Weatherization, is that it?

SIQI ZHENG: Ah, yes, that'd help the building to have better insulation, for example, for the cold weather. Yes?

AUDIENCE: [INAUDIBLE] passive strategies.

SIQI ZHENG: Passive strategies. What kind of passive strategy? Give an example.

AUDIENCE: Like a vent duct where you have a wind--

SIQI ZHENG: Ventilation, like this natural ventilation. They don't use a machine, but you use the natural wind, right? OK, Wilson?

AUDIENCE: Maybe use less gas, all electricity.

SIQI ZHENG: Yes. OK, good. So that's the first thing I want to talk about. Do you want to say something?

AUDIENCE: Yeah, a passive house is because they don't use the energy and also the green building.

SIQI ZHENG: Yes. So you are an expert on passive house. Later I will ask you questions about passive house because today we will talk a lot about passive house. So the three major strategies I look at the high level of because electrification and the passive house, they are specific technologies. But first think about this.

First, use less. You cannot just waste energy. You should turn off the light when you are not here. You should put the temperature not so hot-- I mean, in the winter, inside, the heating, not so cold. And you need to put on a sweater in the summer with very strong AC.

First, change your behaviors. And help improve the insulation of the house so that you first use less-- behavioral side and the insulation side so that you consume less energy. That's number one.

But you cannot really consume zero energy. Otherwise, how can you do? You need to live, work, play, and you need to consume some energy, although you can reduce, reduce to the minimum. But you still need some energy for sure, because you don't want to sacrifice too much of your quality of life in the buildings.

And then, for those energy to the minimum level, switch to renewable energy, either on site or off site. So that's-- basically, you can see these solar panels on the roof and an offsite wind farm and all those things. Then you buy some renewable energy from other places.

And you can generate, but you don't have enough-- too much roof space. You have only limited roof space. So that's the on site. If you cannot do on site, go off site.

And then another thing is you purchase a lot of energy from the city-level grid, the electricity. So then you need to, OK, change from the very, very fossil fuel gas into electricity for major type of energy consumption, especially winter heating, from gas to electricity. And then, if the city also is doing a good job, the city will make this grid decarbonized-- decarbonize the grids, the city grids.

Then the city's electricity is from-- if the city's electricity is from the solar or from renewable energy, then if you switch to fully electrifying, then you are saying you are decarbonizing your buildings. If you only change to electricity, but the city's grid is still dirty and they use coal to generate electricity, then it still won't work.

So that's a collaboration between a city and a building.

AUDIENCE: I remember reading an article talking about that, and they said that even if the cities are not decarbonizing their grid, it's more efficient to use energy because the transportation footprint of coal, oil, it's a lot higher than a lot of electricity. It's very efficient to transport electricity.

SIQI ZHENG: Yeah, that makes sense because the city is big, the economies of scale. They generate the electricity, and then you get electricity from them. It's better than every building buying some coal to generate the electricity by themselves.

But ultimately, oil-- but ultimately, they need to decarbonize the grid so that you can get net zero. And if you use less, and you switch to renewables as much as possible, but you still cannot get to net zero, but you already pledged to be net zero, and what should you do? The only last resort is carbon offset.

For example, MIT, here, our president, our former president, and the new president-- we have a new president, but our former president was very ambitious. They already pledged to the entire world that MIT will become net zero in 2026. Can you imagine, 2026? That's only 4 years or 3 years to go to become net zero in 2026. Do you think that's possible for this MIT campus?

AUDIENCE: Nuclear.

SIQI ZHENG: Nuclear. Yeah, but they cannot just only use nuclear.

AUDIENCE: [INAUDIBLE]

SIQI ZHENG: Yeah. So now what they're doing is to buy carbon offset. But they don't want to look very stupid. So they are talking about how to buy the best carbon offset, because there are bad ones, there are good ones like that. So they create a committee. I'm on the committee. The committee is called MIT Net Zero 2026. And we have numerous meetings to discuss this carbon offset thing because it's no chance to really get to net zero even with this offset.

And then we are talking about carbon offset. This is not my expertise, but we can discuss a little bit. I know you want to say something about carbon offset?

AUDIENCE: Yes. Can you explain how you change from gas-based to electricity-based? And is electricity more cheaper as well? And so I'm understanding how you implement this because it's something that--

SIQI ZHENG: Yeah, later, we will discuss this a lot. Electrification-- that's a focus of this class. But first, let's talk a little bit of carbon offset. And I think many of you heard of the carbon offset-- is good things or bad things. What do you think, whether it's a good thing? What is the limitations of carbon offset?

AUDIENCE: It's difficult to verify, just like what you said, as well as if a lot of the carbon offsets, unless there's actually any-- if you're just buying a carbon offset that is like a forest has been maintained and so that the carbon sink. Well, there's not really any behavior change. That forest was perhaps going to be there anyway. So whoever just can buy it all was just going to buy it at the beginning, and then, well, then they really [INAUDIBLE].

SIQI ZHENG: Yeah. I want to make sure first of you whether you understand offset as a concept. So here I put a small picture here to give you a sense of carbon offset. So basically, see, this is maybe a forest or a wind turbine. No matter what, it's very green. And they can absorb carbon from the atmosphere, or they generate renewable energy without emitting any carbon. So this will help the entire world to reduce carbon.

On the other hand, there is a factory here, and they use a lot of dirty energy, and they emit a lot of carbon emission. But in the short run, this factory really cannot really switch to 100% renewable. How can they do?

This forest will sell some carbon offset because they reduce carbon. And this factory will buy those carbon offset. And so in this way, overall, it will be balanced out. So that's the idea.

So this forest will sell some carbon offset so this is giving money to this. And they can emit, but they will be offset by this forest, no matter where the forest is. This is carbon offset.

AUDIENCE: I know the the limitation about to buy and sell carbon credits. [INAUDIBLE] like, it's the real case [INAUDIBLE], to the real estate industrial sale of carbon offsets. But I know many, many developing countries--

SIQI ZHENG: [INAUDIBLE] carb offsets a lot.

AUDIENCE: Yeah.

SIQI ZHENG: Yes. For example, this factory emit 100 tons of CO_2 emission. And they pledge-- they say, oh, we want to be a good citizen to the entire world. We want to reduce our carbon emission to 50 tons. But how can they reduce? They cannot. Technologically, they cannot.

They buy 50 tons of carbon offset from the forest. Then they say, although we emit 100 tons-- no change-- still 100 tons-- 100 tons, still emit this, but minus 50 tons from the forest. The forest reduces the 50 tons.

And then, overall, it's artificially say, oh, we achieved this. So that's carbon offset idea. But as you said, it's a lot of limitations, especially this additionality. So carbon offset, the challenge of additionality is a big thing, which means of course you will need to verify. You cannot just cheat.

If the forest didn't reduce, you cannot cheat. There is a verification that's very important. But besides verification, this is the minimum requirement. You cannot cheat.

And then this additionality-- additionality means you cannot just say, OK, no matter, no matter, you will sell the carbon offsets, the forest, the forest or the wind farm or all these things. And even if you hadn't sold those offset, you will still have made that effort to reduce carbon offset.

So for the entire society, there is no change. So that's a problem. So here I gave you some examples of this.

For example, this Delta is a big airline company, right? And they emit a lot because they burn the oil for the flights. And then they buy the carbon offset from the Dominican Republic. The Dominican Republic, they have a wind farm there. They have a wind farm. Then they generate a lot of renewable energies.

So this Delta bought some credits from there-- carbon offset credits from there. But later some scientists, they studied this case. And they showed that even if Delta didn't buy that, this wind farm would still be built. It's not depending on whether Delta buy or not.

So this Delta buying something does not change anything that the Dominican Republic will do. So it's not additionality, right? So that's the thing. No matter what, the Dominican Republic still do the wind farm. It's no additional reduction of the carbon from the entire world, because global warming is an entire-world thing, right?

So no matter what you, they still build. So you still emit by your flight. So this carbon offset has no additional net value to the carbon reduction. And General-- GE, this company, and they also did something. They bought some carbon offset from China. From China, they also have a solar farm and a wind farm there as renewable energy. They bought some credit from there.

But then later they found out the China's government, they already heavily subsidized that wind farm. And so it means no matter whether GE will buy or not, the wind farm will always be built. It's nothing to do with this.

So you didn't change the entire thing. So that's additionality. This will be a big problem for the carbon offset. So you just make yourself look good. But actually, you have no additional contribution to the global reduction of the carbon. You just make yourself feel not that guilty when you emit to the air.

So that's basically the problem. But this is not our focus. Our focus is, OK, we know, for example, MIT, net zero, 2026. We know that for now, we have no other choice. We must be realistic. So we are discussing how to buy carbon offsets.

But we know this is just a short-run, very, very temporary solution. We cannot rely on this. If we rely on this, MIT's reputation will be hurt because there's all the problems. So we really need to look at the long-term ways of decarbonize our campus.

Now we talk about technology. Remember, the point is-- today's point is technology versus people. We first look at technology-- so many technologies I cannot cover all. Actually, last year, the MSRED, a graduate from MSRED, Hans, he already got a job in Europe in an ad company. And he did the MSRED thesis on 10 technologies on sustainable real estate.

And his thesis got the best paper award-- best thesis award from MSRED, which is 10 technology on sustainable real estate. I only touch on two. But I think the logic will be very similar. So after you understand these two, then you understand all in terms of economic mechanism, not technology itself.

First is passive house. Second is a heat pump, which is so critical for building decarbonization, building electrification.

So first, passive house-- remember, last session, I talked about this big developer, Millennium Partners. And I talked about a little bit about their journey. Actually, they have dozens of buildings. I only put four here. But this is their journey.

I just want to show that for this developer, not from the very beginning they have the DNA of green or DNA of ESG. No. When they first did their first several buildings-- nothing to do with ESG. Even they have a big problem of the sink of the building.

And then they just want to make sure to please the mayor. They say, OK, this can create a lot of jobs. Then the mayor give them permit to do a building and help the mayor to solve an issue like that. And finally, for this newest building, Winthrop Center, then they started to focus on ESG, or sustainability.

And so here is a story. Now we look at this Winthrop Center. Look at the Winthrop Center to think about more deeply.

So here is a building. So I'm not sure-- next Thursday, Zhengzhen will talk about this case in depth. And we will have a guest speaker from Thursday.

AUDIENCE: This Thursday not next Thursday.

SIQI ZHENG: Oh, this Thursday. OK. This Thursday, the day after tomorrow, Zhengzhen will talk about this building in depth. So I can just give you a very quick preview.

So this is the Winthrop Center. I'm not sure if you can see, it's in Boston downtown. It's many old buildings here and there as neighbors. And they are not-- they are not very beautiful.

So this one is very beautiful. This is very new. And those are old buildings.

And it's so tall. And they have two parts, almost have two half, half. The lower part is office. That's for lease. The upper part is condo, for luxury condo, because that's their competitive advantage. They always build and sell luxury condos in there. That's for sale.

That's for these buildings. Think about this. Now, they really committed-- they really committed to ESG and sustainability. But they still not, like-- for two parts, they still treat them differently, I mean, in term of to what degree you want to achieve the highest sustainability, energy efficiency, they treat these two parts a little bit differently.

One is very, very green, and the other is OK green, but not so green. Guess which part? Which part is extreme green?

AUDIENCE: [INAUDIBLE] extreme green?

SIQI ZHENG: Why? Any rationale? Quick rationale. Why office extreme green?

AUDIENCE: The future tenants, that's what they're demanding. They can market it as being the largest passive house office building and attract financial service firms or others want to be in the area and have a greener footprint.

SIQI ZHENG: OK, you are saying this greenness or this sustainability can be the selling point of the office part. And also because the tenants, they are more sophisticated, they demand. But for the condo, why not? The condo, the rich people, they don't care? Yeah, please? Will?

AUDIENCE: At least operationally, it's your house and it's your condo. You can operate it however you want. You can live in it however you want. You can leave the lights on all day. You can turn the AC to 72, whereas when you're in an office, you have more control over maybe in the winter, you go with a lower temperature in the office.

SIQI ZHENG: Central, centralized control like that. OK, good. So basically, your guess is correct. So both are relatively greener than the neighbors. But they still had a choice.

They made the office part extremely green. Then they got all the certificates. They have the passive house. That's a certificate.

And they got LEED Platinum, and they got WELL. This is a healthy building certificate-- WELL Gold. So they have this, this, this. And for the top part-- that's a condo part-- they did LEED Gold-- still OK, but not so extreme.

So that's the choice. So just as a side note, last session, at the very end, I quickly went through LEED, remember? But Akrisht, today-- tomorrow recitation, Akrisht will cover more about the LEED details, technical details of the LEED.

But overall, LEED is a certificate for the energy efficiency overall of the green buildings. And they were created by this US Green Building Council, USGBC. And they have many, many systems, not just the LEED itself, but they have certified silver, gold, and platinum, at least the four levels.

And more importantly, they have many schemes. And they have new buildings. They have existing buildings. They have commercial buildings. They have residential.

And they have core and shell, the outside part, and the frame. And they have school, retail, all kind of types. So they have many, many subtopics, subsections of the LEED. And Akrisht will cover some details.

And another thing is a certificate of WELL. That's-- they look at the healthy perspective-- for example, water, air internal, daylight, and wellness and comfort, et cetera. So they got this very high level. So that's the certificate.

And as we know, this really help fix that information asymmetry problem, as we discussed. With all this, we're terrible. Nobody can judge. And the developers just self-advertise.

Remember my China paper. At that time, China had nothing. And these developers just said, what do they want you to say? And my building is great. My building is very energy-efficient. You don't need to pay any energy bill.

Then there is a [INAUDIBLE]. And the buyers got cheated. And they didn't know the information, because for the building, they say experience good. They say experience good. You must live there for some time. You'll find out.

So this kind of certificate really helped to fix that market failure problem. That's what we want to mention. And now, say, OK, this Winthrop Center, they chose for the office part, lower part, the office part, they chose this technology, this technology we are going to focus on, which is called passive house.

It's not a house. When I first heard of this technology, I thought this is a house. No, this is just a terminology-- it's energy-efficiency building technology. Passive house, this is from Germany. This is from Germany. It's imported from Germany.

And this is a certificate, but they can train all the developers, all the builders, how to build a passive house building. So the point is the following. Remember, this very, very important point of the passive house is super energy-efficient, reduce energy consumption by a lot by very good insulation, insulation, insulation, and the insulation.

So that's the point of the passive house. You can see they have envelope very insulated and air sealed layer-- add some layers and eliminate some potential leak of the energy, and use a heat recovery ventilation and the window orientation, all the things. Then always they said, for passive house can reduce 60% to 80% of the energy consumption compared to a traditional house.

I don't know if it's true or not. But on average, they reported like that. So that's passive house.

I'm not a building technology person. I can only show you this. But I want to highlight one thing. It's not free lunch.

The additional cost is 3% to 10%, based on some estimate from engineers-- 3% to 10%-- because you really need those materials. You need the actual piece you need to do this.

If you invest more, 3% to 10%, to build a passive house building, you really have the benefits. You have the energy saving-- no, I put 90%, 60% to 80%, even 90%. That's very, very impressive. Very impressive.

And the resilience-- and, for example, power outage. So then you still have that. And the house is not-- very clearly, this is not a plastic bag, OK? Not a plastic bag. Because you say, oh, all insulation, then it's kind of-- no, it's no exchange of the air, no. They have very good ventilation system to make sure the fresh air inside and comfortable. So that's basically the benefits of that.

So then why the Winthrop Center-- I just asked question why they chose the lower part. They chose to go for passive house or extreme, this energy efficiency. But for the upper part, they just chose a relatively OK level. Just now we mentioned some factors.

For example, the office tenants, they are more demanding. Or the offices, they can better control the temperature or something like that. But I think the fundamental story is that they understand the passive house has pros and cons.

And that's from our interview because we need to understand. Zhengzhen and me and Juan, we went to interview them. We understand their logic, and we say they were very smart. They were very smart when they made the decision. It's the following.

Think about comparative advantage. Comparative advantage means, of course, you need to choose the most strengths you have. So that's a strategy. Why they put the condos at the top? Because just now, remember, there are some ugly buildings around this.

So lower part-- no WELL. You open the window, you'll see other buildings. And it's so crowded in downtown Boston. I think Zhengzhen will maybe organize an optional tour if you are interested to go visit Winthrop Center. They are almost done. They're almost done. They're almost completed.

And we know for this condo, very luxury condo, they are so rich. They really enjoy the view of the ocean, of the downtown, vibrant downtown. So a window is so important, and for the office, no view at all. Open the window, see other ugly buildings. So they need to find another advantage.

And now we know, oh, ESG is so hot. So ESG is important. And sustainability is important. All the S&P 500 companies, they really want you to rent some space and put their employees in a healthy and green building, good for reputation and all the things.

OK, no WELL. Let's try Green. [? Upper-- ?] oh, we are so good, ocean and the downtown. And the luxury people, the wealthy people, they really value this. Even without anything about the ESG, they will come and buy. They understand how these rich people, they are thinking. So say, OK, green-- second-order thing, for the office, first-order because no WELL. That's my understanding. But this Thursday, the guest speaker will talk more about this.

And another thing-- let me finish this point. Another thing is passive house-- really, really important thing is insulation. So they want very small windows. If too big windows, too hard-- the cost will go up because you want big window, and then you want a view, then you have a problem with installation. So you need to do a lot, invest a lot for the windows and the walls.

So they want minimum windows. Minimum windows will be a disaster for luxury condos. We'll have a minimal window? No, not good.

So they want big windows. Big windows means passive house is too hard to do. You have a question?

AUDIENCE: Yeah, I was just going to ask about why is it either view or green, like one or the other? I think you just answered it. But also, on top of that, isn't it-- if you go back to the previous picture, you have also-- with the windows--

SIQI ZHENG: Yeah.

AUDIENCE: --the way you take in light changes in the summer and in the winter, right? And if you're in the bottom part of the building, wouldn't that be affected because you have other buildings surrounding the property?

SIQI ZHENG: Oh, yes.

AUDIENCE: [INAUDIBLE] then you can fully do that.

SIQI ZHENG: Right, the top, maybe the ventilation is easier to do, right? That's your point.

AUDIENCE: The [? ventilation-- ?]

SIQI ZHENG: And the ventilation.

AUDIENCE: The [INAUDIBLE], it can [? take ?] you, in the winter, it can [? take ?] you from that angle--

SIQI ZHENG: Yeah.

AUDIENCE: --whereas if you're in the bottom, you can take advantage of that.

SIQI ZHENG: Yes. So that's all this building technology and design perspective to make sure that they can invest reasonable money to do the passive house but generate the most benefit from that.

So then they are not stupid. They are a developer. They are not a NGO. They are not like philosophy. They understand they need to calculate whether that make business sense for this.

So they say, OK, upfront cost at first, the $1.3 billion. And if we do passive house, if we, this lower part, really go extreme green, then plus 3% to 10% of the cost premium, and then we say, OK, reduce utility cost-- at a very rough estimate, and they really had a [INAUDIBLE], and also increased rent and occupancy rate. We all discussed these parts last session. Remember, the benefit?

These all reduce the utility cost. You pay less. And all the tenants are so happy they pay higher rent. And you can lease out very fast. So that's basically benefit, benefit, cost.

They compare cost and benefit. They say, OK, this is a good deal. Let's do it. But actually, at that time, when they made the decision, they were uncertain.

They were uncertain [INAUDIBLE], especially the market. Who knows? How can you be so certain that if you build this, it will become so popular and then all the tenants will come? No. They were uncertain.

So they said, no matter what, I don't care. I look at the long value because I hold this asset. Remember, this is a lease. It's a hold for many, many years. Maybe for some years, not good. But I'm so patient, and I can wait for another 10 years, they said. So I'm not sure whether they were thinking so, but they said so. They said, good, long-term will.

And the condos is your sell. So that's basically OK. Even if no increase, even if this doesn't exist, I'm fine. I'm going to take the risk. I'm the first mover of the market. I'll take the risk.

Actually, this is more difficult for now, remember, because not about Winthrop Center, but because the overall office market after the pandemic, all the people work from home. The office market becomes so weak and so weakened in the downtown-- so very unfortunate. They had such a big chunk of the office part after the pandemic.

And at that time, maybe the green is not the first order at all. The first order is how to convince the firms to get into here and rent your space.

AUDIENCE: I guess, for our learning, is this kind of green versus view tradeoff strategy fairly common and precedented, or is it--

SIQI ZHENG: Not very common. This is just a case study. But the tradeoff of this logic is clear. Maybe for another building, it's not the tradeoff between green and the view, but the tradeoff between green or something else. But this thinking, I want you to have this thinking approach that always there's a tradeoff. You have a question?

AUDIENCE: Yeah, so when the developers do the assumption, what do they assume for the increased [INAUDIBLE]?

SIQI ZHENG: What do you mean?

AUDIENCE: To which percent--

SIQI ZHENG: They had no very accurate estimate.

AUDIENCE: It was just an idea.

SIQI ZHENG: Idea, yes, I think conceptual level. Or it's just a very rough estimate.

AUDIENCE: So if you reduce the size of the window, you get a better LEED rating. But, for example, for the WELL rating, you want more sunlight to come in.

SIQI ZHENG: You need a big window.

AUDIENCE: So then how does that--

SIQI ZHENG: Yes, that's a very good question. So I think that's another tradeoff. I think last session we discussed this. Sometimes, it's a healthy part-- healthy buildings and the energy-efficient buildings, they are not always going to the same direction. There are always some tradeoffs.

But I want to say we cannot think about this in a static view. We need to think about this dynamic view. Dynamic view, benefit-- and further, they thought, oh, people understood a little bit of how important the health is.

And then, after COVID go up-- I mean, the health benefit-- oh, indoor air quality is so important, especially after the COVID. So the benefit go up. This is unexpected, which means they were lucky in term of this.

But, of course, as I mentioned, this work from home, this problem of the high vacancy rate of the office buildings-- thus, they are so unlucky. They just encountered this problem.

And the cost [? is ?] also dynamic. And first, when they planned for the decision, they say 3% to 10% because at that time, passive house was not so popular. They need to send their staff to Germany to learn. Now, so many passive house projects and so many experts and the builders, they understand how to do, when they implemented, 1% to 3%, which is good, which is good for them.

So think about this conceptually. So that means we really need very sophisticated understanding because real estate, even for the construction period, is not, like, one day. It may extend, like, two or three years. And all situations change, especially for the COVID thing. Who can-- who could anticipate that?

They are very brave because I think this is the first passive house office building in-- I'm not sure whether the entire country or just Boston area. I think maybe in the entire country. This is the first large-scale passive house office building because for passive house, they always build multifamily houses or single-family houses-- passive house, very popular, very common.

You go to this website, passivehousema.org. They have a Massachusetts Association of Passive House. All the builders of passive house, they have this association right now. They become a club to share knowledge, information, and advocate for passive house, and also lobby the government to give them more subsidy to build a passive house, all the things.

So go to this website. You will see this-- I think now we have at least-- you can see-- at least 100 passive house projects all over the Massachusetts, Boston area. I'll give you some examples, all single-family or multifamily. It's small. See this small thing?

And they say 80% reduction in energy use. So this is a multifamily, I guess. And this one, this is Somerville. This is close by. If you have time, go there to take a look, this Somerville passive house. Yeah, so this is also-- I think this is also multifamily.

And this one is another one, Union Square one. As you can see, it's also 80% reduction, this one built by our MSRED alum. Zhengzhen and I, we went there two years ago, one year ago. We visited the project. At that time, they had nothing, because they were still struggling with this permit and the community saying-- they have all kinds of community meetings to get support from the community to build.

So we visited Kent. And we know they have this very ambitious goal to build largest passive house, residential, but still residential community in the US. That's also nearby. This is in Newton.

So we have all this. You go to the website. You have all the passive house.

Now let's move on to the second technology. You have a question?

AUDIENCE: Just one more question on the passive house. Is it possible to change existing buildings into passive houses? Because I think, in a lot of countries, making the existing houses--

SIQI ZHENG: Yes, renovation. That's true. Yes, you can. But it will be more costly to do that because you need to change the original settings.

OK, now let's move on to the second technology. I feel so embarrassed that I'm talking about technology, although I'm not a technology person. But I tried my best to explain the technology in a way that we can understand.

Now we are talking about electrification-- means switch from gas to electricity. That's very important. Now, we assume we cannot control the city grid. Now we assume the city grid will become greener and greener.

If the city's grid is greener and greener, it's good to switch from gas to electricity. Think about this-- cooling. We all use electricity. This is ACs. But it's very decentralized and very old-style ACs. It's not very efficient. That's true.

And this is old-style, but this is already electricity, no problem. Heating, especially in the New England area-- still a lot of gas-based heating. The gas-based heating or oil-based, no matter what.

Now it's a very important trend is to change from the gas-based heating to electric heat pump that can use the electricity to do heating. And actually, it can also do cooling. I will let you-- show.

But point is the old-style gas-based-- you have this natural gas-- these are water boilers. And you just boil the water, become hot water, then use the water to heat the building. So you have this.

But if you change it to electricity, then you need to put a lot of this technology, these machine called heat pumps-- big heat pumps, especially the air source heat pumps here. So then this is what we did last year-- it's an office building in New York city. But you can also use this in residential houses.

But this is a high-rise office building. So the point is, electricity is so important. Heat pump is more efficient. But you can see the heat pump. This machine will occupy a lot of space.

That's a downside of this electricity because then you have to sacrifice. You have to sacrifice some leasable space. At first you can lease this out and get rental revenue. But if you want to put all the machines here, then you lose leasable space, which will hurt your rental revenue.

So that's the cost of this. But the benefit, you have a lot of benefit. So that's this.

And heat pump technology-- Google. I just want to say it can do heating cycle and cooling cycle. You will have the same thing. Let me show you the picture here so that you have better understanding.

So you have an outside unit outside your door or outside your house. There's an outside unit, and inside you have-- it's very similar to an air conditioner, but it's a heat pump. And you have this outside unit and the inside unit, and [INAUDIBLE] electricity, and you heat your house.

When it's heating, then you have this refrigerate, and it go through this first. This is a circle that they can just emit heat into the room and become cooler and then become cooler and then get heat from outside and the compressor here, and it becomes hotter. Then it's a cycle here.

And the cooling is the reverse cycle. And then you get cooler, and then you emit cold air into the internal, and then you become warmer and then go outside. So that's a cycle of this.

So basically, you can use this anywhere, not just the heating, but also cooling. And data shows for cooling, it has better efficiency than these old-style, old-fashioned window ACs. So that's why, even in very hot area, you can use it for AC, but in a cold area, you can use it for both heating and cooling. So that's a heat pump.

So now they really promote heat pump a lot because they really want to switch from the gas boilers, the gas-based boilers, to the heat pumps that are fully electrified, only electricity.

Then we have a massive-- I'm not sure, for those who live here for some years, you know, massive. I think you nod your head a lot.

AUDIENCE: I just did this.

SIQI ZHENG: Oh, you applied to this.

AUDIENCE: Yeah.

SIQI ZHENG: You applied [INAUDIBLE].

AUDIENCE: Yeah.

SIQI ZHENG: For your house.

AUDIENCE: [INAUDIBLE].

SIQI ZHENG: For what?

AUDIENCE: For installing [INAUDIBLE].

SIQI ZHENG: Good. OK. [INAUDIBLE], you have an example, yeah? Then, if you decide to install a heat pump, $10,000 you can get from the state. So that incentivizes you to-- [? MacKenzie, ?] to do this.

But whether your neighbors all did this or only you--

AUDIENCE: Just me.

SIQI ZHENG: Just you? Why your neighbors didn't get this $10,000?

AUDIENCE: Right, they-- well, you know, it is a difficult process.

SIQI ZHENG: You mean the application, bureaucratic?

AUDIENCE: Yeah, and actually, a big issue with triple-deckers, older triple-deckers is they don't have the electrical capacity. So we only have 100 amps coming into the building, which is crazy low. So [INAUDIBLE], they literally can't until we get our home--

SIQI ZHENG: OK, good. Who else in this classroom got this $10,000 in your pocket? Of course, because many of you don't live here. Zhengzhen, did you get this? You have a house here. Are you planning to do so?

AUDIENCE: So usually the [? guests-- ?] it's 30 years. So I put my [? guests ?] [INAUDIBLE]. So I guess the best business case is that towards the end of use, it makes more financial sense, that you are going to change it anyway. But [INAUDIBLE] system is working. So that's really the hard part of the industry right now. It's not like that's part of [INAUDIBLE] 100% pure [INAUDIBLE].

SIQI ZHENG: So you are going to wait for another 20 years. When we become 60 years old, we are going to do this. Yes, I also have my house here, and I haven't done this. I haven't applied to this-- not so progressive as MacKenzie.

And, no, I understand. I need to wait for when I get 60 years old. Yeah, what's your [INAUDIBLE]?

AUDIENCE: Oh, I remember.

SIQI ZHENG: OK, you got it.

AUDIENCE: I have a question about how the heat pumps work. So is it-- can it either do heating or cooling, or can it do both at the same time? Because in Massachusetts--

SIQI ZHENG: I don't--

AUDIENCE: --with the shoulder seasons, sometimes, one day, you may have to heat, one day you may have to cool.

SIQI ZHENG: I really don't know how to answer, but maybe MacKenzie can.

AUDIENCE: How easy is that? You just do it on the thermostat?

AUDIENCE: Yep.

AUDIENCE: OK, perfect.

SIQI ZHENG: OK, good. So, yes, for example, one day is cold and the other day is hot. So you switch very easily. Good.

So now we had a very small poll that three of us, we live in Massachusetts, only one person got one [INAUDIBLE], and two of us, we didn't. It's not because we don't want to do so, but we really have a rationale. We have the rationale of this.

So it's not like, oh, all everything is so perfect for heat pump, right? This is really good, favorable conditions. Technological improvement becomes smaller and smaller. This is where we think about office.

If you have smaller, smaller, good. Then you won't lose space. And then you have the subsidy good-- government pay and all those other things. But sometimes it's also some unfavorable conditions, such as the electricity is sometimes more expensive than gas.

It's not cheap. Just because you want to go net zero, then you choose electricity, not because electricity is cheap. So you switch to heat pump. Maybe your monthly bill will become higher because you are using more electricity. And when the gas is cheaper-- of course, now gas is also not cheap. But it depends on the relative prices of the electricity and gas to make business sense. Right?

And another thing-- so you can see that MA is so lagging behind these other states of adoption of heat pumps. MA is here. So that's because of us. We didn't do this. We need to learn how to follow MacKenzie to do this, to push MA like this.

Yes, so that's the point. But then we are now doing research. Me, our group, my lab is doing research on to understand why the slow, slow adoption of heat pumps. Because of what?

Now I'm working with professor Chris Knittel who is a Sloan professor on energy economics. So we are doing. We got a small grant from MIT Energy Initiative because they want to understand.

Then we just surveyed, and we got data from all the houses who chose to install a heat pump in their houses, households. Then we counted their cost. See this is cost.

One square is $100. So altogether, total cost will be $22k. But you can get $10k from the government. So these green squares are the equipment. Just the heat pump itself is a machine. But you cannot just buy a machine and put it in your house. You need to install. You need to hire some companies to install. That's installers.

And then you need to do this labor and electricity and permitting and this, all kinds of things. So the MA subsidy $10k cover about half. And the other, you still need to pay money. It's not free.

So that may be one reason. You still need to go through all this. And also, it's a lengthy permitting process-- not like you fill out a form and then tomorrow someone will come to install. No.

And we also had so many installers. And we found out that the installation fee varies so much across different installers. And we even found some bigger installers, they charge higher price to install. The smaller ones, they charge lower. But the bigger ones, they charge high.

So this market is not mature. So that's one reason. We are still going on the project. And we will find more interesting things.

OK, now this leads to this economics. We cannot just technology, technology, technology. No, even if the technology is perfect, heat pumps still have this low adoption problem, as I just showed.

And think about this. Then we go back to this conceptual-level pro forma we always use as a tool to understand. Then think about this. The arrows, this is a baseline thing, right? Think about upfront cost. You need to invest money, $22k, to install. That's $22k for our house. For such a building, it will be much higher cost.

And then you get rent [INAUDIBLE] if you don't do. Now, remember, I introduced a little bit about New York City's local law 97 in the intro session. It said, by 2035, if you are not net zero, or if your carbon emission is above the cap, you need to pay a penalty to the city. That's why--

[PHONE RINGS]

That's why this is an office building in Manhattan that is under the big pressure to go to this heat pump because they know if they don't do that, later, we'll pay the city a penalty. Penalty becomes negative cash flow.

So if you don't do this, you have this cash flow. And then you compare. If you do this, then which arrows will change, and to which direction? Guess.

Which of the arrows will change if you really decide? It's not a house. It's a high-rise office building like that.

It's a New York City downtown Manhattan building. And the designer of this building will come after midterm to teach three sustainable design sessions. Carlos will come. The other Carlos will come to teach three design sessions.

He designed the building. And the developer-- I think that's Boston Properties, I guess-- they asked them to tell what's the pros and cons of fully electrifying and use heat pump. Carlos had to answer that question-- then how they answer from this economics perspective.

Just a guess. Please?

AUDIENCE: The upfront cost will be much more?

SIQI ZHENG: Yes, you need to invest more money for the machines and the installation--

AUDIENCE: Your operation costs will be much less.

SIQI ZHENG: Go up, reduce operational cost.

AUDIENCE: And you can probably raise your [INAUDIBLE] rates.

SIQI ZHENG: Yeah. And the most important thing is to eliminate what?

AUDIENCE: Penalties.

SIQI ZHENG: Yes. But it's not that easy to judge, as you can imagine. So here is all the uncertainties. That's why this is not an easy question for Carlos to answer.

Of course, we know this will be additional cost because you have those heat pumps. And also, they have specific requirements for the facade because they really need a very good insulation. So if you really choose heat pump, that direction, very good, very specially designed facade, that's another investment.

Oh, thank god, we will eliminate this penalty because at that time, we showed to the city, oh, all electricity and the net zero, no problem. So no penalty. Good.

Who knows about effective rent? Yes, maybe this becomes so popular, and the tenants want to pay more, and you'll get more tenants. But remember, you'll lose some space.

You'll lose some space. Then you put all the machines there. Then you lose the space to generate rental revenue. Who knows?

Operational costs-- who knows? Whether the electricity will become very expensive-- don't know. So all these different scenarios.

So that's why this is not an easy question for an investor or developer to decide whether to go for electrification immediately. It's more sophisticated, more complex because of these future uncertainties. That's another project in my lab. We are doing so many projects. If you are interested, come to me.

This is all the applied research projects. Just now I showed this heat pump of the Massachusetts installation puzzle. This thing is the electrification uncertainty.

I mean, this is natural gas prices because of the Ukraine-Russia War. We don't know. Maybe the gas will be more and more expensive. We don't know.

And another thing is the city grid decarbonization because that's totally out of control, out of the developer's control. That's the city mayor's decision. All the city mayors are now very progressive, say, especially in this New York City case. We will decarbonize our grid by which year, for sure, all new renewables.

But they don't have enough money to do so. They have limited budget of the city. City budget's not enough to do this grid decarbonization.

So it's a rumor. The city's mayor said so, but it's possible it will be 10 years delayed. If this city just promised this but couldn't achieve that, even you as a building become fully electrified, but you still need to pay the penalty because the electricity is not clean.

So then you will complain about the mayor. But the mayor's already gone because the mayor already retired or stepped down. So that's a problem because the mayor cannot be in the position for 10 or 20 years, although they pledged by 2040 net zero.

But the mayor will be gone in three years. And all this politics is so complicated. It's very hard to imagine.

AUDIENCE: What energy sources do you think we're going to have to rely on for decarbonization? Because energy consumption rises dramatically every couple of years.

SIQI ZHENG: Yes. What's your question, [? Percy? ?]

AUDIENCE: So what kinds of energy-- like nuclear, gas--

SIQI ZHENG: OK. The different cities, they are different. Yeah, I think now New York City-- I'm not very familiar with New York City. I'm not a New Yorker. But my understanding is part of the city is more cleaner than the other part. So they have different grids.

And the dirty part is still on natural gas or oil to generate electricity. But they try to switch to renewables. But what kind of renewable? Maybe solar or wind, I don't know. I don't know.

But I don't think there's a lot of nuclear power. I think it's not favorable, the nuclear power here. That's why many nuclear professors in MIT, they are promoting nuclear power because that's green. They promote.

So then my research team, we run simulations. We say, OK, future uncertainty's so much, how can we know. And we run tests on different future scenarios, and we say, which option will be better off under which case?

Option A, I don't care. Keep natural gas for all the entire life cycle. That's option A. Option B, fully electrified-- option B. Option C, flexibility-- the point is, how can we know the future?

Now we want to keep the flexibility first because this is a new building. Then we keep the facade design OK, for future electrification. And we make this floor, this equivalent floor, very tall. But now we don't put in the machines now. We still lease out as a common area to lease out.

And after 5 or 10 years, when we have better information of the price and from the grid decarbonization of the city, then we quickly change. And we let these tenants go. Of course, it's a lease. You can set the lease length of 5 years, 10 years. The tenants are gone. Then you put the machines in. We call it flexibility.

So A, traditional; B, immediately electrification; C, keep the flexibility, invest in some flexibility, and wait for the future. Wait for 5 years, 10 years. Then you make the decision.

Then we make this-- all these simulations, we show that always, the flexibility, option C, always win in all the kinds of cases. Of course, you can adjust the parameter of the fuel transfer and this and that. But the flexibility-- because it has an option value.

The option value is that you invest, and then later you figure out more. Then you decide either yes or no. And you can wait. You can wait for a few years, more years, more years.

So that's an option value there. So that's why the flexibility option always win. We wrote a paper on this.

OK, that's all about technology. Actually, when I talk about technology, not just the technology itself per se, but already some economics and financial analysis of this-- but now I want to further emphasize the people side. You have a question?

AUDIENCE: Yeah. Actually, before we [? build ?] the passive housing, always [? lose ?] a lot of money because [INAUDIBLE] [? doing ?] it because, [? when ?] China builds the passive housing, it will reduce 80% room [INAUDIBLE].

SIQI ZHENG: Oh, space.

AUDIENCE: Yeah.

SIQI ZHENG: That's very similar to the heat pump. It will occupy space. You are saying if you want to build a passive house, maybe the wall will be thicker or the window will have multiple layers. Then you lose some space.

AUDIENCE: Yeah. [INAUDIBLE] walls [INAUDIBLE] always [INAUDIBLE] about the actual [INAUDIBLE] walls above the [INAUDIBLE].

SIQI ZHENG: Energy loss.

AUDIENCE: [INAUDIBLE]

SIQI ZHENG: Yeah, yeah.

AUDIENCE: [INAUDIBLE]

SIQI ZHENG: There's a lot of critiques on the passive house. I think that's good. That's an opportunity for you. You must visit those passive house projects and see what's the difference between those projects with the project you built in China and compare because climate and conditions and technology and all those things, they are so different.

OK, let's move on for people side. We cannot just look at technology, technology, but look at people. The people-- now, there's, of course, so many aspects of people. Here I want to focus on landlord-and-tenant relationship. They're people, two stakeholders, landlord and tenant.

And I will highlight the problem of this so-called split incentive that's a market failure because if we ignore this people side, landlord and tenant, the tension between these two, even if you have the most advanced technology, it won't work out.

To think about this-- actually, we already touched on this. It's not new. Last time we talked, the business case for green buildings, remember, we talked about this chain from tenant to owners to developers. So we already talked about the owners and tenants.

At that time, last Thursday, when I talked about this, it felt like, oh, they are good friends. Owners and tenants are good friends.

They just become a win-win solution. And if it's so great for the tenants, they will be willing to pay higher rent, and higher rent will become higher income for the owners, and owners will be very happy, and they are going to purchase green buildings. It's kind of, oh, everything is so good. Everything can work out.

Now we are looking at this. Performance gap-- if everything can work out, if these technologies are so good and can reduce energy consumption-- because they always have an engineering model. They have the engineering energy model that predicts if you install this, if you do that, you will reduce energy consumption by how much?

We have a very famous professor in this school, Christoph Reinhart, from the architecture side technology group. And he is the strongest research group of the energy modeling.

And then, for the engineering modeling, they have these predictions. But unfortunately, when [INAUDIBLE] the building put into use, and then they always found so-called performance gap or energy efficiency gap or some terminology like that, then the actual energy consumption is far more than-- much higher than projected energy consumption from the engineering model.

Then I just showed this Christoph Reinhart saying we must collaborate. If you only do energy model-- not that useful. You must consider people. If you want to consider people, come to work with Siqi. No, we start with working together. So that's the story.

But look at this. This is the first, the first, this New York City's Bank of America, this new building, the first high-rise office building of-- achieved the LEED Platinum, LEED Platinum, higher-level, not that easy.

However, if you search Google, you will see a lot of stories saying this is toxic, and this consumes much more energy. It's even worse than the 80-years-old-- some old building in-- it uses more than twice as much energy per square foot as the 80-years-old Empire State Building.

So bad. That's so bad. It's so bad. What's the reason? Have you heard of this?

AUDIENCE: Famous Building.

SIQI ZHENG: Famous Building? You know this building? You visited this building?

AUDIENCE: It's a brand-new building.

SIQI ZHENG: Yeah.

AUDIENCE: It's One Vanderbilt, right?

SIQI ZHENG: I don't know.

[LAUGHTER]

By the way, this Friday, some of you will go to New York City to visit the buildings, right? I will be with you. I will be with you for the entire day of tour to visit New York City buildings.

But I don't think we will go to this building. But this is brand-new. This is the LEED Platinum. It said it will be very energy-efficient. It turned out very bad. What's the reason? Have you heard the story?

Because they only-- when they did this, engineers used a model to predict like that. But they totally underestimate the machines in this building because they had several floors of the workstations with huge computer monitors and desks and-- not the personal computers and the servers and big machines. And nobody turned off when they left the building. It's 22 hours and all the days operating there. Then they consume a lot of building, and they make the space very hot.

So that's an example of this. But overall, [? these ?] other examples, [? say ?] this [INAUDIBLE]. It's totally out of the scope. And the possible reasons-- we already said. The engineering model that Professor Christoph Reinhart, they are doing, they don't consider behaviors.

They don't consider whether people, they turn on, turn off the lights and computers and the AC and other things. They don't consider. They assume everyone is such a good citizen, will do whatever they can to reduce energy consumption.

Another thing is construction/operation practice not follow design. Designers, they have a good heart. But the constructors, they just want to reduce their cost no matter what.

I think you heard this story from the recent Turkey earthquake. I mean, the designers also did bad things. But anyway, they did very bad things, and they didn't stick to the standard of the construction.

And the designers, even they design a green building, but the constructors, they didn't follow that when they built. The last one is our focus, which is the split incentive between the tenants and the landlord.

This is very important for us to understand. But first of all, we need to understand the lease. Lease structure-- so I have those lease structures. There are so many types of leases.

But overall, from this side called full service gross lease, which means the tenants just pay a lump sum, monthly lease, monthly rent. Then-- don't need to worry about anything. All the energy bills, the landlord will pay. No problem. Just pay the lump sum, total one number, then nothing to worry.

On the other extreme-- this is the spectrum. On the other end of the spectrum, called triple net lease, which means the tenants only pay the base rent, and then, for other things, all the tenants will pay. All the tenants will pay the bills and the insurance and all the things-- so just a base rent. And then all other things, that's called net lease, net rent. This is gross.

So that's our spectrum. OK, so this is spectrum. Then in the middle is some combinations of this and that. Who will pay what? That's a negotiation between the landlord and tenant.

Negotiation-- you will pay this, you will pay that, and I will pay this. Then it's too complicated. Let's only look at the two ends of this spectrum.

One is gross lease-- you'll pay one amount, don't need to worry about other things-- or the triple net, which means you only pay a net lease, net rent, then you pay other bills-- I mean, the tenants.

For these two, think about-- imagine it's an office building. It's an old office building. It's not a new building. It's an old office building. It's not energy-efficient.

And the landlord is considering whether to retrofit the building, to make this deep retrofit, become greener. Then, under these two scenarios, what do you think will be the challenge?

AUDIENCE: In the triple net situation, the landlord isn't covering the utilities. And so they're going to fit the bill for the retrofit, but they're not going to recoup the savings from the utility costs. And so they're less likely to do it.

SIQI ZHENG: Yeah. Very good. That's another point. The other end? Any thoughts? Will this be a perfect lease structure so that the building will get greener, will get retrofitted? Again, please.

AUDIENCE: The tenants are covering the utilities, so they have no incentive to operate the building in a green way. So they don't care. They can leave the lights on, leave the AC running, all that stuff.

SIQI ZHENG: Yes. Very good. I think you are expert on this. Have you studied this split incentive?

AUDIENCE: No, it was just from the readings.

SIQI ZHENG: OK, good. See, you must read. If you read, you answer my questions.

OK. That's a dilemma. The dilemma is the following. Either way is not perfect. Think about the net lease, the triple net lease.

So the owner, if the owner invests money to retrofit the building, however, the owner cannot recoup the benefit because the tenants are paying energy bills-- the tenant will be, oh, so great. And then, next month, I have so little, so, so low electricity bill. Maybe they even didn't understand why. But the tenants just suddenly got some good luck and got very low energy bill because the owner invests money to retrofit the building.

But the owner says, why I'm going to do this? So stupid. I'm not going to do this. I only invest, but I cannot get the benefit. So stupid. Don't do it. So the owner will lose the incentive to do so, because the tenants will just benefit.

But if you go to the gross lease problem, yes, the owner invests. The owner benefits because the owner will pay the energy bills, then invest and then later lower energy bill. Good.

Then the tenant says, this has nothing to do with me. I don't care, because I don't need to pay the bill. Why I need to care? I still leave the light on, all the things.

I don't need to save energy. I just make myself very comfortable. So there will be a lot of waste of the energy.

So either way is not perfect. So that's why we need some design. That's how the people-- you can install energy, install technology, game over, everything will go perfect. No. People, people, people, and how you can make these two become friends instead of they don't care each other.

OK. So I didn't ask you to read this case. This is the HBS case. But after class, we will upload because it's a very long case, and I only use a little bit at the beginning of that. So I don't want to burden you.

But if you are interested in this case, it's a very good case of the energy efficiency finance in commercial real estate. But the basic story I want to use for now on this point is the following.

This is Rockville City in Maryland. And this guy, this Lundberg guy, he is the owner of a commercial real estate building in this Rockville town. And that is an old building. And he leased to some tenants. It's not a big building. It's medium-sized. I think this is a medium-sized building, a 200-square-feet building, all the building.

But this is a commercial building. For example, there are some shops and some restaurants and some tenants in that. And he has someone audit the building and found it's too not energy-efficient, too old-- really need to retrofit.

If you retrofit, very clear benefit of energy saving because it's too old. And whether he will go for it, that's a question. So that's basically this case. HBS case is about whether-- this case talk about whether to do it or not and also the financing. Today, we are not going to touch on the financing-- that's for later-- but whether to do this.

So this case is the following. Then he made some estimate. He has a team.

He made some estimate. The case is cost of square feet, $4 to $8. If we use median value, that will be $6 per square feet of the initial cost of this retrofit, and then the benefit-- about 30% of energy saving. That's very reasonable, right?

Because you need to invest in this weatherization, insulation thing, actually replace the old HVAC and lighting and all kinds of things-- cost, benefit. Then they say, OK, these are the parameters. These are all about technology, technology.

Then they did this calculation. This is some parameters of this pro forma. Baseline pro forma is too small for you to see. What I want to highlight is the following. This is without retrofit. Without retrofit, look at 10-year horizon. Then use 8% of the discount rate without any retrofit-- business as usual. This building is worth 100-- they say it's 100 million US dollars. That's the value if you do this pro forma.

Then let's look at, OK, retrofit. Good opportunity. Retrofit. And then now we don't think about the tenants and landlords. Are we saying they are a family, all together, a family?

If you think about the family, very good, because you will have energy savings, energy savings, an investment of $6 per square foot, and each year you will have energy bill savings, this 30%, then this is incremental. This is incremental cost, incremental benefit.

That's on top of the baseline-- on top of baseline, incremental cost, incremental benefit. Then you say, OK, positive NPV, positive NPV is $40,000. Do it. Green retrofit. So good.

By the way, if some of you didn't take the real estate finance class, you are not very familiar with pro forma and the financial. Tomorrow, Ankrisht's recitation will cover that. And tomorrow we will have pizza, right? Sanjana? Yeah, we will have pizza for you. It's optional, but for the pizza and for the knowledge, come.

But this missed something, right? Do you think-- overall, as a family, so good. Go for it. But it missed something. You [INAUDIBLE].

AUDIENCE: [INAUDIBLE] to this point, human behavior, we're not sure how the tenants will operate, if they're going to turn on the light or turn off the light, unless they use the occupancy sensors, and then [INAUDIBLE].

SIQI ZHENG: Oh, I think I missed something. I need to say this is a triple net lease. This triple net lease means the tenants pay the energy bill. In that case, what do we think is the problem?

AUDIENCE: The [INAUDIBLE].

SIQI ZHENG: Right. Yes, yes. So basically, triple net lease, and the tenants get all the benefits. The owners bear all the cost. It's a mismatch.

How can this happen? This guy is not-- this investor won't do that. So if-- we are not a family. We are not a family. We are separate. We are separate, two groups.

Now, owner, OK, problem-- owners see energy saving only 10%-- common area, lobby and elevators, something like that, 10%. 90% of the saving will go to tenants. And tenants has zero investment-- free lunch. Zero investment get 90% saving. So good.

And tenants lose money-- the owner lose money so much because investment, but only 10% of the energy saving got there.

So that's the situation. I call it the win and lose-- win-lose. The tenant's so happy, the landlord quiet because this is bad, right?

Negative NPV, who are going to do this? Negative NVP, it's against our investment criteria. So not good.

Any solution? Give you the last chance to say if there is any solution to this if we still stick to triple net.

AUDIENCE: Increase the rent.

SIQI ZHENG: Increase the rent. What's the rationale? If you go to the tenant and say, I'm going to increase the rent?

AUDIENCE: I would [INAUDIBLE].

SIQI ZHENG: OK, show them this. Yes, that's basically to share the benefit. The point is to share the benefit.

AUDIENCE: Make tenants share the cost.

SIQI ZHENG: Yes, yes. That's also to share the cost and to share the benefit. So in this, we have this new thing called green lease. There's many, many green lease right now if you search green lease. Green lease-- so many types of green lease. But the basic point of the green list is cost pass through or cost recovery, which means, oh, yes, the tenant's benefit is so much.

Lower the cost, right? Lower so much cost. 90% of the energy saving go to the tenants. Don't be so selfish. Be generous. Be generous, and share that. It's not just to share, but-- not generous, but we define that in the lease that if you have this energy saving, we share with the owner, share this benefit to the owner in term of higher effective rent so that the benefit can be shared by the owner and the tenants in this way to incentivize the owners to do so.

In this case, this Rockville case, if they share and have the rent increase of this 2.7% as a way to recover the cost, then it will turn around, and the owner's NPV will become positive. Both are smiling and the win-win.

Of course, this is hypothetical. We say, OK, 2.7% increase of the rent will turn this around and have a very good NPV-- all happy. Do this. Final question.

AUDIENCE: Have you seen a lot of general renegotiation of the previous lease [INAUDIBLE] share [INAUDIBLE]?

SIQI ZHENG: Good point. So I will upload this. There is small mini-cases. It's not big cases. HBS is a long case. But there is small mini-cases-- green lease mini-case 1, 2, 3. And you will find it on our Canvas.

The way is they have different strategies to share the cost. But the point is first you need to show-- the landlord cannot just cheat. They need to show.

They have these meters very, very small meters, decentralized meters. They really record and make the show to the tenant, oh, you see your energy meter reduced by what? Then you share as a percentage.

And this one, they work with the energy company and use renewables. And then they told the tenants, you must purchase the energy from this energy company. Because we work together to generate the renewable company from the building, then you must use their energy. That's already put in the lease.

So that's several green leases. And with this-- with this, I'm going to conclude today's class. But now you understand, after class, go to Canvas. You find these green lease structures and also that HBS case.

Last year, after I talked about this green leasing, one of the students-- MSRED student, he had family business back to India. And he learned this, and he started to use green lease for his business in the India office market and got some good success.

So that's a thing that you can-- if you have some internship and-- your own business, you can think about this and how to design a real good green lease-- there's so many types-- to share [? the ?] cost recovery.

OK, thank you, and see you on Thursday for the teaching case, and read that beforehand.