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DAVID HSU: Welcome to another lecture in my series on urban energy systems and policy. Welcome back. Today I'd like to talk about cities and building energy policies. This is an area that I think is really interesting for cities, but also representative of energy efficiency efforts in general. And so what I'll take you through today is how me and many other people in New York City help develop building energy policies that we see continue to be aggressive today.

And just to give you a sense of how this fits in a larger landscape around environmental policy instruments and energy efficiency, this is from a chapter by Peter May in 2003. This is the sort of thing I'd read in graduate school quite a bit, maybe, at the time. And a lot of the debate at the time was about command and control regulation. What could government simply command the industry or private actors to do?

And of course, a lot of debate at the time when I was in graduate school was around charges and special taxes, most notably carbon taxes. There had been a lot of success in the 1980s and '90s with sulfur dioxide abatement taxes. It started during the first Bush administration. And a lot of economists looked at this as an incredibly economically efficient way to achieve environmental policy outcomes.

Of course, command and control regulation and charges and special taxes are not the only ways to achieve our environmental policy goals. Other ways are economic regulation. Instead of incentivizing industry to do certain things, we could also simply pass standards, standards over what kinds of goods can be sold or how certain services can be delivered.

We could give incentives or subsidies directly, including tax credits, a notable feature of the Inflation Reduction Act. And of course, government insurance is a way to subsidize high-risk industries. For example, the nuclear industry is heavily insured by the government. Even then, it has not proven to be cost effective.

Of course, other ways that we provide services or vital services through government, the government can directly provide those services. We can also have government corporations and enterprises. Both examples exist, where the government owns utilities, something we'll talk about later. About 30% of electric utilities are owned by governments. And about 60% or 70% of water utilities are owned by governments. That's essentially direct government provision.

We can set up government corporations-- Amtrak is a government corporation-- or special enterprises. For example, if your city owns an airport or a utility, it may often be on its own balance sheet, which is to say that it runs its own agency. It can issue its own bonds. It's run for hopefully a profit for the city. But it essentially is an enterprise set up to serve the city.

Of course, we know that cities, because of their economic activity, and wealth, and population, have tremendous power to influence the market through contracting and purchasing.

Finally, there's other ways that we can try to achieve our market policy goals. We can implement social regulations. Vouchers are something that's used quite a bit, let's say, in school choice, but something that could be used, let's say, in other areas of our policy.

And tort liability is another aspect where, again, we can try to limit the liability of certain industries. That's essentially another way to provide insurance or limited liability for certain industries that we think might be high risk or we want to encourage.

And the thing I plan to spend most of my time talking about today is public information. We know the government has a tremendous role in providing information to the market. We know sometimes if the market doesn't have-- or the market lacks information, it will not actually grow. Or it's very difficult for private actors to accumulate the information they need to make decisions.

A good example, of course, is the census, which is embedded in the US Constitution. We know the census is basically an essential instrument or essential data set for many businesses to make their decisions. This is why the census is so important.

And so this is something that also I've argued in many papers, but just to highlight one paper I wrote in 2017. I hope the title is direct and to the point. It's called Further Opportunities to Reduce the Energy Use and Greenhouse Gas Emissions of Buildings. It's in the *Journal of Planning Education and Research.* My co-authors and I argued, essentially, that cities actually have many more opportunities to reduce the energy use and greenhouse gas emissions of buildings, an area that I've argued to actually result in a lot of greenhouse gas emissions for countries.

So to give you an example of where they might have additional powers that we might not be using, cities collect about 70% of local tax revenue and about 30% of all state and local taxes in the US. So through their tax power, they have quite a bit of leverage over the private sector.

In terms of infrastructure, cities and state and local governments own about 50% or more than 50% of all infrastructure. They do about 75% of the spending on infrastructure. And as I mentioned before, we often through cities own about a third of electric utilities and 2/3 of water utilities.

And just to give you an example of departments that you could work in in the future that might have leverage over potential decarbonization opportunities, the Department of Finance. The Department of Finance, again, this is where all those tax revenues are gathered and then disbursed into the city government. That gives you a tremendous amount of power if you control where the money is raised and where it flows to. Also has tremendous implications for equity.

The law department is essential to find out-- or to craft laws or policies that are lawful and effective. The fire department obviously has codes over how buildings are built. Power, water, housing authorities. New York City in particular owns a tremendous amount of housing stock. Other large cities own a lot of housing stock. And schools-- school buildings are where kids spend a lot of time. We have tremendous opportunities to improve the environment of school buildings.

So to give you an example of some of the departments involved just in New York City with the building sector, there's the Department of Citywide Administrative Services, DCAS; the Department of Design and Construction, DDC; the Department of Buildings, DOB; the Department of Finance, DOF; the Office of Long-Term Planning and Sustainability-- at the time, it was OLTPS-- and the New York City Housing Authority, NYCHA. All have a role to play in governing the building stock of New York City.

So just to take a trip down memory lane, there have been a variety of New York City sustainability plans. I actually wrote that one on the left, *Sustainable New York City.* I wrote it as a fellow for the design trust of New York City. It was one of the first sustainability plans written for New York City.

I also worked as a fellow on one of the first internal government sustainability plans, started in 2003. And in 2005, the city of New York issued their first what they called PlaNYC 2030. It reads as Plan NYC.

It was issued in 2005 or developed in 2005 and I think issued 2006. But it was a comprehensive suite of plans from the Bloomberg administration to try to improve the environment in New York City and frankly to establish New York City as an environmental leader. The plan was updated in 2011, which is the cover on the right.

And so to take us back for a second where the environmental discussion was at the time, this, again, is the McKinsey 2007 greenhouse gas reduction report that I showed you. This the marginal abatement curve. The argument I made to you last time in class was that you should be on the left-hand side of the curve because these are all negative costs. These should be easy things for you to sell in your career. These right-hand side things may be necessary but are harder to sell simply because it costs money to reduce greenhouse gas emissions. Again, on the left-hand side, we can save money and reduce greenhouse gas emissions.

But if you look closely at everything on the left-hand side, you'll notice that everything here is essentially buildings related. We have residential electronics, residential buildings, commercial buildings, residential water heaters, commercial buildings control systems, and more commercial electronics, virtual lighting, and so on. So many things on the left-hand side save money, reduce greenhouse gas emissions, and are related to buildings.

And so just to again maybe emphasize the importance of the New York City building sector, we know it's some of the most valuable real estate in the world. And just to break it down for a moment, at the time, the New York City government thought about 75% of all greenhouse gas emissions come from buildings. The sector size is roughly about 1 million total buildings in New York City. And a key point that influenced the policymaking around how to affect existing buildings was that one estimate was that 85% of all buildings in New York City that would be there in 2030 already exist. And I think roughly 70% of all the buildings that will be there in 2050 are already existing.

So if you want to influence the energy use or greenhouse gas emissions of buildings, you have to influence the buildings that are already there. We know New York City's already tremendously dense. It's already tremendously valuable. How do we get these owners and these privately owned buildings to change their energy use?

And again there's one point that came out of some of the analyses of the property tax data. It was large versus small buildings. Only 2% of all buildings New York City are above 50,000 square feet, but they represented about 50-- a half-- 50% of all New York City square footage.

And one estimate was they roughly were responsible for about 48% of all the energy use in the city. I can't actually find a source for that. And honestly, some of these numbers at the time, looking back at it, I'm not sure how strong the sourcing was. But this definitely influenced how environmental policies were made in New York City.

And of course, we know there's tremendous diversity in buildings in New York City. We have commercial buildings, industrial buildings, institutional buildings, like hospitals and schools. We have multifamily residential. We have mixed-use buildings. And those are the large buildings alone. We know that of the million buildings, a lot of those million buildings may be single-family homes or relatively small multifamily buildings in the outer boroughs.

But we know that the large buildings are also themselves tremendously diverse. Just take, for example, a campus like Columbia or NYU. Those campuses have large numbers of buildings, a lot of real estate. And even their buildings are used for many different things, both for University purposes and also, let's say, for rental or lease.

And so the question I want to get to is, how do you know which buildings to implement energy efficiency in? I've talked about policy analysis in terms of efficiency and equity. But ultimately, you have to think back to maybe about 15 years ago, when we first started looking at the sector, people didn't actually have any data about the energy use in buildings. The utility only had energy tracked to the meter.

But in general, because of the tenant-landlord problem that we've talked about before, only tenants often get their electricity bills. Or in some cases, only landlords get electricity bills. So tenants don't always know what energy the landlords are paying for, let's say, in a small multifamily building.

Or if you're in a large commercial building, and you're a landlord, you didn't actually know what the tenants were paying for. Even if they're, let's say, a large bank or law firm, you had no sense of how much energy they were paying for. So you had this kind of fragmented information landscape.

And so a lot of the data we started to gather-- I'll go through the policies that created the data first. But there was a lot of excitement about New York City in the early days about gathering the data because the New York City laws that were passed mandated gathering data. So just to give credit where it's due, first, the Institute for Market Transformation on the left started publishing reports on the opportunities for building energy transparency. And they really started to develop a framework for implementing US commercial energy rating and disclosure policies.

They also I think deserve a tremendous amount of credit for going to lots of cities and states, showing them how it could work, and helping to write legislation for how it could work. So essentially, I think they are lobbying for a great environmental policy. And Cliff Majersik, Andrew Burr, Caroline Keicher, and David Leipziger all deserve a tremendous amount of credit.

New York City, the law I'll focus on mostly is local Law 84, a benchmarking report. A lot of work was done by Laurie Kerr, John Lee, Hilary Bieber, Donna Hope, Stacy Lee, and Jenny Cooper at the City of New York. And then a variety of people worked on it from various sectors, including me, Constantine Kontokosta from NYU, Adam Hinge from Sustainable Building Partnerships, and Alexandra Sullivan from the EPA.

And then just most recently, a lot of work on this area has been done by Urban Green Council, including Sean Brennan, Adam Schiabor, Sheena Thiruselvan, Chris Anjesky, and John Mandyck from the Urban Green Council.

So how do we get to this data? The key point was New York City passed a series of building policies. And the key point I want to make is that many buildings were already-- many building owners were already doing a lot of things for energy efficiency. As I said before, New York City has jurisdiction over buildings-- the Department of Finance, the Department of Buildings.

But what happened after PlaNYC 2030 came out in 2006 was developed what's called the Greater Greener Buildings Plan. And that passed a series of laws. The New York City Energy Efficiency Corporation, NYCEEC, was set up. Local Law 85 in 2009 was set up to pass a New York City energy conservation code, NYCECC. Local Law 88 was also passed in 2009 to encourage a more efficient lighting and sub metering.

To think back to the energy efficiency lecture from last time, conservation codes have been around a long time, since 1970s. As I said to you, around 2008, 2009, there's a tremendous amount of interest in making building codes much more aggressive to deliver faster energy savings. For example, City of Seattle, where I used to work, has had since the 1970s or '80s a person in charge of energy code who did tremendous work. But the energy code is only designed to deliver about 1% or 2% improvement per year.

In 2008, 2009, the Obama administration and many cities starting looking to building codes to develop-- deliver much more aggressive savings, more than 3% a year at times. Lighting and submetering, again, is essentially a no-brainer. Because of the rise of light emitting diodes, or LEDs, we have much more efficient lighting than we did before. And submetering was designed to give buildings control over subareas of the building.

Of course, this is essentially something that's built into most modern buildings. So this is something that some high-value buildings were already doing. And so you want to reward owners for doing those things.

The policy I'll talk about today is Local Law 84 in 2009. It's the benchmarking and disclosure policy. It essentially sought to solve the landlord-tenant problem that I talked about before.

It essentially simply said, if you're the owner of a building, you have to go gather the bills for your tenants. It's not actually that hard. You simply have to send a message to your tenants, gather the data, maybe hire a consultant to put it into the EPA database together. But a lot of the infrastructure was already built by the EPA for the Energy Star rating system. But I'll talk more about what the effects of this law were later on.

And of course, Local Law 87 passed in 2009. It required energy audits and retro-commissioning. An energy audit is a much more detailed, in-depth view of a building. Think of it as getting a car tune-up. You take it to the shop, and the mechanic tells you all the things that work and don't work with your building.

Retro-commissioning is the next step. That's essentially a process where you turn all the dials in a building to tune it up again. In other words, once you know what's wrong with the building, you read the manual. You make sure it's performing as the designers intended it to.

Local Law 87 requires I think 10% of buildings in a given year to undergo an energy audit retro-commissioning. This is a much more in-depth procedure. But we have plenty of empirical evidence that energy audits and retro-commissioning is also beneficial. I think Evan Mills from Lawrence Berkeley National Labs in 2011 wrote a paper arguing that, based on 600 buildings or so, retro-commissioning on average would deliver about 20%, 25% savings in energy. That is a non-trivial amount.

Local Law 33 passed in 2017. Gave letter grades for building performance. Just like you see on New York City restaurants an A, B, or, god forbid, a C grade, buildings themselves would get grades for their energy performance.

And you could think about how benchmarking and letter grades are meant to work. Think about what you'd do if you didn't have this kind of information. If you're a tenant seeking to, let's say, rent a space in New York City, and you don't actually know how energy efficient any of the spaces are, why would you pay more for any space if it's more energy efficient? So actually, there's no incentive for the landlord to invest energy efficiency in the first place. We'll talk more about that also.

Local Law 97 passed in 2019. Was part of a, quote, unquote, "Green New Deal" package meant to establish very aggressive carbon budgets for buildings. It is something the New York City government is working on right now to implement.

So just to give you a sense also where the energy efficiency landscape was in about 2009, 2010, on the left-hand side, the codes that were being upgraded. You can see this kind of green landscape. The darker green indicates the more aggressive codes in Florida and Massachusetts.

But you can see across the country in 2009 that there is a Building Codes Assistance Project funded by the Department of Energy. And they're assisting all these jurisdictions, all these states, in developing more aggressive codes. And the spectrum at the lower left shows you how those codes are getting more aggressive over time.

In 2013, this map on the right, you can see that there are some disclosure laws that are nascent across the country. It looks like about 15 or 20 cities and states have passed these disclosure laws. But in 2013, none of the states-- none of the cities had really developed a lot of data yet. This is part of the reason why we focused on New York City so much. New York City, as the biggest city, developed the largest data sets that we can do the most analysis on.

So just to give you a sense of how these two different policies work, on the left-hand side, this is a famous graph you might have seen. It's called the diffusion of innovation curve. You might have heard the phrase early adopters. And it's essentially a bell curve, where the bell curve is divided into one standard deviation, two standard deviation differences.

On the far left-hand side, innovators are the 2.5% of the population that are two standard deviations ahead of the curve. They're innovating, trying new things. The early adopters, the one to two standard deviation part of the population, are people who are adopting new technology. And of course, the rest are the early majority, and the late majority, and the laggards.

But this is where benchmarking is meant to reward some groups over others. For example, if you're an innovator or early adopter, it may cost money. It may cost time for you to do those things. And if there's no information in the market, you won't be rewarded for it. But if we release the data to the public about which buildings are more energy efficient or less energy using than others, then you have an incentive to be an innovator or early adopter.

At the same time, on the right-hand side of the curve, the laggards are the people who are, let's say, doing less or doing the bare minimum. That's where building codes are meant to bring up the floor. They're meant to get the laggards to perform to a minimum standard. So benchmarking and codes essentially work on different sides of this curve.

And so what we found in our first look at the data-- I guess I've quoted the New York City 2013 year two Local Law 84 report-- is you see tremendous variation in all these sectors. In other words, depending on the sector-- multifamily buildings, office buildings, retail, hotel, education-- you can see that there's huge variation between the best performers and the worst performers.

In the retail sector, let's say, there's a 5.6 times difference between typically good performers and bad performers. An office building is a 5.8 times difference. And you can see that there's basically tremendous variation between the best performers and the worst performers. And what you want to do is give incentives or reward the best performers and tell the poor performers how to improve.

And so this kind of ties into a larger empirical literature about what the market for energy efficiency is. For the past 40 years, since the 1970s, there's been a tremendous amount of interest in energy efficiency. But there's also been a gap in investments.

And so the argument is that there's been underinvestment in these energy efficiency technologies compared to the significant potential returns. And frankly, neither engineers or economists explain this gap particularly well. Is this a rational or irrational process?

Economists would argue that-- have argued in many papers that this is actually a rational gap, that the savings of energy efficiency are not necessarily there because people choose not to invest in them. So therefore, there must be a reason why people have chosen not to invest in energy efficiency.

And engineers have focused on the fact that this is irrational. They say, well, the savings are clearly there from well-understood technologies. So this is irrational for people to be using more energy than they have to.

But the paper we read for class today, the Bernstein et al. 1980 paper, is called "Overcoming Social and Institutional Barriers to Energy Conservation." It focuses on six different barriers, including misplaced or split incentives, like the tenant-landlord problem I mentioned to you earlier, the lack of or misinformation among decision makers. If you don't understand how much better a green building or an efficient appliance can perform, you won't take that action.

There may be existing customs and regulation. I talked too last time about how some buildings exist for many different uses. The energy efficiency may not be the principal concern of the owner.

Market structure may inhibit people from investing in energy efficiency. For example, if you're in a highly competitive market, you may simply not choose to invest in energy efficiency, because none of your competitors are.

You may lack available financing and capital to help you make those energy efficiency investments. And you simply may be myopic, which is, of course, a natural human characteristic.

So I teach this paper every single year, this paper that's 42 years old, because I would argue to you, and I think you all probably recognize, that many of these barriers still exist. They're still barriers we need to overcome. And so the question we had was, if all of these barriers vary greatly by individuals-- whether or not you're a tenant, or what kind of owner you are, or what kind of individual you are-- how do I identify who's affected by which barrier? And how do we target our policies better?

So this brings me to how benchmarking works. And it's really an argument about market transformation heterogeneity. So if you start in the upper-left-hand corner, you start with the diffusion of innovation curve. And information enables us to identify who's an innovator, who's an early adopter, and who's a laggard.

But the fundamental question we're trying to get at is, what information will cause action? When you move to the upper-right-hand side, you can see building owners. And the question for building owners is, well, how efficient is my building? Do I know how fresh my building is? And who will I be judged against in a marketplace? So the question for building owners is, what building should I be compared to?

Now, if you know you're compared to other buildings, and if you know that your building can perform six times better, then you actually want to understand, how do I make my building work better? And so that you want to go see what other building is performing well. So if the data was public, you can not only have an incentive to invest, you'd also have an incentive to go find out what works for a similar building.

And that leads us to the question of, what investments are cost effective? And if you make those investments that are cost effective, then, if you skip to the lower-left-hand corner, you can see potential buyers. Potential buyers will reward you for having a more energy-efficient building if it saves them money, which leads us kind of a circle back to, what determines the building energy performance we're seeing in the first place in our information?

If this information doesn't exist in the upper-right-hand corner, then this whole cycle can't work. And this is a virtuous cycle. But if the government passed a law, as it did with Local Law 84, to gather the information or compel building owners to gather information at relatively low cost, once you inject the information to the market, you can get building owners to act towards investment. You can get potential buyers to reward those building owners. It becomes a virtuous cycle.

So what we found in some of the initial reports was that different property types comprise very different portions of the total energy use of the city. But even more interesting to us was that if you looked at the buildings-- and we coded them to keep them anonymous on the bottom.

But also, on the horizontal axis, we actually grouped them by consultant. You can see that different groups of consultants actually came up with really different results for what the energy use was in the buildings. And this is simply because people have different processes. They measure different things. They also look at the data differently.

And so it was interesting. We actually would get all the consultants in a room. And we'd show them this graph. And we'd show them how much their energy use they measured was different. And we were trying to improve the data quality.

So this is to say that if you are trying to affect the overall market, we first want to work through building owners to gather the data. But then we recognize there is a relatively small number of consultants servicing all these owners.

So in New York City, when we first implemented this law, when New York City first implemented this law for buildings over 50,000 square feet, it only affected about 10,000 buildings. But those 10,000 buildings were serviced by a much smaller consultant industry-- I think roughly 500 consultants so. Still a very large number. But if you think about the fact you're trying to affect a million buildings, it's much easier to work through 10,000 building owners and 500 consultants than it is to try to tackle the entire city or make it a public information campaign.

Having said that, you know that all your building owners are owned-- your office buildings are owned by a relatively small number of owners, whereas multifamily buildings, there's many more buildings, but also, many more owners or many different kinds of owners. This suggests you need different kinds of campaigns to target this information to different owners.

So to give you a sense of some of the results from this law, this is something I found in a 2017 paper, that the first three or four years, my co-authors and I found that this law actually reduced energy use intensity, which is the energy use per square foot, by about 12% to 14% over the first three years. We were quite surprised how much energy reduction it delivered because that's much more aggressive than the building codes I told you about before. That's roughly about 3% or 4% per year at a minimum.

If you look over the last 10 years of data, from the benchmarked emissions and energy trends, you can see that site energy use and total emissions have steadily decreased over the last 10 years. This is from a report from the Urban Green Council in 2022.

To make the point again that this is unusual data, or this is a new data set that we really didn't have 10 years ago, this is a data from the effects of COVID-19. And you can see that the Urban Green Council graphs it here. We saw that energy use had decreased in January and February and decreased in April and May between 2019 and 2020. And we knew that from the electric utility because the electric utility delivers all the power.

But what we didn't know before developing this benchmarking data set was how it affected different buildings and how it affected different buildings in different places in New York City. For example, we knew that energy use was going down at the beginning of COVID. And we knew that estimated occupancy went down quite a bit. But we didn't necessarily know where.

Some of the benchmarking data revealed to us for the first time that water energy use decreased in Manhattan and increased in the outer boroughs. This is clearly because people aren't commuting into Manhattan. Roughly 4 million people used to come into Manhattan every single day. And we know that some Manhattan residents were more likely to decamp for places outside of New York City when the pandemic occurred. So we can actually see in a localized way where energy and water use are increasing or decreasing.

And so what we've seen over the last 10 years is an explosion of these benchmarking laws. When I first got involved in this I think about 10 years ago, there were about five or six cities that had passed benchmarking laws and had not yet implemented them. New York City wasn't the first to pass the law. I think San Francisco was. But New York City was one of the first to really put that data into action. And because New York City has the most buildings, it was the most interesting data set for me and others to analyze.

You can see at this point, benchmarking has spread to about 40 or 50 cities. This is a very popular map that the Institute for Market Transformation keeps updated because they've helped pass these laws in many of these places through lobbying and through education of public officials.

And so to give you another sense of how important building energy efficiency policies are and where they're going, this is always a report I'd like to show. This is another graph that McKinsey consultants use quite a bit, but also other business-type consultants use. It's called a waterfall graph. It shows you where you start-- let's say, in 2050, business as usual-- and what steps you'd have to take to reduce to your goal, which is 2050 carbon reductions, deep carbon reductions by 2050 for New York City.

The somewhat entertaining thing I find about this report is that this is from a report called "New York City's Pathways to Deep Carbon Reductions." It was issued on December 30 of 2013, essentially the last day that Michael Bloomberg was in office. And he issued this report because he'd already done a lot to try to pass [INAUDIBLE] policies. But this is kind of the equivalent of the midnight report you pass for your predecessor to have to deal with. Bill de Blasio, when he came to office, actually increased the climate commitments of New York City.

But the crucial thing I want to show in this report is that the 2050 business-as-usual case is a very slight reduction from the 2005 emissions levels that the Kyoto Protocol measures against. But you can see of the 55.7 million metric tons of carbon dioxide equivalent just from New York City, of the savings to get to the 80-by-50 goals, or the 80% reduction by 2050, roughly half of that is going to come from buildings alone.

Most of it is going to come from existing buildings' energy efficiency. Some is going to come from fuel switching in buildings. And a little bit is going to come from making new buildings energy efficient. That again reinforces the point that most the buildings we're going to have in 2050 are already built. We need to change the behavior of people living in those buildings or owning those buildings.

The power sector-- we're going to get some savings from clean power and distributed generation. For the transportation sector, we're going to get some savings. We're going to get relatively little savings from solid waste. But you add the buildings, the power, the transportation sector together, and you get to fairly deep carbon reductions for New York City-- more than 80% reduction by 2050, which was the original Paris Agreement goal. Now our goals have become net zero by 2050, which is more aggressive still.

To give you a sense of how some of this kind of analysis percolated into city-level reports, this should be a familiar graph to you. This is a marginal abatement cost curve. But this is specifically for the building sector in New York City.

So you can see that they've measured out all the possible savings you can have in buildings. These are all the negative ones. Almost everything is negative compared to this few interventions that are relatively-- cost more. But I would argue that anything below about $150 per ton essentially is something that we should do because it's lower than the social cost of carbon. That pretty much describes about 23 of the 28 total metric tons carbon dioxide equivalent per year potential.

You can look at the biggest area is probably residential freezers. Again, not necessarily a topic you thought you might focus on, but a topic that has very high impact.

And so to get to the most recent New York City law, passed in 2019, these are carbon budgets for buildings. The highlights are that it affects buildings greater than 25,000 square feet. It sets increasingly stringent limits on carbon emissions per square foot in 2024 and 2030.

So in two years, we're coming up on the first marker, which is not the most aggressive one. 2030 is a much tougher target to meet. It gives building owners the flexibility to comply with this law through renewable energy credits or emissions offsets.

And notably, the city of Cambridge is considering similar carbon budgets for buildings. But they're not allowing renewable energy credits, which means that a building owner can't just go on the market and purchase a renewable energy credit, which may not have the decarbonizing impact we want it to have. I'll talk about renewable energy credits more in a few lectures from now.

It allows for some affordable housing to choose low-cost energy savings measures instead of meeting these emissions limits. It sets up a new Office of Building Energy and Emissions Performance at the Department of Buildings, again, spreading this throughout the city government. It has a strong advisory board to help refine emissions metrics and limits.

And also, crucially, it calls for creating a carbon trading study and implementation plan because even relatively new buildings in New York City will not be able to meet the 2030 limits. Let's say you built a new building around 2000. And you got a LEED gold certification even though your building had natural gas. Or natural gas at the time was relatively clean compared to consuming other forms of fuel.

By 2030, that building may be out of compliance. And so what you might do is actually choose to trade carbon credits. This is essentially a cap-and-trade program just for buildings.

You may choose to spend your money not on upgrading your 20-year-old natural gas system, but upgrading, let's say, 10 buildings in-- 10 multifamily buildings in the outer boroughs because that's relatively cost effective and has the exact same greenhouse gas emissions abatement potential, which is to say it's cap and trade for buildings. We want to look for the lowest-cost, highest-impact alternatives. And it does give very stringent penalties for non-compliance and also gives variances for financial hardship for owners.

With the Urban Green Council, in 2019, I analyzed the economic and employment effects for this city. It does affect the total output of the city. And it does affect the earnings of the city. But crucially, look at the number of jobs in 2024 and 2030. To meet the less stringent 2024 goals, we were going to-- it's expected to create nearly 20,000 jobs. But to meet the 2030 goals, it's expected to create, but also require, 180,000 more jobs.

We talk about this as a good thing in terms of green jobs, to create 200,000 jobs. But it could also be a potential constraint, which is to say that if you can't get enough affordable housing or enough people to fill these 200,000 jobs, this carbon budget may not happen.

So this is to say that workforce is considered to be one of the biggest possible obstacles to achieving the carbon budgets for buildings. We can increase the value of the buildings. We can increase output and earnings in New York City. Building owners may be willing to do it because it's cost effective. But if you can't find the workers, the policy may not be effective.