THE BROOKINGS INSTITUTION
***Climate Sense* podcast**

"How do we decarbonize the stuff in our lives?"

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Episode Summary:

The climate implications of our "stuff" economy—appliances, cars, clothes, roads, buildings and more—are enormous. The industrial sector that makes all this stuff accounts for 30 percent of U.S. greenhouse gas emissions. In this episode, host Samantha Gross talks with Rebecca Dell, senior director for industry at ClimateWorks Foundation, about ways to make the industrial economy—from steel to chemicals to plastics—cleaner.

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GROSS: This episode is about stuff. Most of us buy a lot of stuff, live in houses full of stuff, but don't think much about where all that stuff comes from. If you've ever wondered about the greenhouse gas emissions associated with all the stuff in our lives, this episode is for you.

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DELL: My name's Rebecca Dell. I lead the industry program at the Climate Works Foundation. It's a grant making organization that's focused on climate change. And on the industry piece, we focus on the most greenhouse gas-intensive industries. So, these are heavy industries like steel, cement, plastic, fertilizer that are the main drivers of greenhouse gas emissions from all of manufacturing and construction activity around the world.

The industrial sector includes the material economy. So, it's stuff—it's not energy. What that means in practical terms is mining, manufacturing, construction, waste processing. So, all of the ways that we are making and manipulating stuff in our economy.

And in the U.S., according to the U.S. Department of Energy, 30 percent of our greenhouse gas emissions come from the industrial sector. Sometimes when people ask me to summarize what my job is, I say making stuff without burning the planet.

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GROSS: I'm Samantha Gross. I'm the director of the Energy Security and Climate Change Initiative at the Brookings Institution and I've spent my career focused on energy and environmental issues. I've been in Washington for more than 20 years, working on energy policy in government and private industry before I came to Brookings. But I started my career as an engineer, designing technical solutions to environmental problems. My work now focuses on how to achieve a transition to a clean, zero-carbon energy system—the technical, political, and social challenges in getting from here to there.

For this episode, I brought in the right person to better understand the climate implications of our stuff economy. A good place to start this discussion is where in the process of making stuff the most greenhouse gas emissions occur. The industrial sector is huge and produces thousands upon thousands of different products, but most of the greenhouse gas emissions occur in just a few industries.

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DELL: So, here in the U.S. our highest emitting industrial sector is the chemicals industry. Everybody knows that they don't like chemicals, but very few people have a good sense of what they are. And the chemical industry actually is a huge part of our total economy. If you look around at almost any object in the world and you ask yourself, is that made out of metal, is that made out of wood, is that made out of concrete? If the answers are no, no, and no, then almost certainly that thing is the product of the chemicals industry.

So, that includes plastic, it includes fertilizer and other agricultural chemicals, it includes things like solvents and household products. It includes synthetic fibers. So, most clothing that's sold in the United States is the product of the chemical industry.

And the chemical industry uses fossil fuels as their feedstocks. And we have pretty low-cost fossil fuels here in the United States. And so, we have a very large chemical industry to take advantage of that. And that's our highest emitting industry.

The second highest emitting industry in the U.S., if you want to count it as an industrial sector, which the U.S. government does, is the refining industry. So, turning crude oil into motor fuels.

And the third highest emitting industry is the steel industry. And that makes sense because, again, if you look around at stuff, you'll see an awful lot of steel. We make cars, we make buildings, we make appliances, we make flatware. It's all steel.

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That top three list is similar to the global top three list, but it's not exactly the same. The global top three is steel, cement, and chemicals, whereas the U.S. top three list is chemicals, refining, and steel.

GROSS: Three of the four very high emitting industries make something that we consumers generally don't buy directly. Fuel refining is the exception. But chemicals, steel, and cement aren't products we buy at the store; they are raw materials that go into many other products we buy, or construction projects that we take advantage of, like buildings and roads.

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DELL: When you think about the highest emitting sectors, things like chemicals and steel, what you'll notice that all the highest emitting sectors have in common is we take some raw material, usually something we dug out of the ground, and then we transform it from a raw material into a useful industrial material. So, that first step of turning basically a rock into a useful material.

And usually to do that, we actually have to rearrange the atoms into different molecules. And rearranging those atoms into different molecules takes a lot more energy and it produces a lot more greenhouse gas than the subsequent steps in supply chains that are mostly focused on taking these useful materials and putting them into different combinations and sizes and shapes to make useful products.

So, we're really focused on what are sometimes called the primary commodity industries. So, what causes them to have high greenhouse gas emissions is the same thing that creates some of the challenges to reduce the greenhouse gas emissions, which is first, most of these industries require truly eye watering amounts of energy. That first chemical transformation, often what we're talking about here is basically melting rocks.

And then on top of that, we often are using energy inputs to drive chemical reactions in a way that creates additional greenhouse gases. Sometimes we have a situation, like with cement, where there is actually CO_2 that is stored in rocks, and we are releasing that CO_2 into the atmosphere.

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Other times, for example, with steel, we're using fossil fuels to do a chemical reaction, and the byproduct of that chemical reaction is more CO_2.

GROSS: These processes that use so much energy are key parts of our modern life. Steel and cement are the main components of our built environment, from roads to skyscrapers. And as Rebecca said earlier, chemicals are everywhere. From fertilizers and fibers to pharmaceuticals, the basic processes of chemistry touch our everyday lives in countless ways.

We're used to thinking about energy efficiency, but we can also think about efficiency in our use of stuff—material efficiency. The lowest emissions product out there is the one that we never used at all.

[8:02]

DELL: Most people are familiar with the idea of energy efficiency—that you don't have to reduce your quality of life, you don't have to reduce your level of consumption, you can provide the same services with less energy. What most people are a lot less familiar with is the idea of material efficiency, which is exactly the same concept. Same services, less stuff.

And because we haven't really made any serious or organized efforts to promote material efficiency in most cases, there's a lot of opportunities to make progress here. So, to give you one example: we talked about cement as being one of the global highest emitting sectors. We have huge opportunities to reduce the greenhouse gas emissions from the cement industry through greater efficiency.

And the way that we do that is, first, we can blend our cements so that they have a smaller percentage of the most greenhouse gas intensive ingredients. Most of the emissions from cement are associated with making an ingredient called clinker. So, you could blend your cement with less clinker. Then you can blend your concrete with less cement. You can make concrete that's the same strength, has the same engineering properties, just has less cement in it. And then you can design your buildings to use your concrete more efficiently.

Now, there's huge opportunities to do this.

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Some estimates are that if we maximize all three of these levels, the cement level, the concrete level, the structure level, we could reduce our cement consumption by three quarters. Are we actually going to achieve that in the real world? Probably not. But maybe we could get halfway there, and that would make a huge impact.

GROSS: A quick note about cement versus concrete

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for those who don’t work with cement mixers all day. Concrete is the finished product, the stuff that roads and buildings are made of. Cement is the part of the concrete that binds it all together, the glue that binds rocks and sand together and allows us to go from a product that we can pour and shape to something rock-hard when it dries.

This savings in material use that Rebecca describes sounds like the proverbial $20 bill on the sidewalk—if it’s really there, why aren’t we picking it up? It sounds like a no-brainer. One reason is that building materials is a very conservative business that doesn’t like change. And for good reason; we can’t have buildings and highways collapsing because the concrete didn’t perform. But innovation and testing can get around that problem. We know how to make sure that new materials will perform as expected. The bigger problem is much simpler than that.

[11:10]

DELL: The problem is that right now people don’t really have an incentive to do that. The reason that there is so much opportunity for efficiency is that our current systems are pretty wasteful. And the reason that our current systems are wasteful is that cement is extremely cheap. So, if you think about an 18-wheeler that is filled up to the statutory maximum weight for driving on an interstate highway in the United States filled full of cement, that 18-wheeler will have less than $3,000 worth of cement in it.

When people are weighing do I want to spend my time thinking about how to reduce my cement consumption, or do I want to worry about other aspects of my project, they don’t waste a lot of time on optimizing cement use. Because why bother? It’s cheap. The reason to bother is because of greenhouse gas emissions.

And we’re starting to see movement in that direction coming from both the construction industry and also from parts of the government that do a lot of construction, like the department of transportation and at the federal level, the General Services Administration.

There’s a larger point here about what is the progress that we can make through changing our practices? And what is the progress where we need to change our technology or our products? And when we talk about material efficiency, a lot of that has to do with practice change. There isn’t a technological barrier to blending your cements and concretes differently. In fact, these are practices that are widely used in other countries—in Europe, in South America, in Canada.

But you do have to make some incremental changes, or you have to make some changes to your practice. And there are transition costs. You would have to learn new things. You’d have to just get people comfortable with new options.

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GROSS: This is such an interesting point. Unlike a lot of issues in climate change where we’re looking at fancy new technology to reduce emissions, a big barrier here is just caring. We need to decide that material efficiency is important enough to make the effort. Even though the cost savings from using cement more efficiently are small, the greenhouse gas savings can really add up. So, from a policy perspective, how do we make people care?

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DELL: I see this as a great role for governments, because in any one of the 50 states of the United States, the largest purchaser of concrete is the state department of transportation. So, if state departments of transportation and the federal Department of Transportation went around saying, hey, we want these different mixes, we want these more climate safe mixes, for our projects, then they would immediately become available for the whole market for any construction project who wanted to use them.

So, there are costs associated with making this transition.

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But the government can have a really, really useful role at a very low cost in making more efficient alternatives available to everybody.

GROSS: In some instances, material efficiency means using less of a product in the first place, like we're talking about with cement and concrete. In others, recycling is an important part of material efficiency—reusing materials at the end of their useful lives.

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DELL: We've talked a lot about the opportunity for efficiency with cement and concrete. The situation looks a little different in other industries. For example, in the steel industry we actually are incredibly good at recycling steel. Between 85 and 90 percent of all the steel in the United States, when it reaches its end of life, gets recycled already. So, this is a highly material efficient system, and there's not a huge amount of room for improvement in steel.

When people think about recycling, the thing that they usually think about is single use plastics. Now, there is a *lot* of room for improvement on single use plastic recycling in the United States. The EPA estimates that less than 10 percent of single use plastics are recovered for recycling at the end of their life. And the amount that is actually recycled is much less than that.

So, why do we recycle 85 or 90 percent of steel and only 5 percent of plastic? It all comes down to cost. Steel is cheap to collect for recycling because it usually comes in big pieces and it's easy to separate from other materials because it's magnetic. So, you can just take a big pile of metal, put a huge magnet over it, and get all the steel out.

And when you melt down old steel to make new steel, you have a lot of ways that you can improve the quality of that new steel, and you save an enormous amount of energy compared to making steel from iron ore in the first place.

So, basically you have a situation where collection cost's relatively low. Quality of product is pretty good.

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And the energy savings are huge. So, you put all that together, and you don't need to care about climate change to recycle steel. It happens by itself. It just makes business sense.

GROSS: Steel recycling is a good example of what can happen when all the incentives align to make material efficiency work. Steel is easy to collect for recycling and recycling it uses much less energy than making new steel. We don't need new policies to encourage steel recycling—it happens automatically.

The question for me is how do you make material efficiency in other substances, like concrete or plastic, operate like steel? You don't have some of the natural advantages of steel, so we need to figure out how to set incentives and policies to make efficiency and recycling more attractive. Plastic in particular raises many challenges.

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DELL: There's many different kinds of plastic. They often come in very small pieces that are just very widely distributed around the economy. It's hard to separate plastic from other types of waste, to say nothing of separating one type of plastic from another type of plastic. If you take a lot of different kinds of plastic and you melt them all down together, what you get out is something that's very low quality. You can't use it for most of the things that we use plastics for. And the difference in the energy requirement between the new stuff and the recycled stuff, you save energy, but you don't save as much energy as you would for a metal.

And so, you put all these things together and absent any intervention of the government or any environmental motivation or anything like that, the incentives to recycle plastic are very low.

But it's important to remember that plastics are less than half of the chemical industry, and single-use plastics are about a third of all plastics. So even if we did a perfect job of recycling single-use plastics, that's a relatively small bite out of the chemical industry overall. And there may be fewer opportunities for material efficiency in other parts of the chemical sector.

GROSS: I asked Rebecca for her advice for listeners on recycling. Recycling is one of the more visible, action-oriented things that many of us do for the environment in our day-to-day lives. Are there any rules to live by for all of us?

[19:35]

DELL: People think that they're doing an environmental service by erring on the side of putting things in the recycle bin. But you're like, no, if something's in the recycle bin and it's not recyclable, then somebody, sometimes a machine but often a human being has to pick that thing back out. So, when in doubt, throw it out.

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GROSS: Wishful recycling is real. I've certainly been guilty of it myself. I hope this thing is recyclable, so I'll put it in the recycle bin. But different communities have different rules for what they take and how they manage recycling. Learn the rules for your own community. Just because a product has that little triangle symbol on the bottom doesn't mean that your community can recycle it. And know that putting non-recyclables in the recycling increases costs and may even keep recycling from being cost effective. So, please follow Rebecca's rule: when in doubt, throw it out.

Apart from material efficiency and recycling—using less stuff and reusing our stuff when we can—how do we decarbonize these emissions intensive industries? We can't cut back and reuse our way to zero emissions. No matter how much cutting back and recycling we do, we'll still need new stuff, so we need to learn how to make these materials with much lower emissions. I asked Rebecca to walk us through how we might do that.

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DELL: The specific technologies that we can use to get close to zero greenhouse gas emissions vary a lot from one sector to another. But all of the pathways fall into five buckets.

The first bucket is material efficiency. We can deliver services with less stuff and thereby reduce emissions.

The second bucket is carbon capture and storage. Conceptually, this basically means we just keep doing basically whatever it is that we're doing today, but we try and vacuum up all of the CO_2 and stick it back underground.

Bucket number three is hydrogen. A friend of mine described hydrogen to me as the answer to the question that hasn't even been asked yet. People think that hydrogen is a kind of Swiss Army knife that's going to save everything. In reality, hydrogen is a useful energy carrier and a chemical reactant. But it's very energy inefficient to use it, so we're going to only want to use it in the cases where we don't have a viable alternative.

Bucket number four is biomass.

And bucket number five is direct electrification. Figure out a way to do the same chemical reactions, produce the same products that we are using today, but do it with electricity instead of chemical energy sources.

GROSS: These are all promising techniques. In fact, we have a whole episode on hydrogen earlier this season. But they aren't all created equal. How do we think about when to apply these different ideas in different sectors?

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DELL: I put these technologies in a hierarchy more or less according to the amount of clean energy that they will require. So, material efficiency, that one always goes first because it saves energy and typically there's no technology risk, but it can be hard to change people's practices. So, do as much of that as you can, but you can't efficiency your way to zero.

So, the hierarchy starts with material efficiency, then direct electrification. Our best source of clean energy is through zero-carbon electricity. And so, we want to use that efficiently. And the best way to use that electricity is to just use it directly as opposed to transforming it into something else and then using it.

So, those are the two that we should really be focusing on, and the two we should consider our best choices in all circumstances.

Of the three remaining—CCS, biomass, and hydrogen—I think then it becomes much more kind of circumstance specific about how mature is the technology? Is the biomass actually sustainable in its source? Is there a convenient alignment between your local economic geography and the storage geology for CO_2?

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You end up having to ask a lot of these more circumstance specific questions for how you want to use and where you want to use CCS, biomass, and hydrogen. But in all cases, material efficiency and electrification are going to be your best choices.

GROSS: This all sounds good in the abstract, but it's helpful to walk through how an industry is really approaching the process of decarbonization. Efficiency and electrification are always a good idea, but we need stuff, and electricity can't do everything, as we talked about in the electricity episode last season.

Steel is a great example for understanding how to approach decarbonization in an industry. Since we're so efficient at recycling steel, further big reductions in emissions are going to need to come from the production process.

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DELL: To give an example of how we might think through these tradeoffs, the steel industry is the world's highest greenhouse gas emitting industry. So the steel industry is responsible for about 4 billion tons of CO_2 equivalent emissions per year.

If the steel industry were a country and you ranked countries from highest greenhouse gas emissions to lowest, the rankings would go China, the United States, the steel industry, and then India. So, the 1.4 billion people of India emit less greenhouse gases than making steel.

Now, when we think about how do we make clean steel in the future? Well, first, obviously, we want to max out our material efficiency and our recycling. There's not enough steel in use today that we could only use recycled steel. We are going to have to continue to make some new steel, particularly to supply the needs of low-income countries that haven't yet built out their electricity infrastructure and their road infrastructure and their rail infrastructure and modern housing. All of these things require a lot of steel as they develop.

So, there are two major pathways that we're thinking about for how do you get greenhouse gas free steel made from iron ore. One of them uses hydrogen. The other uses electricity directly. The hydrogen one, the technology is very similar to a technology that already exists that uses methane to make steel. And so, if you think about what is the smallest increment of new technology that we need to get to to get really clean primary steel, the hydrogen pathway is your best bet.

And I've never met anybody who thinks that the hydrogen pathway won't work as a technology matter. People argue about how much it's going to cost, but I've never heard anyone say, I don't think it's gonna work.

However, if we use the hydrogen pathway and we use electricity to make our hydrogen, it's going to use *much* more electricity than if we're able to use the electricity directly. At the same time, the direct electrification route is at a much lower level of technology readiness.

And so, it still is a question—is the direct electrification route going to work and is it going to work in time to help us meet our 2050 goals? I think probably, but we're still a few years away from knowing.

GROSS: Just a reminder, many countries, including the United States, have goals of net-zero greenhouse gas emissions by 2050.

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DELL: So, this is an example of, sort of, how you tradeoff between what we know will be a more energy efficient option but may not actually work versus an option that will use more energy but we know that it's going to work.

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Probably what we want to do is, like, try both. There's probably going to be some circumstances where we're going to want to use both.

GROSS: These hard-to-decarbonize industries also tend to be very capital intensive, low-margin businesses, exactly the kind of environment where competition is fierce, and change is hard. Governments and policy are likely to be important players in bringing about change, since it will be hard for individual companies to make the changes on their own.

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DELL: Governments have a really important role here. In fact, they have four really important roles. First, they have a role as a customer. They can buy the green alternatives, and in so doing they can create markets for those green alternatives.

Second, they have a role as an investor. So, they can give money to support the development and deployment of particularly new technologies that might be too expensive or too risky for private companies to take on on their own. The Inflation Reduction Act included almost $6 billion for something called the Advanced Industrial Facilities Program, which is intended to do exactly that. So, the DOE is supposed to allocate this to cooperative projects with firms around the United States in multiple different industrial sectors to help them demonstrate their technologies at commercial scale, move them from ideas to actual practical commercial technologies.

In addition to being a customer and an investor, governments have a really important role to play as a coordinator. So, these big industrial facilities, they require a lot of infrastructure to support them. They require energy infrastructure. They require transportation infrastructure. And these kind of ecosystems of multiple industrial players and the infrastructure to support them and the supply chains between them, they can emerge by themselves over time, but that typically happens very slowly. That takes decades, and we don't have decades. So, if we want this to happen quickly, we need the government to have an active role in coordinating the different firms and the infrastructure together.

And then finally, the government has a role as a regulator. It's the government's job to make sure that every company within its jurisdiction is conducting its business at an appropriate level of environmental performance. And so, the government needs to have that role, and it needs to create expectations with companies about what is the direction that the regulations are going to go in the future so that, hey, your business might be very dirty today, but get ready, because that's not going to be acceptable in the years to come.

GROSS: It's important to point out in this discussion that when we talk about decarbonizing heavy industry, we're not trying to get rid of heavy industry. We need the products that these industries make. They are some of the building blocks of modern life. If we want to build a greener economy, we're going to have to do just that: *build* a greener economy.

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DELL: Sometimes people perceive there to be a conflict between better climate outcomes and our manufacturing and industrial activities. I don't see that at all. First of all, in order to achieve our climate goals, we are going to have to build a ton of stuff. We are going to have to build wind turbines, and solar panels, and heat pumps, and electric vehicles, and on and on and on. And you know what all of that stuff is made out of? It is made out of steel, cement, and chemicals primarily. So, meeting our climate goals is going to create *huge* demand for industrial production.

That means, first of all, it's even more important that we reduce the emissions from these sectors.

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We don't want our efforts to stop climate change to become a driver of additional emissions. But also, it means that if we can build clean industries then we are in a position to have a huge competitive advantage. People are going to want these technologies; they're going to want these products in large volumes around the world for decades to come.

There's a lot of exciting progress that's being made, but unfortunately, most of it is not happening here in the United States. The most advanced projects in low-carbon steel, low-carbon cement, low-carbon chemicals, almost all of them are in Europe.

And some of them are in Asia, but very, very few of them are in North America. So, if we want to be able to lead in these industries, if we want to take advantage of this opportunity, we're going to have to get moving and we're going to have to do it quickly.

GROSS: The Inflation Reduction Act of 2022 is doing exactly that: pushing for the U.S. to have an advantage in green industrial production. Our abundant energy resources bring advantages in many industries now, like chemicals, and we want to continue these advantages as industries reduce their emissions. We want the United States to continue to lead the world as an advanced center for all kinds of industry and manufacturing, and that is not at odds with our climate goals.

We don't want climate policy to be about de-industrializing. We want it to be about *re*-industrializing and making the materials of the future better, here.

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Many thanks to the experts I talked to in this episode.

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You can find episodes of *Climate Sense* wherever you get your podcasts and learn more about this show at Brookings dot edu slash Climate Sense Podcast. You'll also find my work on climate change and research from the Brookings Initiative on Climate Research and Action on the Brookings website.

I'm Samantha Gross, and this is *Climate Sense*.