[SQUEAKING]

[RUSTLING]

[CLICKING]

JUAN PALACIOS: So connecting to the course, so far, we've been talking a lot about planet and environmental and reducing energy for the sake of saving the planet. And what we are going to talk about today is not talking about outside the building but talking inside the building. So how can we actually think about the strategies of investing in buildings that will improve the lives of people in the building, like us. And we will talk a little bit about this classroom. We have a sensor over there that is monitoring the air quality in these classrooms, so we will see how good the CRE is with us in terms of the places that they put it.

Here are some of the key formulas and key diagrams that Siqi always uses for the lecture. So here is one of the key things of the business case for green buildings is that the tenants are going to be better off in a green building than in a non-green building and mainly because you have, on the one side, energy costs, environmental damages, but especially-- and I will show that this is the largest part of the pie because employees are going to be more productive, healthier, more comfortable, and they are going to choose to be in those buildings.

And therefore, the corporate tenants are going to make larger bids for those buildings. That's the theoretical link. And then we are going to talk about whether that happens in the market or not. And also not only today but also on Tuesday, with Siqi that is there, talking in the corner, is going to happen.

Also, we are going to analyze that decision in one specific building in New York, and we are going to have a lot of discussions about under which conditions this will be holding and which conditions it is not going to hold in because we have here people from Latin America, Europe, US, different parts of the United States, Asia. It's not going to apply to every market, but the fundamentals are going to be there.

Whether the market is going to appreciate it or not, that's a different story. But the core technology is going to work in the same way. The core idea of the engineers behind the design of those buildings is going to be very similar into why they are going to promote air quality in the building, why are they going to upgrade the HVAC, systems in the building, and so forth.

So the fundamentals are there. And now the key question afterwards-- and we are going to discuss a little bit later-- is whether the market is going to be ready or not. But today, we are going to learn about the fundamentals.

So why it's also important for the general sustainability in the real estate sector is that, if you see where the evolution of the certificates are going, is that, at the beginning, they were mainly, mainly focusing on saving energy, reducing emissions, and so forth. Actually, at the very beginning, only saving energy because there was not even the Kyoto protocol back then but really saving energy, reducing the energy cost.

It was the beginning of the energy crisis in the 1970s and '80s in the United States and Europe and so forth. So that was the focus of green building certification. As we move towards the present, you see that health starts to appear more and more. And you see that it takes more a larger role in the green building certification. And you even have, since five years ago, certifications that are specifically focusing on health and well-being in the building.

So you see that in the green building market and the green building sector, the role of health is going up more and more, especially since COVID-19. David, tell me.

AUDIENCE: Just a question, I guess.

JUAN PALACIOS: Sure.

AUDIENCE: Are there studies, like longitudinal or discontinuity studies, done on whether people are-- do take less sick days?

JUAN PALACIOS: Yeah. We'll show you later. Actually, I did one. I'm very proud of it.

SIQI ZHENG: [LAUGHS] That's Juan's PhD dissertation.

JUAN PALACIOS: And the work of a lot of people. So there is-- actually, you are in a very good city for health and well-being in the built environment. So you have me. That's great.

But beyond me, you have the Harvard School of Public Health. You have Joe Allen in HBS. You also have John Macomber. They both wrote the book on *Healthy Buildings.* They are very big into understanding what is the business case and what are the effects of buildings on human health. It's quite a lot. Ariel.

AUDIENCE: What are you talking about in the 1990s to solve [INAUDIBLE]

JUAN PALACIOS: Yeah. So that is something that was a rebound in the way that we understood sustainable buildings in a way. Well, not actually it was-- I don't think that they were talking about sustainability. But anyways, in the 1970s and '80s, they were experiencing this very similar environment as what we are experiencing now with the energy prices, very expensive because of international conflicts and so forth. The price of oil went up by a lot.

And then all of the sudden, you went from almost paying nothing for energy and wasting a lot of energy, not only in cars but also in heating, to being actually paying a painful price for every degree that you put up in the heating in the building. So one of the things that the physicists and engineers figured out is that, hey, you know what? One of the most expensive things that you can-- that you need to do in a building is to bring fresh air from the outside because, every time that you bring some fresh air from the outside, you have to bring it to the temperature that people inside the building want to have.

That means bringing from 0 degrees Celsius to 20 or from 90 degrees Fahrenheit to 60 or 80. I don't know. Fahrenheit is something that I still have to work on, but let's say from the 90s to the 80s. Anyways, that is one of the most expensive things that you need to do in a building. So what do you do?

Let's reduce the amount of air that you bring to the building. That comes with reducing ventilation rates, but it also comes with designing buildings that are practically bunkers, where there is no filtration of air from the outside. That is great for reducing energy consumption, but it creates a lot of problems with air quality.

So that was when the term of sick building syndrome was coined, where people will get into their offices and will get headaches. And they will get a lot of problems that are just purely related to the place where they were working. And not to say the risk of infectious diseases, like COVID and so forth, where basically we are all sharing our air.

I'm throwing a lot of droplets on you guys, so the only ones that are preventing you from breathing what I am exhaling are these guys there that are trying to suck the air faster than your lungs can breathe it in. So all of these problems were happening in the '70s and the '80s. There were a lot of problems in the office sector, especially, and that was something that we're trying to remediate afterwards.

All right. And to understand the role of buildings, you have to understand the role of environment on our health. We have people from all over the world. I think that things like-- we have a lot of environmental threats, but I'm going to show you the two most prominent.

This is a satellite image of the level of air pollution all over the world. You see that almost in any-- you can find your city here. You can see that anywhere where there is a city, almost there is a red spot. That means that there is a high level of air pollution.

So it's almost like pollution is the shadow of humankind. So because the way that we move, we generate pollution. The way that we heat our buildings, we generate pollution, so forth. And we are trying to remediate that, but that is now the reality for all places in the world.

And what you see is that WHO considers that as one of the largest threats, actually. As you see here, 4.2 million premature deaths due to inhaling air pollution across the world. That comes because, when you inhale, these little particles that come out of the exhausts of buildings, and power plants, and so forth into your lungs, that damages your lungs. That gets into your blood flow. That also hurts your cardiovascular system.

And ultimately, and that's also something that we've been discovering for the last years and now is one of the most serious threats, it gets into your brain. And it affects your cognitive performance. So all of those things are things that are out there, and you guys have been breathing quite a bit of it already on the way home to here. All right.

So that's one of the things that the building is trying to prevent. And I will talk a little bit about it because the air that we are breathing here is being brought up by these guys, these systems. So we are not breathing through a window or anything. So this building is between us and those red things that you see there. It's between us and those cars that are polluting and so forth.

So all the time that we are spending here is actually a time that the building can reduce our exposure to those things and make us breathing healthier air that we will have outdoor at the door of the theory. So the question there will be some of the strategies that we can do to make that air as healthy as possible. That will come with investments in the HVAC system and so forth.

This is one of the key things, especially in areas like California, where you have wildfires but also Beijing, Delhi, and so forth, where there is a lot of focus on, how do you filter the air in a way that you reduce as much as possible the level of particles that people will breathe in? So that's one.

The second one is temperature. We are talking a lot about not throwing CO2 to the atmosphere, but we know that if you throw CO2 to the atmosphere, the whole-- the planet will warm up. And the amount of heat waves and so forth will increase.

There are a lot of studies to show that-- the effect of heat on human health and cold on human health. And there is around five million premature deaths every year due to being exposed to extremely cold or extremely warm weather. So again, one of the things that our weather-- our building is doing is that we are not exposed to the cold weather outdoor in the City of Boston today and being freezing there, being sitting down. But actually, we are in a very comfortable, rather even warm room here that is trying to make our temperature exposure better than it is out there.

So buildings, the way that we are conceptualizing this-- and there are way more things that we can think about. But today, what we are going to conceptualize is buildings that are going to generate an environment that is better than out there. That's how we are going to think.

So we are not thinking of building generating problems by themselves, that there is also some things related to materials and so forth. But mainly the way that a lot of people are conceptualizing healthy buildings are buildings that are creating a better environment. And it can also be creating a better physical environment, so it will make you move more, that you will be moving out there with different staircases and so forth.

But basically, buildings are trying to make us better off than out there. That's the definition of a healthy building, very layman terms. And this is important because, if you think about your daily life-- and this is an old survey, but it's still the survey that everyone quotes--

we spend 90% of the time indoors. This is something that they did these surveys about across the United States to show how many people will-- where will people spend time in. And you see that if you sum all the indoor places in their home, their factory, or a bar, or restaurant, most of it happens to be indoors and in a building, actually, except for the vehicle part.

So 90% of our time, our air, our temperature, our movements, our light is shaped by a building, giving the building a very big role in our lives and, therefore, giving the building a very big X and power to shape our health, shape our well-being, and so forth. And indoors is not always so great, not in Europe, not in the US.

So you see around 5% of people in the United States live, on average, in a house that needs certain work. That can be moderate. It can be severe. But 5% of people that need to live in a place better than they are doing now.

If you go to the renters, this will be double. So one out of 10 renters will actually be living in a place that needs some work. If you go to the low-income renters, that will be way more, so it would be 15% of the population will be there. So if you especially dig into the subpopulations that will need more support and actually the ones that are probably suffering for with the most severe health problems, then this is actually worse than the graph that you see for the entire population. And the same for Europe.

But we are going to talk about not so much about the people that are-- about the buildings that make us sick, but we are going to talk about investment strategies that will actually try to promote health and make us healthier in a way. All right. So the whole lecture today, how can we invest in a building to make it to make us healthier? How can we actually think about the health implications of investing in any of those technologies?

And this is important for both. Before, there was not a lot of reactions from the public sector. But if you really look at the amount of money that governments spend in health, it's around-- in a normal year for a lot of countries, almost $1 out of $10 that we generate goes to paying health care and to make us avoid from dying or make us less sick than we are. Basically, $1 out of $10.

And if you see that what happen after COVID, you see that, in places like the United States, things skyrocked. So it's a substantial amount of all the money that we generate in a country going to health care. And also there are a lot of estimates of cost of unhealthy workers for private sector. This is one of the most famous articles from the *Harvard Business Review* that estimate that $150 billion per year in the US office sector goes to pay workers that are not fully fit.

So they are going there with burnout problems. They are going there with some physical problems and so forth. They still earn the full salary because they show up in the office, but they are not performing at the best. And that goes back to things like the sick building syndrome, where you make someone work in a place that makes them miserable. And then they, therefore, cannot exert their full potential.

And I will also show you that there are some things that you can think about compensating, like kind of, oh, I have low concentration. But I stay extra hours. So I bear the cost as an employee. I get some extra coffee, and I still-- even if I feel a little bit dizzy or whatever, I'll just get the job done.

But when it comes to decision making, when it comes to negotiations, when it comes to being a boardroom and you need to make a sharp decision, that cannot be compensated. If you make a bad decision in a strategic meeting, that is going to haunt you for the rest of the quarter, at least. So if that is affected by the place where we are making those decisions, even at the very low margin, you will see big consequences because these are big numbers.

The 10% of the GDP of the United States is a big number. So even if you do a 0.5% change on this number, it's going to be a big change for the whole country, the same for $150 million for the US sector. So we are going to be moving in those margins, small impacts but hopefully credible. But if you make a small impact in a big part of the pie, it's going to generate a big impact after all.

And that's different from the energy efficiency, where utilities, as we will show in the income statements from tenants, utilities to be relatively small part. But we can actually make a big impact with energy efficient investments. But you need to make a big impact because, otherwise, it will not make a meaningful change in the income statements of tenants.

But here, it is-- you have a large share of the pie. It's very difficult to make even any small impact. But if you do, you have very big numbers that will actually make a very big impact after all when you compute that. Any reflections, Siqi?

SIQI ZHENG: Yeah, that's why the CRE, we are committed to make this place a very healthy place.

JUAN PALACIOS: Amen.

SIQI ZHENG: We are going to renovate this lecture hall to make it healthier. And you understand the facts.

JUAN PALACIOS: Exactly. So if you want-- if you have any requests, please send an email to Siqi with a nice sofa or something. I already doing so.

SIQI ZHENG: Yeah, but after you graduate.

[LAUGHTER]

Office visit.

JUAN PALACIOS: But you can always come-- you will anyways come for the commencement. So imagine being here with a nice sofa, and I think that would be nice. Great.

OK, so now that we understand the science and what buildings do to-- what environment makes to us and the prospects of making a lot of money, let me go really into, first, the impact of buildings or the proven impact in the research of buildings on human health by me but also by others. And then also not only on the occupants and the people, the users of those buildings, but also how that scales up all the way to an investment valuable decisions.

So how the tenants will actually be able to pay for this or not and why would they pay, so basically thinking about the accounting of those. So my employees are healthier, but that doesn't mean that I care. But actually, if that means money for me, then I will care, and I will actually make sure that I'm in the best office-- or that office is at the best performance that it can be.

But then also, of course, talking about when we climb the ladder, also some barriers to adoption. So even if we prove that these buildings make people healthier, even if we prove that these buildings will make people more productive, is this going to scale up to the final decision maker that is able to actually put the money to make that investment? And we were talking before with William about the fact that sometimes these split incentives are not easy to solve.

And we will have them here again. And actually we'll have a little bit more complex flavor than even the energy efficiency for certain reasons. So we need to understand both. We need to understand what is the potential of these investments, but we also need to understand very clearly what are the barriers and also start the conversation about what are the solutions. So this is the whole purpose of the conversation today.

And finally, to wrap up, to connect to the first two lectures of the course, including also the introductory lecture, the three first lectures of the course, connecting healthy and green, and is there a trade off or not, and so forth. And if we have time, given a projector part, I can also give you a glimpse of how COVID is going to shift or is shifting all of these things. All right. Jason.

AUDIENCE: How do you design these studies to control for all the other factors that go into-- because, often, healthy building, green buildings are also just newer buildings, maybe with a better layout, or more ergonomic furniture, better lighting. How do you control for the fact that it's the healthiness or the greenness that is what's causing productivity increases?

JUAN PALACIOS: Can you hold on that for like five minutes? I have like three or four or five slides for that for you. Then you throw all of those comments to me. But that is going to be an important part of the lecture.

So that's exactly-- that's exactly what we are here. Actually, one of the main purposes of Siqi and me in this course is actually to giving you the right thinking tools to evaluate those in a way that is a fair assessment and is an actual assessment of the future that you want to evaluate and not something else because that's something that you can carry for anything that you will do in your job afterwards.

I can teach you everything from the current technology now. But if it changes in five years, you are not going to be in a very good position. But if I teach you how to think about any evaluation of a technology, you can carry it for green, healthy, smart heat pumps, hydrogen. Whatever it is, you will think about the exact same in the exact same way.

So we are going to do that today. We are going to do it tomorrow. We are going-- not tomorrow, sorry, next-- well, actually, maybe tomorrow in Naco Taco. I can also give some of those.

[LAUGHTER]

But next week with the green-- Siqi's lecture, there will be a lot of it. We call it apple to apple comparison. So you really want to compare things that are exactly the same except for the fact that that specific feature that you are looking at is changing. All right.

So in terms of what we can do in the building and given that city is going to put a lot of money, what can we do to this lecture hall to make it-- there you go. We have an inquiry already.

AUDIENCE: What always bugged me about this lecture hall is there is no outdoor light.

JUAN PALACIOS: Wait, wait one a second. Siqi, can you take notes?

SIQI ZHENG: OK, yes.

[LAUGHTER]

Very important.

AUDIENCE: There's no outdoor light, and so--

SIQI ZHENG: But this is really hard.

AUDIENCE: --it's harder to see the-- one, you don't get the health benefits from it. And also you don't see the time pass. And so you're just like, I've been in here for so long. And the hours just--

[LAUGHTER]

--go by and by. You're just like, what happened to the day? That's my biggest complaint with this room.

JUAN PALACIOS: Can we test that? How long do you think that you've been today here? Six hours, eight hours?

[LAUGHTER]

AUDIENCE: I don't know. 25 minutes?

JUAN PALACIOS: No, actually, today it feels shorter than it is. You've been here 40 minutes.

AUDIENCE: Oh, OK.

JUAN PALACIOS: Is that a compliment? I'll take it as a compliment. Let's slow down time for now. Anyone else?

Any inquiry. So we have-- OK, let's bring it back to here, lighting and views, I will I will call that one. Lighting and views. Anything else? John.

AUDIENCE: So ergonomically, these chairs are designed to stay in place. So we're always kind of like portioning our spine. After we've been in the chairs three hours, we kind of walk like this.

[LAUGHTER]

JUAN PALACIOS: No, it's very important, ergonomics. Anyone else?

SIQI ZHENG: Yeah, we will fix that.

[LAUGHTER]

We will change all the chairs.

JUAN PALACIOS: Becky?

AUDIENCE: Also related to the chair, I would like to know if there's any fire retardant in these fabrics because they can be very hazardous to your health.

JUAN PALACIOS: Yeah, materials.

AUDIENCE: And so, yeah, if these coatings of all the materials have VOCs or not.

JUAN PALACIOS: Correct.

AUDIENCE: Yeah, so?

JUAN PALACIOS: Very important, materials.

AUDIENCE: As well as the carpet, yeah, the VOCs.

JUAN PALACIOS: Yeah. VOCs, so we were talking about outdoor air quality problems with pollution and so forth. But of course, we deploy things in buildings that are, a lot of times, poison and poisoning us. So that's important, and that's something that the science is getting there. But there's a lot of information asymmetries. There's a lot of opacity on what each of these materials have in them that can actually affect us in one way or another.

AUDIENCE: It's just small, too, so that if you skip class, it's very easy to get caught.

[LAUGHTER]

JUAN PALACIOS: That I don't know that we will fix but valid concern. And so we have materials. We have ergonomics. We have light and we--

AUDIENCE: [INAUDIBLE]

JUAN PALACIOS: Anyone? [INAUDIBLE]

AUDIENCE: I don't know how the conditions of ventilation sitting in here, but after [INAUDIBLE] class, which is three hours, at the end of the day, I can't focus, and I actually get a headache. Not all the time, but sometimes.

JUAN PALACIOS: Ventilation. So here, we are testing it. This guy, I don't know whether you guys can read it. It says 700. When it will get to 1,000 or 900, then these things we'll actually start consider as not healthy.

We are keeping it below. But we will show you that even going from these levels all the way to 500 can actually have a benefit from concentration and so forth. But that is definitely one of the key things that, at the moment, because of COVID but also beforehand, ventilation is being considered the flagship of healthy buildings. So if you are in a building that is not good in terms of air quality, it's very hard to argue that it's healthy.

Anything else? One more. Give me one more. We talk about views. We talk about ergonomics. We talk about VOCs and materials. We talk about ventilation. We talk about-- Tamar.

AUDIENCE: Lights.

JUAN PALACIOS: Lights. Artificial lighting, yeah. This--

AUDIENCE: And also just the tone of them [INAUDIBLE]

JUAN PALACIOS: Yeah.

AUDIENCE: [INAUDIBLE] if it could imitate-- last time I got light that imitates the sun.

JUAN PALACIOS: Yes. Yeah, that's an important one. I have a joint position with the University of Maastricht. There you have Philips, and Philips is developing a lot of work into trying to mimic natural light.

The reality is that you look at the science. It's very hard to mimic it, but there is definitely a room for improvement in terms of what we have here and what we could have. But it is very hard to mimic any effects that the Sun has on us in our circadian rhythms and so forth. But we can make our lives less miserable by being here. Yeah.

AUDIENCE: Those two lights kind of makes the PowerPoint hard to see somewhat.

JUAN PALACIOS: That I can fix right now.

[LAUGHTER]

Can I fix it? I don't know.

SIQI ZHENG: You can set at 2.

AUDIENCE: I don't know if you can control every single one of them.

SIQI ZHENG: Lights, 2.

JUAN PALACIOS: That's great. Sometimes, actually, just about asking the right question.

[LAUGHTER]

AUDIENCE: And also, I noticed--

JUAN PALACIOS: Something about me, my perfume?

AUDIENCE: The 10 slots works for ours. But if it's a student from Sloan or Harvard, it just doesn't work.

[LAUGHTER]

JUAN PALACIOS: That's an easy fix, too.

AUDIENCE: Yes, much bigger.

SIQI ZHENG: Oh, they are super.

AUDIENCE: Yeah.

AUDIENCE: Oh. We should ask them [INAUDIBLE]

JUAN PALACIOS: We are not inclusive. All right, guys. But these are-- let me-- I put it also in the reading notes. But these are-- pretty much we hit into everything that is there. We missed noise. This is sort of a bunker, so we don't really have a lot of noise. That is good.

But of course, comes at the cost of not having any views or anything like that. Plants, we don't have any plants here. Siqi has the office full of plants, but she didn't dare to bring any one here.

And then, as we say, design and so forth, and of course, there's a lot of work into the access and the design or something of how you make people move in a building. So you see that, in a lot of these healthy buildings, when you enter, the most prominent thing that you have is the staircase to make you go up, and move, and exercise.

And in some others, what you see most prominent is an elevator. And we are not talking about the high-rise buildings, where you don't have any alternative there. But we are talking also about four- or five-storey office building, where you could definitely walk upstairs. And you still make people the default and ask them to go to an elevator.

All right. But what I like is that almost-- I assure you that what I like is that almost, in any class, I always come to the conclusion that this graph is intuitive for everyone. We all think that there is a better way to design buildings and along the same dimensions. So this is nothing that is rocket science. It's not that I'm asking you how an RNA vaccine works. This is something that, if you give people the opportunity to talk, they will always point out the same problems. Tamar.

AUDIENCE: Are these all being measured [INAUDIBLE]

JUAN PALACIOS: So a lot of the top part are measured at a continuous basis. So this guy is measuring-- is a chip sensor, and it already measures thermal comfort, already measures indoor air quality and ventilation, not very difficult to measure the tones and the intensity, especially the intensity of light. And noise and acoustics also very easy to measure.

A lot of these guys will be way more qualitative to measure and will be-- the studies will be a little bit less strong than what you have out there because also this comes from environmental science. This comes from more the psychology and softer part of the scientific world.

AUDIENCE: So you don't need the bottom parts to be included in order to determine the--

JUAN PALACIOS: Yeah.

AUDIENCE: [INAUDIBLE]

JUAN PALACIOS: I mean to be comprehensive. But you definitely-- there is definitely studies that would say that makes a difference and so forth. With this one, you can actually almost pinpoint like what you will do in a basic real estate economics, like elasticities, and so forth.

Like for every unit increase that you will have in indoor air quality, how much you will expect in any of the outcomes and so forth here. There is no unit increase in biophilia and views. Either you have them or not, and it's also very complex. So what do you see outdoors and so forth?

But there's a lot of studies, especially in hospitals about recovery times and so forth of patients when they are having natural light, when they are having certain views, when they have wooden rooms instead of just this whitish room. And so for, actually, the hospitals, there are a few podcasts that I'm happy to put in the Canvas if you find it interesting. But this is the place where we would really need all of these technologies to be the best.

And unfortunately, this is where we make the worst design options that is actually very, very sad, that we actually make people going through one of the most difficult moments in their life, from the family side or from the patient side, in the rooms that are actually white with no consideration for design and making them more miserable than their disease will actually even make them. So there's a lot of-- they're very interesting topics.

AUDIENCE: I have a question.

JUAN PALACIOS: Of course.

AUDIENCE: Have you heard of any research based on carpets and allergens?

JUAN PALACIOS: Mhm.

AUDIENCE: Because I know as we walk over it, it releases a lot of particles in there. But it seems more modern buildings don't go for carpeting that seemed to how [INAUDIBLE] comfort or, yeah.

JUAN PALACIOS: Yeah. There are quite a lot of these things out there of like the risk, the problems with carpets, and VOCs, and so forth, and the dust that will make people less healthy or, in schools, make asthma attacks and so forth more likely and so forth. There are a lot of these things.

But the problem is that when it comes to-- when it comes to materials, the problem of thinking about it in a systematic way is that, when it comes to make decisions for your own building on how do you upgrade them, there is not a lot of information about any of these things, composition and treatment, along the way.

So we don't know where these-- what kind of paint they put in these wood to make it more resistant to different things and so forth. So it's very hard to understand the chemical composition of anything like that. You will expect that-- and that's one of the discussion points of the *Healthy Buildings* book of these Harvard professors, you will-- they put it in a very nice way.

You will find it crazy nowadays if you will buy any-- can I take this? You will buy any drink or any food item and you will not see the composition of every single thing that came into the production of these guys. But you cannot see anything at all when you buy any building or almost any building component that you want to deploy in a building.

So to have this strategy in a systematic way, we are a long way down the road to go. And that also affects, by the way, a lot of the problems when it comes to energy efficiency, that we don't have these building passports that will actually understand-- let us understand what is all the elements, and the characteristics, and the efficiency, and so forth. So then we could actually just-- as almost like a Lego type of work from an engineering perspective to see what type of elements do we need to upgrade to have the biggest impact because we bought something that we don't know what has on, and we have to even break the roofs and so forth to understand what is really in there or get into the machines and so forth.

So it's very hard. We don't have a systematic information system on components in buildings. And that's something that will require those type of strategies to flourish. Yes.

AUDIENCE: So the light of this room and the [INAUDIBLE] are the essential factors, conditions to the house building because, before I worked in the headquarter above the house building and pretty high standard about the [INAUDIBLE]. So [INAUDIBLE] and control the lights [INAUDIBLE]. So it is important in the industry.

JUAN PALACIOS: Yeah. Yeah, very important. Yeah, yeah. Lighting is something that is definitely affecting a lot of our biorhythms and so forth. And then you can go against the clock and the day if you flatten it out over the entire day.

All right. Today, we are going to talk about, mainly for the sake of time, because otherwise we will have to be here as long as the studio class and the other day or ventures, and it's really not the purpose to lock you up here for five, six hours today. So I'm going to give you-- we are going to walk through the whole value chain of ventilation and air quality just to show how to think about it, how to be critical about it, the science, how to be knowledgeable about, how tenants will think about it, and also how to discuss what are the barriers to it. So let's go through two basic examples and then climb from the very bottom all the way to the very top.

And you will tell me when you have any questions and comments and so forth. OK, I like this lively discussion, so I'm very happy today. I think that we are beating the previous class last year.

It was very lively. You remember, [INAUDIBLE]? You were always a quiet guy, though.

[LAUGHTER]

Very, very smart. That's why we picked him to TA. And I'm actually even his thesis advisor. But quiet, you are quiet. But at Naco Taco he talks. Tomorrow, you can come.

[LAUGHTER]

You do, do you? You see. You put him in Naco Taco, he talks. That's the impact of buildings.

All right, so the [LAUGHS] exactly. I don't know. I haven't-- I cannot say that. So all right, so first thing that we are going to do is how we are going to connect these different strategies. How are we going to evaluate the impact?

So I don't know whether you guys have done any work on funds, but you have these impact funds. What they do all the time is to-- one of the things that you need to do to create an impact fund is to show the impact that you do, that you create with the investments that you do with the money that you have in the fund.

So let's think about healthy buildings studied from the impact fund perspective, so how we actually are able to evaluate impact in a way that we can go to investors, developers and pitch it to them in a way that say, hey, do you want to generate a building that can promote x?

This is one technology that you need to deploy because I know what is the impact of that. For that, there are multiple ways to think about it. But one of the most intuitive ones that I think, especially when it comes to air quality, is coming from the environmental science and the environmental science literature, where when you want to evaluate the impact of any threat, any poisoning element, you have different steps.

So you have-- first, you need to understand what is the concentration of that threat. So if you want to think about what is the impact of ozone, or VOCs, or PM 2.5, or something and so on in a given building or in a given part of the city, you first need to know how high is the concentration of that pollutant or chemical in that area. So the first thing we need to do is assess how large is the threat, how much of that pollutant that we want to reduce with those investments is.

And then we need to know-- because, ultimately, what we want to understand is the impact on people, we need to understand for everyone that passes by or every one of the target group that we have, the occupants, the employees, and so forth, how much exposure they get. And that is break out in two parts, how much they get exposed every time that they are exposed and how often they get exposed.

And let me give you an example. For example, we get these kitchen there that is locked up to almost everyone except for Siqi. So that's your private kitchen, no? I don't even have the code.

SIQI ZHENG: Faculty, researchers, and the students. If we want to use a kitchen, become our researchers.

[LAUGHTER]

JUAN PALACIOS: [INAUDIBLE] is always good. So there might be like a gas leakage, and almost nobody will get a problem because nobody is there almost any time. I've been there probably twice in four years.

So that's one of the examples that, if you really want to be a meaningful investment, even if you have a high concentration of a problem there, of a pollutant there, you probably don't have the best investment in terms of improving health because nobody really gets exposed. Now, a gas leak is very harmful. So if you spend a few minutes, you probably get passed out, and you might actually die.

There are other things like poor ventilation that are definitely less harmful, but everyone is exposed to. For example, in this room, we keep climbing up, not yet there. But imagine that guy goes double. None of us will die. Maybe some of us will get sleepy.

But all of us are exposed and for several hours during the day. So then when it comes to improving that one, it's much better because, yeah, the concentration or the harm of that concentration is much lower. But the exposure is much larger.

So this is what we need to understand very well, first, how much we are exposed. So what is the concentration of whatever factor we want to improve? How harmful it is, and that will require to look into the literature and the standards from ASHRAE, from EPA, and so forth to understand how harmful that is. So it's not the same being exposed to CO or being exposed to NOx, or then being exposed to VOCs or CO2. Those things is something that you need to understand, and that's why the public health literature, epidemiologists, and so forth end the lives.

So we can break the process of understanding the impact of an investment in two sides, so understanding the baseline concentration and how much we actually reduce the concentration and then understanding the actual exposure and the actual impact on the people. So there's going to be an assessment part, and there's going to be an attribution part that is going to, ultimately, connect to the health, and well-being, and performance of people.

So if we don't understand that black box on how people are exposed to that investment and how people are exposed to those threats, then it doesn't matter whether we are measuring everything all the time. We will not be able to connect an investment in the building to the people that are using that building. Is that clear enough? Or we make it more complicated? Clear enough. Julio.

AUDIENCE: How can you compare the impact that a pollutant has on someone? How can you compare--

JUAN PALACIOS: CO2?

AUDIENCE: --lowers the concentration until it kills them? You have to put it on a scale, right?

JUAN PALACIOS: Well, that is-- yes. So there is one thing, there is some basic tools of exposure science. That is, you have the dose response function. So that's something that you can compare with the same outcome, what will be the impact of every unit of intake of that pollutant on that given outcome?

When you want to compare across outcomes, that is something that comes down to, what do you value as a company? Or what do you value as a country? So how much do you value one person dying versus 300 kids scoring lower on a test that will let them get a worse job afterwards?

So there is some subjective part there that will come down to policymaking and preferences and so forth of people that are just not objective. It's just-- we have a lot of discussion about the value of a life, the value of a statistical life. That's how they call it in that.

Those are things very subjective. At the end of day, it comes down to the priorities of your firm, or your local government, or yourself if you are thinking about, how do you want to improve the families-- your family's situation? Anything else? Yeah.

AUDIENCE: I have an interesting phenomenon, during 2015 to 2018, Beijing fire pollution is very [INAUDIBLE] and affected our house. So developers preferred to build the [INAUDIBLE] building. But after that, because the pollution improvement, and the developer will not prefer to build the house they're building because it's pretty high cost that the rent may be a little increase.

JUAN PALACIOS: Yeah.

AUDIENCE: So it's very interesting.

JUAN PALACIOS: Yeah, Beijing is also a good example because Beijing, you have two things going in parallel. On the one side, the local government-- and the same as the national government-- tries to put down pollution that Siqi's-- a lot of work there. She's the expert.

And then on the other side, you get people-- exactly. So the threat, the other threat is going down. And therefore, what you are preventing people from being exposed to is also going down. So then the benefits of improving filtration in China starts to be less problematic than when you go back to 10 years ago or 15 years ago. When was the peak of pollution, Siqi, in China?

SIQI ZHENG: Yeah, I think that's more nuanced because, although the absolute level of the air pollution is going down thanks to the government regulation, but people's awareness is going up. So the wheel is going up, so more and more people are willing to pay higher price for lower air pollution, so the absolute level may be down.

But now people are more and more worried about this, and they care more. So they still want healthy buildings.

JUAN PALACIOS: And we know that because of your work. It's true.

AUDIENCE: But actually, developer and customer have to pay for the green building That house they're building, the cost is higher--

JUAN PALACIOS: Much higher.

AUDIENCE: --than the green building.

JUAN PALACIOS: Yeah, the features. It's not cheap. That's why we're here.

OK, so in the assessment part into the detection of how big is the problem and how much actually we have a threat in our building, one of the things that is very powerful in the real estate industry and engineering side is that the price of these guys, of those sensors is going down dramatically. So it used to be that something that would measure CO2 with any trustworthy accuracy will cost like $10,000. And this guy cost me like $200.

So it's very big drop. And also the connection to the internet also makes that the human side of operating those devices is much, much lower because, beforehand, I would have to have one person going with it all over the place and pay that salary to measure anything and to do an assessment while now I can just connect these guys to the internet. They will be loading all-the-time data, and that will ultimately generate-- give me the answer of how big is the pollutant concentration and how big is the problem and so forth. And on the other side--

AUDIENCE: From the other eye, [INAUDIBLE], she is working on very exciting project downstairs in [INAUDIBLE] lab [INAUDIBLE] scanner. Do you want to say something about that?

JUAN PALACIOS: How big is the pollution in this area?

AUDIENCE: Yeah, actually, the pollution in Cambridge compared to a lot of the rest of the world-- as you saw, like 90% of the world breathes polluted air is pretty decent here overall, but there's high spatio-temporal variability. So as Siqi was saying, even though absolute levels in some parts of the world are going down, we're starting to understand more and more of it, both in the scientific way and in the public perception way.

And also the World Health Organization is constantly re-evaluating and understanding how they recommend or how they make those guidelines on what safe exposure is. And so I think, with the latest round of revisions, that's what kind of pushed this number up so high for us to understand that, wow, we are not doing so well in terms of mitigating a lot of the root causes of this work.

So there's a lot of interactions and there's a lot of interplay between the built environment, especially in urban areas, transportation, air pollution, and, as Juan was talking about as well, personal exposure. Different groups are exposed in different ways depending on what they do, their incomes. Unfortunately, especially in the United States, race is a very big indicator of exposure to air quality and poor environmental conditions. So it's a very complex set of topics. But as Juan showed us, there's some really nice ways that we can combat it.

JUAN PALACIOS: Yeah, exactly. And I would say, like the WHO puts the alarm up, which means that it puts the level of acceptable exposure down every time. So it goes like 40, 25, 10. And it seems that it will get to 0 because any particle that we will breathe will generate, somehow, damage.

And on the other side, the data from people, our phones are generating so much data of us and all the wearables, some people I can see here with Apple Watches and so forth. So we now have access of pools and movement and so forth from a bunch of people that were actually very unaffordable, again, a few years ago.

Now, when it comes to the attribution side-- so how do we connect these data together? Or how we do connect the data from buildings to any outcome of people? This is where the striking difference comes with respect to evaluating energy efficiency investments, where everything is mechanical.

You know, as a facilities manager, at which level you are running the engines of an HVAC system, and you can actually see very accurately what that will imply for the energy consumption of that building and the CO2 emissions and so forth. You cannot do that with the health implications of that specific action. You can put the HVAC system up, but, ultimately, the health impacts of that comes down-- interacts with the behavioral and the people's behavior and also with what happens in the city as a whole, too.

So if we are in a very severely polluted day, as [INAUDIBLE] said, there is a big spatial and temporal variation, which means that, on some days, we will be exposed to three times the level than another day. And actually, from my research, I could see from the data always the case that it can change very rapidly from one day to the other because one of the things that brings pollution is wind.

So in the city like Boston, if the wind is blowing from the sea, very good. If the wind is blowing from a city like New York and the power generation system of the State of New York, very bad. We have no control. It can change very rapidly, and it can be-- and it doesn't matter for our lungs because we are still breathing the pollution no matter what the source is.

So in that sense, the same action that is improving the filters or improving the HVAC system can have very different consequences on the health given the environment but also given the people. If I make this lecture hall very healthy and nobody shows up-- we're going back to the exposure part of the equation-- then it will have no impact on you.

If I want to see what is the impact of that investment on the grades of you guys and everyone connects on Zoom, yeah, fantastic. No impact on that. We will have to put very large couches for us just do napping here because that would be the only use of that lecture hall.

So all of these behavioral things make it very hard to assess but also very hard to just understand from a mechanical perspective what will be the consequences of that. And what we are going to talk in the next five to 10 minutes is going to be about, how do we design studies or how do we design evaluation systems so then we can actually assess the health implications of those impacts, taking into account that there will be always a behavioral layer in between the action of the facility manager pulling up the engines or the action of the developer upgrading a system in a building and the ultimate consequences of the people that we care about-- the residents, the employees, the clients, whatever it is?

If you go to the marketing literature, there is also-- we don't talk about it here, but there is a lot of data on how people behave in a supermarket. And there's a lot of tactics to try to get every penny from our pockets every time that we enter in a Walmart, or in a Costco, or in Prudential Center, and so forth.

Look at Siqi. She's always buying these [INAUDIBLE] from Prudential Center. It's all because of you are [INAUDIBLE] by the design.

All right. So going back to Jason, this is your moment of glory because I prepared this lecture, this slides, exactly to tackle those questions. So when it comes to understanding the impact, as you said, it's very hard because, if you just-- whatever the difference between a healthy building and a non-healthy building comes in terms of health and performance, let's say that we find that the people living in this house are being 5% healthier and 5% more productive than the guys living in this house.

Now, the question is, what generates those differences? It could be some features there that could-- they might have better ventilation and so forth. But the level of health, especially when it comes to air quality, is very much shaped by the environment where these guys are. So it's very hard.

You have different things like green areas and so forth that will actually affect the ultimate level of environmental conditions in this house. And that will actually be very different if we have, in the other side, factories and so forth. So the outdoor factors change, and we have to control for that in one way or another.

And also one of the important things that the occupants are also different because, if you think about that area and if you think about that house and those two houses are put in the market, then the question is, why would you go to the one on the right? Why would you go to a house that is in the middle of an industrial area, gray, full of clouds? Not good.

So the reason why you would go to that house is either financial-- you can afford-- you cannot afford to go to the one on the left. And that means that you probably cannot afford also other things related to your health. You might actually not have the best health insurance. You might not go to the gym. You might not do all the things.

Or even if you have it, it might be your choice not to pay the premium for this house. And it might be your choice also, therefore, not to go to the gym because I just want to save all my money or whatever. Or I just enjoy doing all the things, enjoying going to the cinema and enjoy going to the gym. So your value of any health strategy that you have in your life, not only the place where you live, is probably much lower than the guy that lives in this house.

And that introduce a lot of problems because all the difference between these two guys are not related to this specific guy here but is related to these but also to the people that lived in there. And therefore, if we let people choose the environment where they live, where they work, then we will always have this problem confounding our studies and introducing and basically inflating the difference between this building and this building because all of it is inflated by the outdoor environment and all of it is inflated by the people that live here versus the people that live here.

AUDIENCE: [INAUDIBLE] this kind of looks like a picture of the suburbs versus the city.

JUAN PALACIOS: Also.

AUDIENCE: Moving into the city isn't because you don't have the means to live in the suburbs. It's a choice. You want to cut down your commute time. You want to be closer to amenities. You want to be closer to work.

It's-- I don't think it's just a you don't have the means to live here. Just it's city living versus suburban living.

JUAN PALACIOS: Yeah correct. So then that would also be like, if you prefer to live in the suburbs, it's very hard to imagine that that's the only thing that you differ from the person that wants to live in the center. And then those differences will not be intertwined also with anything that affects your health because, if you live in the suburb, maybe you appreciate also some walks in the evening while the guy that lives in the city center, he has appreciated to go to the bar and have some beers with the co-workers after work, alcohol versus active living, very big for health.

So that's just one example. But basically, once you introduce people sorting into places, either within the same neighborhood or across neighborhoods, then you always have the problem of, if I attach any differences in your health or in your performance to the place where you live, to the building that you live, is it really a fair comparison? Or you are actually blowing up these differences by all the other things that he does? So the challenge here is that.

Because you have this human layer in between the actions of the facility manager, or the architect, or the designer and the people that, ultimately, you care about, you have to take those things into account very seriously. And that's what we try to do, the people that try to do these studies.

And I will show you a little bit a few techniques that people use. There you go. This is one. One is we don't let people decide their exposure to something, but we actually manipulate that exposure in an experiment. So we invite people-- when we care about how ventilation affects people, CO_2 levels affect people.

So this guy is measuring in PPM the concentration of CO_2 in the room. So basics of CO_2, when we breathe, we take oxygen. We exhale CO_2. And then the concentration of CO_2 in this room will be up or will be like-- the CO_2 that I'm exhaling will stay here until the room refreshes the air with outdoor air and brings back oxygen.

So if this room would be empty, it would be around 450. That is the outdoor levels. When we come all in and we are generating CO_2, the room goes-- the CO_2 levels in the room goes up until these guys refresh the air.

So one of the things that people do is that they bring people-- some of the techniques that people do in research is that they bring people to a lab, and they manipulate the environmental conditions while they are doing a task. So they are interested in how cognitive performance is affected by levels of CO2. What they did was bring in around 24 people, healthy office workers, to a lab in Sierra Cruz, and they will have to work in that lab for a whole week.

And every day, the scientists will manipulate the level of CO2 that these people will be working on for six hours. And at the end of the day, they will give them a cognitive task to see how their decision making is affected by the level of CO2. In the best day or in the best CO2 levels, they will have around 550 PPM is almost outdoor levels. It's the best that you can have.

In the medium level-- so what they will say like, a green building day, it will be 945, almost double. And in a conventional level, it will be-- where most of the people will be exposed in a normal building, it will be around 1400. These were the levels that actually we observed a lot of times around MIT before COVID, but this was like the conventional level.

What you see is that in any level for the performance, as you go to lower levels of CO2, the level of cognitive performance increases. And this means that people are better able to process information and are better able to strategize with those. They were having all of these complex cognitive tasks that I'm happy to talk about it more, but they are developed by psychologists to understand how you your decision making is impaired by CO2 level.

This is their study that everyone quotes when they are thinking about ventilation and air quality in buildings. This is by Joe Allen here. The first author is this professor at Harvard Public Health, School of Public Health. He's the most famous guy doing these studies. And this was the study that made him famous, bringing 24 people into a lab and manipulating the levels of CO2. Sometimes science can be simple, powerful, and, if you're a Harvard professor, impactful, too.

[LAUGHTER]

AUDIENCE: I got a question, really interesting research. I never saw--

JUAN PALACIOS: Thank you. [LAUGHTER] I appreciate it.

AUDIENCE: So in this research, is that saying, simply saying-- from your perspective, is that saying that the high concentration of carbon dioxide will decrease the concentration of [INAUDIBLE]? Or is it simply saying, because the level of carbon dioxide is higher, it means there's less fresh air and less oxygen?

JUAN PALACIOS: That's a very good question. Yeah, these two things are always convoluted, but in this case, the level of ventilation was keeping constant. And they just artificially put CO2 in the room with a gas bottle. So this one is purely CO2 levels.

But in this-- in the real world, so I did, for example, a study trying to measure with those sensors the levels of CO2 in classrooms of-- the classrooms of 6,000 kids. And I will get, over time, changes in CO2 levels after school term, three years and connected to a test score, seeing that actually there are big differences when they are exposed that.

That is convoluted with ventilation. So you are not only exposed to higher levels of CO2 but also probably VOCs and other things that are more prevalent in the room, where the level of the ventilation rates are lower when you are putting flushing less oxygen in. Yeah.

AUDIENCE: Have you seen a big difference between a home setting versus an office setting? Or homes that occupants might have a higher-- if you're using a gas stove or you have--

JUAN PALACIOS: Oh yeah, there is very interesting study in-- the exposure science studies in homes are usually less prevalent because you have less ability to measure and so forth. But there is one done by researchers at MIT, where they install all sorts of sensors in homes. And there was like your toaster is killing you. So that was the MIT news headline because, when you switch on the toaster, there was a big spike in particles and so forth.

I think that it depends-- One of the things that is important to understand in all of these healthy buildings is that there is no such a thing as one homogeneous, one thing that is healthy buildings. There is a multidimensional aspect. So in some things, some chemicals, you will be more exposed in certain offices than at home because you use different cleaning products. You also have different ventilation systems and so forth.

But some others, you will have way more exposure at home and also depending on the neighborhood and so forth. So it's very hard to say whether it's healthier at home than healthier at the office. There are some chemicals that will be much more prevalent at home than at the office, and the other way around will also hold, too. Carlos.

AUDIENCE: I have a question. As we're looking into real estate-- like office, lab-- and all this stuff is being basically imposed by public policy, at least in the States and Europe, Are there any studies and any actions being taken, for example, like at the school level?

JUAN PALACIOS: Yes.

AUDIENCE: Because school properties are also real estate and are publicly owned-- it's the public policy is basically making mandatory for private investors to mutate or retrofit or whatever their assets into green assets because of being prone to environment and sustainability. Are they doing something with their assets, publicly owned assets to improve or show some support?

JUAN PALACIOS: Yeah, so for-- yeah, more of the-- most of the investments that you will see in schools will be done by public governments or school districts in a way, some of public or public good money. There are a lot of money being pumped in since the COVID because the schools closures was one of the key things that were happening because these buildings that were very poorly maintained, especially the HVAC systems in the US, you will have one out of two schools that are not having the HVAC system up to speed.

And they will need to modernize, or replace, or even install. So school systems are really bad. School buildings are really bad. And now they were also very densely populated, so they were at the epicenter of this COVID outbreak.

So now they are getting a lot of public money. That's what they are having. All right. And the same happens with particles, it's one of my research. We had with chess players, the strategic decision making is also impaired.

And again, being back to the point, this is nothing that you can compensate. If you are making a decision and you made that decision and it's worse off, then you can not just replace it by extra coffee and staying extra hours. You made that decision. It's going to hound you. So if that decision making is impaired, you have very bad consequences.

One of the things that I am-- that it also happens in the office building with respect to health. There are several studies. This is one that I did, was basically understanding what are the impacts of moving from an normal office building to a healthy building. Basically, a lot of stuff happening in here for the technology around ventilation.

They have natural ventilation principles, where they don't rely a lot in a mechanical ventilation system. But what they have is a solar chimney that will actually make the air circulate, very high ventilation rate in that one, very good building. And they actually work with me to understand what are the impacts of this building on health.

So we worked with them for over two years, for three years. So we were with them before everyone was moved. And then 70% of the workforce of the municipality were moved to this healthy building, and 30% was staying here. And the reason why they stay here is mainly because they were not exposed to the public very well.

So if you don't have a lot of meetings with external people, if the citizens didn't have to meet you, then they will not have you in the flagship building. But they will keep you where you are, which means that it's also a very nice environment because it's actually not you, again, who decides where you want to go. But it's actually the municipality, very random decision.

It forces you to stay where you are. Or it forces you to change. Actually, this building is even put in an area where it's more polluted. So it's actually we were expecting that one to backfire. And they worked with us to be able to assess the health and well-being of people and also the sick leaves around-- the changes in sick leave.

And what you see is that when you measure how these people feel, the people we were seeing the prevalence of sick building syndrome-- so the amount of people going there with fatigue and other symptoms. And you will see that almost one out of two will be suffering from that before moving. And then as they moved, the people that were to a new building, went down by half the amount of people reporting sick building syndrome. And the others stay where they are.

So this gap here will tell you the difference in health associated with the building. And if you will do the quantification and link it to the sick leave and so forth, you will see that, if you will capitalize, that investment will be around 2.5 million euros that these municipality's actually getting by just having people taking just less days of sick leave. So it was around one to two days less sick leave, and that is what you will get there.

Now, why is this important not only for the municipality but in general for corporate tenants is because, if you look at the income statements of tenants, you will see that most of the money of a corporate goes to pay employees. So we were talking a lot over the first two lectures around the-- not only because of the money but also the CO_2 emissions involved in it. But basically, about this $3 part of the pie-- so basically this is the 3-30-300 rule is the proportion of money that goes to utilities, rent, and payroll.

We were talking about that part of the pie, and now we are talking about that part of the pie. So even one very minor change in here will generate, ultimately, a big impact in the income statements. So we are going to talk now about how to quantify those. You want to say something?

AUDIENCE: Yeah. Well, a good example to support this house they're building in China, a very famous developer called Binjiang. And another of them is famous about the house building, and they want the same location. The [INAUDIBLE] projects are always priced higher than competitors and always count higher than 10% to 15% price than others, competitors. And always the consumer prefer this higher price because they also know what happened to them. But that self-limitation about this [INAUDIBLE] building, make it low cost is not--

JUAN PALACIOS: Yeah, we'll talk more on Tuesday also about these differences in market segments and so forth. Yeah.

AUDIENCE: About those people who were asked to move to [INAUDIBLE] or [INAUDIBLE] that have to deal with the public city. Would it be the case that those people have healthier lifestyle than tend to get sick like others?

JUAN PALACIOS: Yeah, well, that would be the reason why you will have a baseline. So we then-- before they were moved, so if these people were just in general different-- they are. They are different people and so forth.

But basically, what we are using is the differences in health symptoms and sick leave before and after they were moved for everyone. So you are looking at within person variation. So in that sense, you are not comparing people to people. You are comparing someone before and after the move for both groups. And the difference in the delta for the people that moved and the people that didn't move is what gives you the impact of the building.

All right. So if you think about the translation of that into money for the average tenant, you see that most of it is a fake company, a fake company that the income statements that the professors at Harvard came up with to show how to quantify those benefits for tenants. See that average center will have $6 million in revenue, $3 million in payroll. That is half of it. And then you will pay $300,000 in rent, $30,000 in utility, and so forth.

And you want to consider what will happen if you double the ventilation rate from 20 CFM per person to 40 CFM per person and see what will be the impact. So if you bring the science into play, you will be like, OK, the cost will be around $1,006 That will be the cost of doubling the ventilation. That is still a quite significant part of the utility, but it is what it is.

And now, if you get people less sick, it means that basically the way that they conceptualize is that you have to pay less number of people because now you are paying some people that will be sick. Or you have to pay less number of days per person because, some days, you are paying, and these people are sick. So you could just do the exact same revenue with just less money because now these people are fully operational, and they work all the time.

And they are also more productive, so they are actually more able to produce whatever they are doing or better quality. So that's how it is. So in total, this is the amount of benefits.

So you see that anyways, again, small impacts on here and here will have a big impact on the ultimate bottom line. And that's the message here. Even if you are very conservative, you will have-- because you are chipping in this big, large shares of the pie, it will be a very, very powerful impact on your income statements as a tenant. So if you believe any impact, then it's worth probably going for it because anything that will impact these large numbers will have a big impact here.

Now, and I will also-- for the split incentive type of bargaining, William, you can still-- because you grow the pie so much, the landlord can still say, hey, give me some part of this because I'm the one making the investment. And you still have a lot of margin to make both a win-win. Now, you have to communicate, and we will talk about it later.

Siqi, maybe I need to use five minutes of your lecture on Tuesday. Siqi, welcome. How are you? You enjoying it?

SIQI ZHENG: Any time.

JUAN PALACIOS: There you go. Any time. That's what I like. Let's blame the projector.

But I don't want to rush the last wrap up because actually it's connected to you. But basically, here, you see the idea also that we talk at the beginning. You grow the pie, and you have the negotiation. How much you are going to give and so forth? And what is the approach to that negotiation is something that is for the next part. I will-- I promise that I will only take five minutes and in a way that is connected to your lecture.

But I don't want to keep you longer than we are supposed to. I want to take some questions, and then we are going to go up. But one last slide.

This is just a hypothetical case, but this is a slide that will show you what will be the numbers if you will use the best science that you have to understand what are the impacts of increasing ventilation rates, either doubling or increasing by 20% in an average office building in the united states. Actually, for the entire office building portfolio in the United States, what will be the consequences for the energy cost, the absenteeism, the sick building syndrome, and, therefore, the performance here? And what will be the net present value impacts of that?

You see that, if you will double the ventilation rate, even before COVID-- this is a study of 2012, but it's the most comprehensive one. You have still $37 billion gains of doubling the ventilation rate, and you will have 20%-- if you will increase by 20% the ventilation rate, you will still have $30 billion gains if you compare the cost versus the benefits, using the best science available.

Now, these numbers are big enough that, even if you have a big margin of error, big error bars there, as you like to do in the science literature, you will still have a positive number. So I don't want you to memorize 37 or 13, but I want you to walk through it when you have the time before the midterm to see the whole logic. And you see and realize that, even if you have some uncertainties in there, the gains are so large that is worth considering.

And we will talk more later about the barriers. That will be how we're going to wrap up everything. But just for you to go home, saying, there is something to gain. And then maybe in Naco Taco, you want to talk about why wouldn't you do it.

And now I will take the last question, and let you free. Rohit.

AUDIENCE: Yeah. So these slides before this one, when you had the survey, I think the costs were higher than the benefits.

JUAN PALACIOS: Well, the cost only for that part, yes. But the marginal-- this is the marginal benefit of making the building sustainable, not only healthy but also improving the energy efficiency and the circularity. These are-- I can talk hours about this building.

It's a building that is also based on principles of circularity. The building is made-- we actually brought the MST Netherlands folks there. The building is made in a way that all materials can be upcycled, from the tables to the concrete and so forth.

So that requires also an extra amount of money to select those materials, have the people there to make sure that they wouldn't treat it in a way that will make it less upcycleable and so forth. So all of that is 3.4. They didn't quantify how much. It was exactly the healthy aspects.

Everything was a bundle. What they quantify here-- but this is only the healthy aspects that already will cover quite a big chunk of it. And then if you put the changes in operation because you have a natural ventilation system instead of a mechanical ventilation system, so you need less operational cost of maintaining that HVAC system and so forth, that cost would be much, much higher.

SIQI ZHENG: No, it's 2.5 million per year all.

JUAN PALACIOS: No, it's capitalized.

SIQI ZHENG: Capitalized.

JUAN PALACIOS: Yeah, everything is capitalized. Good question, Rohit. Thank you so much, guys. I'll see you tomorrow and on Tuesday. We'll grab up. Thank you for all the questions. Appreciate it.

[APPLAUSE]