**Transcript of episode 2 (english version)**

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**Verena Göswein:** Hello everyone and welcome to the Circular Eco BIM podcast series. My name is Verena Göswein and it is my great pleasure to moderate this podcast. The podcast series is part of the Circular Eco BIM project. The project is developing a platform that makes use of building information modeling to improve the circularity of new and existing buildings, considering the life cycle impacts. The project is funded by EEA grants and developed by different entities from Portugal and Norway. As our objective is ultimately, to improve the sustainability of our built environment, we are making use of this opportunity to connect with different experts that are working towards that same goal.

In total we produce four podcasts where we discuss different topics of the circular economy, buildings and the construction industry. In each episode, we have one guest from the circular Eco BIM project consortium and one external guest.

Today's topic is "Metrics for Circular Construction". We will discuss how to source, manage, store and analyze data of materials and buildings. According to the principal: "if you can't measure it, you can't manage it", we will talk about where to get and how to collect relevant data, how to do when you when data is missing, and how to manage data over time, as well as about future opportunities arising from digitization and other trends.

I have with me today Rolf André Bohne and Eirik Resch. Rolf is a member of the project consortium, an expert of sustainable buildings and a professor at NTNU. Eirik is our external guest today. He's an expert of life cycle emissions of buildings and sustainable cities and has published numerous papers about building material emissions.

But before I let my guests introduce themselves just a couple of words about myself. I am the technical project manager of the circular Eco BIM project in my role as a senior consultant at 3drivers, a sustainability consultancy in Lisbon. Well over, I am a postdoctoral research associate at the Chair of sustainable construction at ETH Zurich. My background is in civil engineering but I'm mostly interested in interdisciplinary approaches of climate change mitigation.

So welcome! Thanks for being here. Would you maybe like to introduce yourselves?

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**Rolf André Bohne:** Yes, welcome everybody. My name is Rolf André Bohne and I'm a professor at the Norwegian University of Science and Technology. My background is in natural sciences, but I've been working on material flows and environmental impact from the built environment since 2000 and I have a PhD in industrial ecology from NTNU. So, mostly I'm working on environmental impact assessment of buildings and infrastructure.

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**Verena Göswein:** Thank you so much Rolf, I'm very excited to have you here. Eirik, do you want to do the same?

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**Eirik Resch:** yeah! Hi, thanks for having me. My name is Eirik Resch. I'm a researcher at the Norwegian University of Science and Technology. My background is in natural sciences, where I took a degree in physics and then pursued in industrial ecology degree after that. So, you can say I have expertise in natural sciences and also environmental assessment. Then I followed up with a PhD in applied mathematics, combined with architecture and computer science also at Norwegian University of Science and Technology and in Denmark, at the Technical University of Denmark.

So that's my technical background. The research that I've been doing revolves around the carbon footprint of buildings and construction projects and I have developed some methodologies for improving those assessments. In my PhD I also collected a data set of previous studies and I applied the new methodologies that I developed on those data sets to calculate a number of metrics and to arrive at some insights based on that.

On the side of my research, I also founded a company, one and a half year ago, which is called Reduzer. Reduzer develops a software for performing these carbon assessments of buildings. So that's the applied part of my work.

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**Verena Göswein:** That's great, I think it's very nice that you're with us today to tell us more about both the theoretical and practical side of all of this.

So, maybe let's start! First topic on the agenda today is collection of data. But maybe just a couple of words before : Why are we talking about all of this? When we speak about sustainable buildings or circular buildings what we usually mean at least when we refer to environmental impacts is that we want to reduce the environmental impacts over the life cycle of the building and that also includes the end of life of a building, meaning what happens once the building is demolished or in the better case deconstructed. Is that something we can do with the material? For example, for reuse or can we recycle some of these materials on site, for another building or for different purposes?

And there are different methodologies and concepts that have evolved around all of this. Well, worth mentioning is definitely the circular economy that wants to move from a linear to a circular use of materials and this can also be applied, of course, to buildings to minimize construction and demolition waste. Another thing that seems worth mentioning is life cycle assessment. That's a standardized method to analyze the environmental impacts related to building construction use and end of life. But of course it's a quantitative analysis and as such it requires lots of data and lots of information about the building, all its components and materials. And that's where we start.

So could you maybe tell us a bit about how you use data and what kind of data you collect?

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**Eirik Resch:** So collecting data, in this field, has been traditionally kind of problematic because a lot of the time the results are published without all the background data so it's not common that the studies are fully reproducible. And that's been part of my work to kind of try to promote publishing all the input data for these carbon assessments and then organizing them in a structured database. So that, based on those inputs data we can recalculate the assessment with any methodology, with the methodological differences in system boundary and calculation methods. So they would work for any previously performed study.

So where to get that data from? Most of the time, the building owners or the environmental consultants will be sitting on this in industry and in research it's the researchers who would have that data. So there is a lot of data available but it's not centralized, it's not available to everyone, so the struggle is maybe to kind of get a common platform or common format, to share this data.

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**Rolf André Bohne:** Well, what Eric mentioned, this is a big problem because traditionally if we go hundred years back, we had like 50 defined different materials entering constructions. And today, we have something north of 75,000 product names each of them with their own secret recipe. And secret is a key word here because they don't really want to distribute these data that we need for these calculations.

The other thing that is problematic when we're doing the calculations is the kind of service life, Eirik mentioned it briefly but kind of, different products in buildings have different lifespans so in the end we don't really know these things. And this is really difficult when you want to compare different materials in buildings, because: Okay, you might get the data from somewhere, as Eric said, these are often in the hands of the consultants, and there's a lot of economic kind of, in sentiments to not distribute these data evenly or openly. So, this is a big problem in order to select this and then they also have small, maybe very good producers of something that can't afford to make an EPD of things.

So there's a huge variation here and it's difficult to find data, the calculations are not so difficult. To get good data is difficult.

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**Verena Göswein:** Yes, you mentioned a good point which is that maybe some manufacturers don't have the means or maybe also the aspiration, that would be my question, to invest into creating open information about the environmental impacts of their products. Is that something that you experience and that you see as a challenge at this current moment in time?

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**Rolf André Bohne:** Definitely, a challenge. I mean if you ask a paint producer to give you data, he will refuse because by the time he is giving us the data, the competitor is able to kind of decode his recipe, so he would lose his competitive advantage, which is what is hidden in the paint. For smaller producers there's both. There are those who are very forward leaning but can't afford it, and as you said, there are those who are not forward leaning that want to hide it. And you have, but I think most of them at least where we are here, in Norway, they're doing something in wood so they are not really reluctant to do so, they just don't have the means to do it because it costs too much, both time and money.

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**Verena Göswein:** Could we maybe talk again about system boundaries? Could you maybe try to summarize why this is problematic, and what we need to pay attention to when we run an analysis and we use data that's maybe not specific to the context or to the product that we are analyzing?

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**Rolf André Bohne:** You can start with: What is a square meter? It's utterly difficult. You have many different definitions of what is the square meter of a building across Europe: is it heated, not heated? It is inside the wall, is it outside the wall? I mean to just agree on something that simple would be very.

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**Eirik Resch:** So I think we can distinguish between the material level/the product level and the building level.

There are kind of different issues with those two. For the product level the manufacturers won't give us access to all the background data, so we need to rely on the results, and they are externally verified by a third party person in environmental product declarations (EPDs). So we just have to rely on that data to be correct. On the system boundaries that are included there, they should be determined by the standards and they are determined by the standards. These standards, they vary a little bit all across Europe and across the world, so that's a problem, but in general they're quite similar for the products.

But when we move on to the building level, there is a lot more freedom for the person doing the assessment. Even though we have some standards they're very open and not very clearly determined. So they leave a lot of room for the person doing the assessment. One of those things that is usually determined is the footprint of the functional unit that we compare on for the whole building, but it differs across different countries and like Rolf André mentioned here. And that's, of course, a major one, but there are a lot of other differences, like the lifespan of the building for the study period that is used, the time horizon and also, of course, which products are included, what parts of the building do you include ?

So if you only get the final result of let's say 500 kilograms CO2 equivalent per square meter of heated floor area, that's an example, that doesn't really tell you much because then you get another result from another study, which is 700 kilogram CO2 equivalent. Those numbers alone will not tell you what was included in the studies and therefore you really need to have access to the data that was used like the inventory of bill of materials. So if one of those studies, the one with 500 was including only the structural parts of the building and the other with seven hundred kilograms CO2, was including the finishings and fittings and the windows and doors and flooring and the screws maybe even. I've never seen that but yeah.

So It really matters a lot that when comparing studies, the system monitors are equivalent or more or less equivalent.

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**Rolf André Bohne:** What Eric touches now is kind of utterly important because when you want to assess a building you basically want to assess two things, kind of : everything it takes to make the building, which is all the materials, and then you want to assess what is happening when you use the building, that is basically mostly via energy input. And then, what is included, in kind of, making the building? It's very important and as I assessed, you cannot collect everything, it's impossible. So very often you see that people are guessing and very often they are not including the fastening systems or kind of the ventilation system because it's very poorly described data. So a lot of these metal parts are not included and kind of, in our case, in Norway, we make a lot of things in wood, this is very important, so we end up with kind of not so good LCA. And then you start using the building and then it kind of goes : Okay, how many years are you dividing this upon ? iI is really important, but also are you using gas ? Are you using electricity ? And if you're using electricity, what kind of electricity do you count ? Do you count the national one or the European one, the forecast one or the yesterday one ? And everything of this is important.

Then you have different incentives so if you want to put photovoltaics on the roof, you want to have the electricity as bad as possible to get to show how good you are, how smart you are to put these PVs on the roof. But if you kind of want to be on the cheap shot, you don't want to insulate so much in cold climates. You want the electricity to be as cheap as possible, so we can say that it's nothing to save on insulating better etc.

So, it's very important to have strict rules on how to do this and you also need to define all these things. What we start within the analysis is to describe the goal and scope of the analyzes and our studies show that these are very often missing or poorly described I would say.

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**Eirik Resch:** I just want to continue a little bit on that because that's what a lot of my research has revolved around. All of those parameters that Rolf André mentioned now is impacting the results a lot and therefore it's so important to have the original assumptions that were made and the original inventory of all the materials like : what was the basic stuff? So, what was the quantity? What's the quantity of each material? What is the lifetime that was assumed for that material before it needs to be replaced?

Also the degree of recycling, if this product will be reused and so on. All of these parameters and more need to be available for further study to be comparable, because if you have that, then you can just redo the calculation with a different building service life for a study period or any of the other parameters and that's kind of having the data uniform format for the different studies. And then redoing the calculations, based on whatever assumptions you would like to make, that make sense. That's what we're trying to do also in the software that we're developing at Reduzer so you can actually rather than just do many different assessments based on different methodologies, let's say the Norwegian standard methodology or the future built methodology or the European taxonomy or Level(s) method, you can the redo the assessment for those different ones and get comparable results.

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**Verena Göswein:** That's great because I think nowadays we are at the point where maybe let's say project developers and investors are converging towards EU taxonomy but still there's quite a big gap between what's happening in research related to building sustainability and what then practitioners are doing, right? So as you say, there are so many different methods and standards and often I think they deliver different results so it's important to have that in mind when you run an analysis.

Well, another thing that I wanted to go a bit into better detail is when we talk about circularity obviously the end of life is very important. And when you do an LCA for a product or even a building there's a big difference between saying: Oh, I assume that at the end of life of my building everything will be landfilled or incinerated or I assume best case, and everything can be disassembled and reused. And that, of course, causes very different results, and I think, maybe there's a challenge of moving beyond that and trying to inform people: Okay, it is an advantage of recycling and reusing the materials, but how do you actually achieve that, right? What do you think, what kind of information such as data could be collected and stored that can help people inform on that ?

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**Rolf André Bohne:** Well, when it comes to circularity this has been a topic as long as I've been in this business, which is since the late 90s. What you see is that in general there is a demonstration product of how good this can be every five years and then there's not much happening. All over materials, this is being kind of systematized so I know that in some countries, they have been good at recycling bricks. Those countries as Denmark, Netherlands, Belgium, even Germany, at least parts of Germany, they don't have much natural rocks so they have a material constraint that kind of drives this, but then you also find that this is very difficult because it depends, when you build the building you're going to recycle. If it's too new it's impossible because you have used cement in the mortar between the rocks and it is glued so heavily that you cannot separate them. So, this is kind of very difficult. So, if you have old rocks and you can get them apart, but if you have newer buildings, you have to kind of cut treat it almost like concrete, you have to cut out panels and reuse, which makes it much more difficult and.

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**Verena Göswein:** That's fantastic, no? Like we're trying to improve but actually what we're doing through our new construction methods is that we're hindering the disassembly and reuse of materials.

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**Rolf André Bohne:** Yes and that goes back to what I mentioned in the early beginning, that we kind of had 50 well defined materials that we knew how to use and reuse hundred years ago and now we have some more than 75,000 different things that has the small changes to them, so we don't really know what is recyclable or what is toxic. So just think of sealant on tubes, you have like in the store 30 different for the same thing, some is good and some is not so good. So, this is very difficult. And then you also have changes in construction techniques. So we now want to have longer spans and more open rooms, which makes reuse of beams and elements maybe difficult, because they are too short and there is no way to make them longer. So there's a lot of structural kind of hinders towards recycling. But we kind of should go somewhere, maybe towards the standardization of widths, heights of floors, or ceiling heights in order to get this into the system.

But the problem now is that what we are talking about is already built.

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**Verena Göswein:** Yes, definitely. That's the difference, right? Do we want to reuse our existing buildings in the future or are we talking about making new buildings more circular?

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**Rolf André Bohne**: I think we need to do both. But then we need to kind of map the existing buildings docking. This is being done in various forms and with various purposes, but in the future, we are all dreaming of this digital twin where we can kind of select these, and this is what our project is also about, kind of: can we understand this system? So we can kind of have some donor building there which we can then take parts of and put into a reset that we're building somewhere else, and I think this recycling is very good, because now towards renovate Europe, I would say, because Europe wants to renovate. At least I've heard this story for 15 years now that you really need to renovate its building stock. It currently is less than 1% renovation every year. In order to reach the climate goals, we have to be above 3% every year. We cannot make this with new buildings, because then that will totally destroy the carbon footprint, but if we’re going to do so, we have to be smart about it and for Europe, I think the numbers are quite striking they're going to at least reduce with more than 50% the carbon footprint of the existing buildings that this energy use. And by doing so they're going to renovate them and they are going to create some more than 2 million jobs in doing so, which is also very important and now also with the Ukraine crisis it's even more on this, because you can save a lot of natural gas import from Russia, so I think there will be a tremendous focus on this in the near future.

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**Verena Göswein:** Well, maybe now, we spoke so much about all the different types of information that's available and that's needed. Shall we maybe talk a bit about who should store this information? And how should it be stored over the many years to come, considering that a building usually stands for let's say 60 to 80 years? Is this something that should be the responsibility of private or public entities?

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**Eirik Resch:** Well, it goes back to the previous question also that reuse, if the purpose is the circularity of building products, then one thing is the reuse today, so reuse of existing products when demolishing or refurbishing building, and the other thing is designed for this disassembly or future reusability so reuse then vs future reusability. And for storing the information now it's the future reuse ability that matters so I think that building owners should be required to store the data about how it was constructed and how it can be disassembled, how the different products can be disassembled. And if we go back to calculations as well, if it's designed for easy disassembly then that will make it more likely that that product will be reused in the future so that should kind of give some benefits in the calculations or the likeness of the product being we reused in the future is increased. And who should store this data? We could kind of say that it should be just centrally stored for all buildings and the government will store all that, but we don't want to do that for our personal information, private information and the building owners or even the manufacturers, maybe, of the buildings, they don't want that data to probably be given away to some central entity, so they would like to have it, but should at least be required that it will be documented. I don't know, what do you think, Rolf?

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**Rolf André Bohne:** I think that for a long time the society has had a strong interest in buildings and that's why we have the cadaster, of kind of, who owns what? What is the reach of your property, etc, etc? I think, as Eirik says, you don't want to store everything in the cadaster but I think a lot of the information needs to be stored there so it can be kept in a kind of a good way. But then you also have some concerns about this in kind of what is the information there in kind of is it in everybody's interest to know your internal separation and layout of your building, yes or no? But in terms of circularity it's kind of very interesting to have as much as possible, especially about all the internal design, which wall is load bearing etc, etc? So it raises a lot of questions that this is kind of what we as a researcher want in terms of circularity is not necessarily what the lawyer or somebody else wants in terms of.

So I think there's some work that needs to be done there, but I think that a lot of the information should somehow be connected to the cadaster so it can be used in planning, and this is also the digital twin approach, I think.

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**Eirik Resch:** I am in an office here next to another company that they are developing a central platform for building owners, so they kind of get all the data from operation and all the material use and the renovation and so on, into one central platform so it's kind of a digital twin but with lots more information into that same platform, everything about the building. So the building owners would want to have that data, they want to keep kind of they want to know as much as possible about the buildings and then they can also automate the operation to some degree, so they want to have all that information, but, as some of that can be required to be to be reported and openly available or started centrally, a lot of it still is private to the buildings, I think, but some parts of it could be public.

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**Verena Göswein:** yeah, I think there's a big opportunity and building information modeling on BIM, because I think originally, the idea was to use it more for let's say maintenance activities and to inform on that, but it has evolved to consider also other dimensions in terms of sustainability and material emissions all of that.

The question is, maybe, do you think it makes sense to have such a detailed data repository for all types of buildings everywhere, or could that even maybe create more problems than it can offer solutions because, again, this requires to manage the data over time ?

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**Eirik Resch:** We can start with the larger projects but in theory I don't think it's a problem to serve for any building. There is the information it is somewhere to begin with, like when the materials are first purchased. The information, most of the information is already there. It's just that we don't have a good way of managing it. So, I think it's more about the technology becoming mature, so that not so much time is wasted on kind of inputting the data and so on. So I think that will come with time, but a good starting point is to require it from larger projects for let's say buildings above 1000 square meters, for example, just as a good starting point.

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**Rolf André Bohne:** Yeah I agree with that Eirik. We kind of need to start with the kind of large projects and projects run by professionals and I think that a way to build up this is to do it over time, so you don't try to do it for existing buildings, unless they are changing them. So every time you want to renovate, or kind of make changes to a building, you should demand some documentation from now and onwards. And because I think it's not possible and then there's big structural differences between countries in Europe, some have kind of a high degree of personal ownership but, like Norway where, kind of, 80% own their own homes but in other countries this is totally opposite only 20% own their own home. So the real estate market is run by professionals to a different degree, so there are challenges in doing this in a kind of a holistic and transparent way across Europe. And then you also see the people moving between countries, if not to live there, but to kind of work and make buildings. We have a lot of non-Norwegian working in our construction sector and I guess that is the same for many other countries so you also have to agree, not only on what data to store, but then kind of, what language.

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**Verena Göswein:** Yes, but maybe here, the European Union can play a big role, no? I mean, of course I know a lot of construction workers come from outside the EU, but at least to come up with a standard framework, standard language for data storage and management that can maybe be helpful also for communication inside the different countries, considering that the workforce comes from different places in the world.

I think we're slowly moving towards the end but one question that I really wanted to talk to you about is, you mentioned it before talking about cadasters: So how do we move from having detailed analysis of one specific building towards the city scale or looking at a full building stock?

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**Rolf André Bohne:** Holy I guess. I think this is like eating an elephant. The only way to do it is to take one piece, at a time. So I think, as I mentioned, you have to start with all new projects either if it's in renovation or newly built, you have to select where to start, and you have to start. And if we are lucky, I mean if we are going by the current rate, we will be finished in 100 years. If we’re going by the rate we need to go to we can do it in 30-40 years but that's the time frame because most of the buildings we are talking about are already built and that's not going to change.

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**Verena Göswein:** That so you would say, it will be a bottom up approach that slowly will fill in the gaps product by product building by building and have a really big database that contains all the information at the city scale.

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**Rolf André Bohne:** I think it will be both a bottom up, which I just described, but I think that also needs to be kind of some superficial top down, where you kind of scan aerial photos, satellite photos where you kind of do things.

**Eirik Resch:** Drones as well. Drones mapping the building.

**Verena Göswein:** Good point. Yes.

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**Rolf André Bohne:** yeah and then you then you will just kind of say that this is typically something from this period of time and then you have average data put in, just for kind of planning. Because you need to plan this material company that is going to do this, recycling, reusing they need to have a rough idea of what's coming. Otherwise they will be too big or too small, and it will collapse on economic terms.

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**Eirik Resch:** My journey in research started actually with Rolf André Bohne. During my master's thesis he was my supervisor and we had a really interesting topic. That was top down on this issue so kind of what are the impacts of the city structure, the height of the buildings and others like the size of the city and the transport use, energy use and material use. So that was kind of a very top down approach to the same issue, so maybe we can keep the same top down approach and then fill in the gaps with all the new data that comes in, from newly constructed buildings and then also some new technology can help us with scanning the existing environment. I think there are huge opportunities there for combining both a top down and a bottom up approaches. So I haven't seen Rolf in a long time so it's really good to be back and discuss these things with you.

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**Rolf André Bohne:** Same Eirik. Same.

*00:32:36.222 → 00:33:07.406*

**Verena Göswein:** It's nice that the circle is coming to full close. I think we've discussed a lot of interesting issues related to data for circular buildings today. I would like to thank you for your time but close the podcast with one last question.

And that is that if you could maybe recommend a paper, a podcast or a movie that is related to circularity or sustainability in the wider sense doesn't have to be scientific, for maybe the interest of our audience to learn more about this topic.

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**Rolf André Bohne:** yeah maybe I can start on that. We're not talking about buildings, but building is part of the bigger picture so kind of, what why i'm interested in this is kind of save the world if you want in the bigger context and it's all about the planetary boundaries, so that is how much can we consume of space, materials, energy and still having a green planet or blue green planet. And for this I came across some months ago a very good episode on netflix by all things. Johan Rockström, he is very good, he is the leader of the stock on resilience Center and he has led the research group that has investigated these planetary boundaries in all means and how dependent humans are on the ecosystem services in order to have a good life and David Attenborough, another hero of mine, has teamed up with Johan Rockström and made a fantastic 75 minutes episode on this on netflix on planetary boundaries, where they basically go deep in and explain all these fantastic scientific papers in a very good way. So I highly recommend people to just search for Johan Rockström and David Attenborough on netflix and you will find it.

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**Verena Göswein:** I can support this, this is very fantastic yeah. Thank you Rolf, Eirik do you also have a recommendation?

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**Eirik Resch:** I'll just take Rolf’s recommendation and have some entertainment this evening I guess.

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**Verena Göswein:** Very good, well, thank you so much, maybe just to summarize a couple of things that I noted down that I found interesting. When we talk about circularity, unfortunately most efforts are not related to the desire to do better, but often also to material constraints, meaning we don't have enough, so we need to make an effort to reuse what we have in stock. But that standardization of building elements and construction could help to disassemble buildings and the future so that could be one of the efforts that we invest our time in. Talking about data storage, sensitive data as a problem both for manufacturers and for building occupants. However, it would be interesting to have a central storage by a public entity of all buildings available in the future. And then talking about data collection, we need both a bottom up and top down approach when we talk about scaling up data efforts so having a building by building combined with the, for example, remote sensing and drones use that allows us to decompose and analyze facades and buildings.

Well, thank you so much, I would like to advertise also our next podcast. We will talk about policy and circular construction. Our guests will be Agathe Kuhn from Longevity, a consultancy in the UK, and then Antonio Lorena, who’s the Managing partner of 3drivers, a sustainability consultancy in Lisbon.

It was great having you Rolf and Eirik. Thank you so much for your time, I hope you also enjoyed it and see you next time!