S U N Y College of Environmental Science and Forestry Campus Conversations: The Podcast
Season 2, Episode 5
Dr. Deepak Kumar, Assistant Professor, Department of Chemical Engineering
Dr. Timothy Volk, Professor and Associate Chair, Department of Sustainable Resources Management
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Tim Volk: Some scale-up efforts in the past around biomass, I think have put too much risk on the landowner and I think that needs to be equalized through the system.

Deepak Kumar: It's an interdisciplinary research where to make the overall process sustainable, you need to collaborate with molecular biologists, chemical engineers, environmental scientist, material scientists so that we can look at the whole chain starting from the raw material acquisition up to any use of the product.

Tim Volk: A little over a third of all our greenhouse gas emissions come from transportation.

Deepak Kumar: So, we have basically millions of tons of this waste available which industry has to handle right now as a waste. And we can use it as a source, carbon source to produce bioplastics, or any other high-value bioproduct.

Joanie Mahoney: Hello, it's Joanie Mahoney, president of SUNY E S F. Back for another campus conversation with professors Deepak Kumar and Tim Volk. And looking forward to our conversation today. So, Dr. Tim Volk, I'll start with you. Will you take a minute to introduce yourself?

Tim Volk: Great. Thanks very much for the opportunity to be here, Joanie. And so, I'm a professor here in Sustainable Resources Management. My focus is in the Sustainable Energy Management Program. So that's where I do my teaching. My research is really focused around biomass as a source of renewable energy. So, even more now I really deal with woody biomass. A lot of my time is with shrub willow as a fast-growing source of woody biomass that we can then turn into a host of other products. So, heat, power, chemicals, biofuels, that's where you have colleagues like Deepak, because I know nothing about turning wood into other products. So, you got to work with lots of other people to make these systems work. But I've been here for about 25 years or so.

Joanie Mahoney: And you and I crossed paths in a previous life because as part of the Onondaga Lake cleanup project, your research was instrumental in some of the waste bed remediation, on the Onondaga Lake cleanup project. So, you were one of the faculty that I knew by name before I came here to E S F.

Tim Volk: Yeah, so we met a number of years ago, I think was a very chilly day up on the waste beds when we, one of the first times I met you. But yeah, that's been a great project with Honeywell over the years, right? They're looking for alternative solutions, greener solutions to address the issues out there on the settling basins. And we've been able to develop a system that I think meets their needs, but also creates all sorts of other opportunities for growing biomass and making renewable energy here in the community.

Joanie Mahoney: And we definitely want to hear more about that. And Deepak, can you introduce yourself?

Deepak Kumar: Thank you for giving this opportunity. And I'm an assistant professor in the Chemical Engineering Department. I'm also an adjunct scientist at the Institute of Genomic Biology at University of Illinois at Urbana-Champaign. My education is in agricultural and bioprocess engineering and research here at E S F is around making high-value materials from low-value inputs. But as Tim was saying, we have to be more specific. So, what we're doing is we're looking on agro-processing waste streams and converting those into high-value products. Some of the products like were mentioned and others are like bioplastics, natural pigments. So, basically what we call biocircular economy concept. And it involves both new technology development as well as computer modeling for sustainability analysis.

Joanie Mahoney: You know, one of the things I'm sure people listening to this will see is that having a college community with a mission that's so narrowly focused means that everybody that I talk to overlaps. We're all working toward the same big mission and vision for the college. So, let's just start with the basics. What is the bioeconomy?

Tim Volk: So, I mean, really the bioeconomy, Joanie, is anything starting with biomass-based materials, right? And making different products out of it. So, there's a bioeconomy already in place. So, if you think about the forestry and agriculture industry, for example, that's our current existing bioeconomy. What we really want to do, I think, is use more biomass largely to replace fossil fuels. So, where do we bring fossil fuels into our system now and make products out of it? So, think about things like fuels, right? Or plastics that Deepak was mentioning, like chemicals that are made from oil or other fossil fuels now. And what we want to do is substitute that with our feedstock, with biomass, right? And convert it and make products that we need in the rest of the economy. One of the big benefits of this really has to do with circulating carbon, right? So, we're all, I think, aware now of the climate change challenge that we're facing and the issues that are, you know, that are ahead of us and that we need to make some dramatic changes quickly. So, if we can remove that fossil carbon out of the system and make the products that we still want, we can cycle carbon. So that's one of the attributes of it is that we take C O 2 out of the atmosphere. That's what plants do. And then we take that biomass. It could be wood, it could be oils from an oil seed crop. It could even be waste streams, organic waste streams that we have and turn them into valuable products. When we do that, turning into valuable products, that's the value-add-in. And that's where the job creation is. That's where the biggest economic benefits often occur.

Joanie Mahoney: What drew you to shrub willow as the biomass that you wanted to specialize in?

Tim Volk: I lived and worked in West Africa for three and a half years. So, I did small-scale agriculture, forestry, development with communities there. When I came back from that experience, my wife's from upstate New York here. I was looking for work, something to do. I was having a hard time finding a job. Valerie Luzadis actually introduced me to a guy that was working here, Dan Robison, and Dan had spent time in Ivory Coast, and I sat down and talked with him, and we connected over West Africa. And then he said, you know, I have a Ph.D. position here. If you're interested in coming and doing graduate studies and it was around shrub willow. I'll be honest with you, a Ph.D. was not in my plan. I'm grateful for the opportunity and I love what I do. So, it's really turned out very well, but it really

was a connection with Dan. The thing that drew me to it, Joanie, was that it was very applied, so they were working with farmers, trying to help them to understand how to grow this crop. That's what I've been doing in West Africa for three and a half years, is working in local communities. And so, I really wanted to work in an area where the work I did had immediate benefits to people on the landscape in communities, farmers, landowners, right? And then I kind of got into it and I've been doing it now for a couple of decades.

Joanie Mahoney: Isn't that interesting? I've been fascinated by the answer that I get to that question from faculty here at E S F : How did you end up in the specialty that you have? So, were you looking at it as a feed source for energy or as a source of remediation for sites like the waste beds, or both?

Tim Volk: So, originally when Dan was working here, they had just got funding from the Department of Energy for a project called Biomass Power for World Development, and it was really focused on finding alternatives to coal to generate electricity. So, we worked with what was then NYSEG and Niagara Mohawk, they still owned power plants back then and those two companies were looking for alternatives to reduce the amount of coal they were using. So, that project was really built around this idea of coal firing. So, you put ten or 15% wood into a coal system that reduces your coal use, it reduces your emissions and the other pollutants associated with coal. The remediation stuff came later when the energy market started changing and there was less interest in biomass as an energy source. And we started looking at other alternatives of things we could do with all this information we learned about shrub willow.

Joanie Mahoney: So is your work and the work of your colleagues before you, what led E S F to have the combined heat and power plant here on campus as a source of our heat off of fossil fuels?

Tim Volk: I think part of it was, you know, the work that we do here at E S F related to biomass, wood, out of forests, sustainable forest management, all those components of it. Right. And ending up using those products here on campus. I think Neil Murphy wanted to walk the talk. So, we talk a lot about biomass and managing forests sustainably. He wanted to bring it through to the point of let's use some of those products here on campus for heating power like we do so fossil fuel consumption and bring in woody biomass as an alternative. I think it was a goal to bring that to who on campus gives students an opportunity to actually see it in practice and increase our sustainability and reduce our greenhouse gas footprint.

Joanie Mahoney: And it's done all of that and more just walking up to the window and seeing the display there is such an educational tool for people who come through to understand what the benefit is of using the biomass as an energy source. Deepak, you use the biomass for a different reason. What are you doing with that same biomass?

Deepak Kumar: Well, I would say the reason is still the same. We want to protect the environment, replace petroleum-based products. But instead of focusing only on biofuel, we are looking at other high-value bioproducts, also, specifically bioplastics. And as we all know, plastic pollution is a big concern these days. It's on everyone's mind. And we are trying to identify technologies through using the same feedstock,

including shrub willow, as well as other agro-processing waste to produce these bioplastics, which can replace these petroleum-based plastics. The industry is growing significantly. Currently it's between, although the exact numbers are different, but $5 to $7 billion global industry by plastic industry and it's increasing at a rate of about 15% every year. So, it should double within 5 to 7 years. So, there is a there is a market need for that one to develop these technologies. But at the same time, as I'm saying, as Tim was mentioning about bioeconomy, so one significant component of bioeconomy is using waste streams, because in that way we're getting environmental benefits in two terms. One is we are using renewable carbon source to produce a replacement of petroleum-based products. And the second thing is we are avoiding getting those waste into landfills. And third is obviously economic benefit to the industries which are producing these waste products.

Joanie Mahoney: And if I understand them right, I think one of the biggest issues with plastic besides the use of fossil fuels is when they break down and end up in our water and fish are eating.

Deepak Kumar: Yeah, you're absolutely right. That's the big concern. We see the pictures showing piles of plastics in the ocean environment and also, as you mentioned, the conventional plastics also they're basically fragmented and get into a creating environment which we call microplastics, which is a big issue for aquatic animals and that environment. So, yes, and so the bioplastics which we produce, they are completely biodegradable and bio-compostable. So that's that's the focus.

Joanie Mahoney: And will we be recycling them or will they go to a landfill for composting?

Deepak Kumar: That depends on which type of product we're making out of those bioplastics, right? Because there is a lot of application starting from packaging material to automotive parts to appliances so that they would have different use and different type of end life. But, we have researchers with overlapping research ideas. So, I have some colleagues in my department who are working particularly on recycling of these plastics. Of course, these are biodegradable, but it will take time. So, idea is if you can shorten that life, if you have to recycle immediately so you can hydrolyze these and wear two monomers and use them back to make bioplastics.

Joanie Mahoney: So, if I'm a young person and I want to get into this field of trying to invent a better plastic, something that performs the way plastic does, but isn't the environmental harm, that's a chemical engineering path?

Deepak Kumar: There are a lot of aspects in this research area. So, as you mentioned, one is making better plastics. So better could be, again, depending on the application, the properties requirements are different. Second, could be making it more economical. Third, could be more environmentally friendly. We need, we don't need to produce it only on the lab scale. We need to consider the thing with the technology which is scalable, right? So that the actual industries can invest in that technology and again scale that up. You can go through chemical engineering it out, but it's an interdisciplinary research where to make the overall process sustainable. You need to collaborate with molecular biologist, chemical engineers, environmental scientist, material scientist so that we can look at the whole whole chain starting from the raw material acquisition up to any use of the product.

Tim Volk: We've got to talk about this whole system, right? , the stuff that Deepak does is great and I could never do it. It's well beyond my understanding. So, you need people in those fields that are very specialized. But the reality is, if we're going to move the whole system, we need people in every field. We need people that would do economics or lifecycle analysis, but we need people that address policy issues. We need people that work with the communities and people to help understand how do we get people to adopt and pick up new habits and ways of using materials or selecting different materials. So, we need people in every almost every field imaginable because if we're going to move the whole system, not just the little slice that we do research on, you need this breadth of people from all these different disciplines. So, people that are interested can tackle this from lots of different perspectives. There's lots of other ways to be a part of the system and making the world a better place.

Joanie Mahoney: So, it's been my personal experience that people want to be part of the solution, and if they want to be part of the solution in your world, knowing what you've learned, what would you like us to be doing to support the planet based on your research, both of you?

Tim Volk: First of all, is understanding where we're at at some high level, we have a climate challenge, right? This IPCC report that came out just a few weeks ago when you just started yesterday, like a number of years ago, actually. But we've missed that opportunity. We've got to do a lot of things, which means everybody needs to start making some choices. So just having an understanding that that's an issue and a challenge and then thinking about where do I fit in, right? Where do I use energy at home, in my transportation system, in the materials that I buy and use? How do I dispose of materials, right? Is there, am I throwing out organic material? Can I be composting it and using it in a different way? Awareness, I think, is the first part. And then finding some little steps that you can take to make a change. I mean, maybe you want to change your energy system. Maybe you want to sign up for community solar, which is available all across the region. In many parts of the country, you can sign up and get your electricity from a community solar system, for example, as opposed to just off the grid, which then puts more funds into that system, which allows it to grow and build and become more and more of what's going on.

Joanie Mahoney: How likely is it that we're going to put a dent in our energy usage in the United States? Are we moving in that direction?

Tim Volk: When you ask that question, I go to this what's called a Sankey diagram that I use in class. It's just a flow of energy. On one side. It's got all the sources and then it goes through industries. On the other side, it's how much is useful energy at the back end and how much is wasted. When you look at the diagram that's done by the D O E, we almost two-thirds of the energy that comes into our economy ends up as waste heat. It doesn't drive a car down the road. It doesn't produce electricity, it doesn't make a product. It's the byproduct. There's going to always be waste heat in energy systems, were never going to be 100% efficient. When I look at that and 60% of the energy we bring into the economy is wasted or lost and not used, we need to make dramatic changes. So, the big, the big fields, it's transportation and electricity generation are the two most inefficient systems.

Joanie Mahoney: You know, I hear that as a tremendous opportunity when you refer to that report that came out about how dire things are, at least knowing that it's under our control to make a difference. When you have such a big amount of waste, then you know that the solution exists and that we can be doing something about it. So, Deepak, I'm interested in your answer to that question, but were you going to weigh in on this part of the conversation?

Deepak Kumar: I mean, we all can make a difference by making correct choices as well as especially like when we talk about recycling and how how we are disposing organic waste as well as even the plastics. When we say like I know we see the recyclable plastic, but do we really throw plastic bottles there? Not everyone, right. So those are the choices which we can make at least to protect the environment. And second thing is which from the government side, because a lot of these bio-based industries are driven by, you know, unincentives. Government is already making changes. Obviously, they are providing incentives, but they will have to think more in which direction the economy needs to move and what are the priorities and accordingly, set the incentive to at least for the initial years to make these industries grow more.

Joanie Mahoney: We've had that some part of that conversation here too, and about how, you know, the policies with incentives really are incentives for people of means. People that are living paycheck to paycheck aren't going to be able to avail themselves of that incentive. And that's really where the density of people is. And so, the government really needs to think about how they're going to affect the masses of people that will more likely move that dial. So, you know, it's a coincidence that you're talking about do we put the plastics in the recycling bin? I happened to see in the New York Times a quiz and it was interactive. And you could put the items into the trashcan or the recycling bin and it would tell you whether you were right or wrong. And I feel pretty well informed and I was trying, and I got a lot of them wrong. And that's a problem because when people don't know, I think it's hard enough to educate people and get them to do the right thing. But when it's so utterly confusing, I think three or four of the items, I think I move them over to the recycling bin and it said it's complicated rather than right or wrong. And then there was more detail and I thought, wow, I can't imagine how many people are already lost. What are we supposed to be throwing in there generally?

Tim Volk: I think the waste management center here at the Sustainable Materials Center where Kate Walker and Mark are leading up to working on this. One of the things is to try and clarify that communication. But we do need to make these messages as easy to understand and for people to implement as possible, right? And trying to remove some of the complication. And I think this other issue that you were talking about, right? So, how do you get how do you reach disadvantaged communities? Right? There's this whole initiative in the C L C P A, the Climate Act here to do that. And we just actually had a student defend this morning who was looking at this issue in terms of solar installation and incentives that New York State has done and it is not equitable. So, there are these great solar incentives out there. But if you don't have the capital to make that change, that's a barrier. Even more so, if there aren't people coming to your community talking to you, maybe in your language, which may not be English, then you're not going to learn about these, then how do you find out about it and even find out if it's an opportunity, So that, you know, Jessica Howe who did that work? You know, I

looked at one of her graphs and I said, you know, we've changed in 2015. But the problem is that the non E J communities, the wait for solar is still growing faster than it is for the E J communities. My comment to her is you need to have a couple of graphs on what's up with the incentive programs and how we should change it, so that it's more equitable and accessible, right? It's an accessibility issue in many ways.

Joanie Mahoney: That's how I've seen it from over here. And I would say with a lot of the federal dollars that have been put forward to stimulate the economy in light of the COVID shutdowns, that's an opportunity. And, you know, maybe we should be giving people a premium for their old gas-guzzling cars, you know, to get those off the streets rather than the way we're coming at it. It's interesting that your student has learned that, but a faculty member at E S F not being able to pass the "what do you put in your blue bin" is a problem for the county and the planet and not really for you. So, how about the other kinds of biomass, Deepak? You work with some other materials besides the woody biomass.

Deepak Kumar: Yeah, sure. So, we are working on a lot of different waste streams. But from New York context, I would say two are particular important. Acid whey from dairy, dairy processing industry, and waste fiber rejects from the recycled paper mills. So, acid whey, that's a byproduct of big yogurt manufacturing and cream cheese manufacturing. So, as we all know, Greek yogurt has like skyrocketed last 15 years. So, in in 15, 15 years ago, the market share of Greek yogurt, hold 1% market share of total yogurt, and now it's around 50%. And for every kilogram of Greek yogurt production, we produce around 2 to 3 kilograms of acid whey along with it, which is a burden on industry. And New York is a leader in Greek yogurt manufacturing. So, we have basically millions of tons of this waste available, which industry has to handle right now as a waste. And we can use it as a source, carbon source to produce bioplastics or any other high-value bioproduct. So last year we published research on that where we demonstrated that we can use all carbon sources available in the acid whey, which are mainly lactose and lactic acid to produce high yield of bioplastics. The second feedstock which I mentioned waste rejects so that also we already have funding from New York Department of Environmental Conservation through the S M M Center, which was mentioning. So, these are the waste which is coming from these recycled paper mills, because when we do several rounds of recycling, the fiber gets shortened and stiff, which reduces the paper quality, or we can see the paper strand. So, they have to reject some of those fibers. So, this is a waste which companies have to sometimes pay a tipping fee to get rid of it. It goes to landfill and a research at E S F we have shown that this is a very valuable feedstock because it contains about 40 to 50% cellulose. We can convert those to sugars which can be used to produce biofuel or bioplastic. So, these are two main streams. But other than that, we are working on like brewers spent grains from brewing industry. Apple pomace, because again, New York is a big apple producer, and recently we started working on hemp processing waste from that is coming from C B D oil industry.

Joanie Mahoney: It's fascinating that now people are going to be looking at these waste streams as assets rather than a tipping fee to get rid of it, we might find somebody who would like to buy it because they're manufacturing things based on the research that's being done here.

Deepak Kumar: That's right. So that's why we count these as sometimes negative cost feedstocks. And that's where the big advantage is. But the problem is, one, is the low low-cost carbon supply and the production cost. So, you're working on these and using these waste streams, which are, if not negative cost at least zero cost. So that will significantly cut the production cost of bioplastics or the other bioproducts. But at the same time, they will give economic advantage to the industries who are generating these waste streams and, plus, obviously, environmental benefits.

Joanie Mahoney: What's the what's the toughest hurdle that you have in your research right now?

Deepak Kumar: The answer could be in various ways. So, one hurdle could be depending on if we are looking at the lab-scale kind of yields and just solving a small issue right now. That would depend again on the feedstock. For example, in the case of acid whey you have to develop new microbes which can handle acidity and still produce bioplastics. In the case of woody biomass or other lignocellulosic biomass, we need to first reduce the biomass recalcitrance by putting some energy in that, so that we can release more sugars out of it. But what my endeavor team we are working on is we are not looking at the small scale. We integrate our work along with the economic analysis and lifecycle assessment. So, we are looking at from the starting only when we develop process looking at the commercial aspects so we develop the process simulation models. So, we developed the biorefinery, which is in our mind or which is on paper, in actual computer to see that what would be the capital investment required or what would be the production cost, energy use, emissions, and everything. And we feedback that data during process development, after identifying which are the bottlenecks in the process so that we are not wasting time.

Joanie Mahoney: So, you're actually looking at a plate and saying this is how much this is going to cost over the lifetime of producing it and using it and disposing of it. And that is where the economist Tim comes in, is to help talk about those lifecycle costs.

Deepak Kumar: So, Tim, you can chime in. But let me answer first. So, when we say when I was mentioning process simulations and techno-economic analysis, that's more on the conversion part. Like because you say it's early scale technology, I can for example, I said we made bioplastics from acid whey, but is it commercially viable? I mean, how much you are producing from a kilo of acid whey and how much energy maybe you're putting more energy in producing it than actually you are kind of for you are going to get benefit of replacing petroleum-based plastic.

Joanie Mahoney: I gotcha.

Deepak Kumar: So, I do that work. Then I give that data to our colleagues who work on lifecycle assessment and as Tim was mentioning, policy analysis and everything. So, we integrate everything using those data as well as experimental data to see what's the overall sustainability of the product.

Tim Volk: I think if we think about this whole issue of trying to scale these up, right? I mean, so back when you asked me what interest got me into willow, right? It was this idea of doing applied work and then helping to scale it to solve a problem on the landscape. And so, when we think about scaling willow and using it for end products, the biggest challenge really at this point is the economics. We've got a system, is it perfect? No. But actually if we get a bunch of farmers to grow willow,

they're incredibly creative. They'll improve the system probably faster than we can as researchers, because that's just, they want to optimize their system. You know, the challenges we can grow this fully biomass. We know it's got great benefits in terms of greenhouse gas reduction compared to other fuels. But the economics aren't there because they aren't. The value of it is not high enough. And part of that's because the products we make out of it right now. So, willow, that's grown in the state and there's about 1200 acres of it, and it's all going to a power plant to make electricity. You know, it's 25 or 30% conversion efficiency. You're not getting all the energy out of it. And so, the price that's actually getting paid to farmers for those woodchips is relatively low.

Joanie Mahoney: Compared to corn or something else they could be growing.

Tim Volk: Right. Yeah. So, they're not going to keep growing willow, if the only outlet's to sell it to a power plant. But if Deepak can figure out how to take some of that wood and turn part of it into bioplastics, and we have a stream that goes off and makes renewable diesel, find some other partners and turn it into sustainable aviation fuel that we need, those are higher-value products. Then the value for the landowner goes up, and then they are more interested in going in. So that's the biggest barrier I think to advancing this system is how to make the economics work. And it really needs to be done in a way that it's equitable across the system. I think have put too much risk on the landowner and the farmer to take most of the risk. Everybody needs to benefit, but everybody should share some of that risk as we grow the system at the same time.

Deepak Kumar: I agree with Tim, and that's what like we can do, at least to some most of that analysis through this techno-economic analysis, which me and Tristin Brown and our colleague, we work on that because once we have these computer models or this techno-economic analysis framework, so we can do the what we call that sensitivity analysis like, okay, what will happen if the feedstock prices, the 15% higher than what we use in the base case, 20% higher. And that way we can figure out up to which like if let's say we make the model from woodchips to bioplastics so we know what the selling price of bioplastic is. If we set that so we can see by varying the price of woodchips, they tell what price the process will be still profitable. So, in that way, at least we can do some initial reanalysis before inputting a lot of resources into that.

Tim Volk: So, I think the other thing in that, Joanie, I think if people don't understand techno-economic analysis, and I don't understand it, right? And so.

Joanie Mahoney: I'm not sure I can say the word, Tim.

Tim Volk: I'm going to give you the high level thing, and Deepak can correct me. So, the thing that I find fascinating and really this is, again, Tristan Brown and he's been a colleague now for a number of years. And I've learned a lot from him. But he can build his model. Deepak can build his model from the bench scale. And you make some assumptions so we can make bioplastics in the lab. Theoretically, how would we scale that? And you build that into a model. So now you build a model plant and you run this analysis. And the thing that's great about it is, okay, so here's the overall economics, okay? If it doesn't work, we've got to either lower the cost or raise the price. But then he can look at and figure out, okay, so if we can improve the efficiency of the microbe by 5% and the economics through the

system change, that's the techno part of the economic analysis. So, pull a technology lever and see how much it changes the economics. Oh, if we pull that 5% change, the economics look much more attractive. Then Deepak can go back to his bench and figure out, okay, I need to figure out how to get a better microbe in this slice of the process.

Deepak Kumar: Thanks, Tim, for clarifying that. Yeah, exactly. That's what I was saying. We integrate this process from the start of process development. So, basically, we are guiding our research through this integrative system analysis the D L C. So, we know which are the hot spots where they are either, as Tim is mentioning, energy-intensive or will create more emissions or which are very sensitive. Like, let's say we change a little bit of efficiency, but it's going to significantly impact the final product cost so that we can focus our research on those areas.

Joanie Mahoney: You mentioned the Sustainable Materials Management Center that you are working with. And you also said C L C P A, and that has come up in this conversation. But will you remind people what the C L C P A is?

Tim Volk: So, the C L C P A is the Climate Leadership and Community Protection Act. So, that's legislation that was passed in the summer of 2019, and it sets in law mandates for New York State to reduce greenhouse gas emissions. So, 40% reduction in greenhouse gas emissions by 2030. So, I often look at my students in my class and I tell them, are you looking for a job in the energy field? Because we've got a lot of work to do in the next seven and a half years to hit that target. 2050, which is most of our students' careers. 85% reduction. The C L C P A says 85% reduction in greenhouse gases by 2050 based on what we were doing in 1990. So how do we do that in New York State? In New York State, actually, our biggest source of emissions is transportation. About a little over a third of all our greenhouse gas emissions come from transportation. Buildings is next. We can do a lot to improve the efficiency of a lot of our buildings and save a lot of energy, right? And reduce greenhouse gases by thinking more efficiency. Then electricity is down low. It's actually only 13 or 14% of our greenhouse gas emissions. But one of the drives to turn our electricity system into a low-carbon or zero-carbon emissions system is because we want to electrify so much. So, your vehicle, we'd like to run that on 100% clean electricity. But as we build that system out, we need to change our electricity generation system. That's all the focus on building out wind and solar and other systems so that we can electrify more parts of our economy here in New York.

Joanie Mahoney: You mentioned Tristan. Bob Malmsheimer and the rest of the team, you have a role in that C L C P A. When I look at that report, I see E S F as a lead or a participant in multiple areas, in that C L C P A. So, am I correct in telling people that the most aggressive climate plan among the states is here in New York, and it's E S F that's at the table trying to figure out the solutions to meet those goals?

Tim Volk: E S F certainly has a key role. When they passed the C L C P A, there's an overall committee of 20 people appointed by the state, and then they've got these seven working groups around it that are really dealing with sectors of the economy and they feed into it. So, Tristan works on this one related to industries, right? And the challenges that they're going to have to decarbonize the industries and so has lots of direct input there. Bob Malmsheimer works on the Agriculture and Forestry Working Group, so wrestling with the issues on how are we going to

lower emissions in agriculture and forestry. And then on the forestry side, how are we going to soak up more carbon with our forests across the state? So, they've had lots of input on that. I think on the other side, there's an there's an environmental justice working group. I think Lemir Teron and maybe others in environmental science have been putting direct input and have lots of input into that. I'm sure there's others on campus. So there's lots of places where the work that we do, the research we do, the knowledge we have is feeding into that process. Next week, we'll host the public hearings here on campus. And I know there's lots of people that are preparing to do comments or submit written comments if they can't be there in person right from here on campus, including a number of students. E S F has got lots of places where we have fingerprints in that process. And I'll give you just one more example. So, about a year or a year and a quarter ago, the D E C, the Department of Environmental Conservation contacted us and said, we've got to put out this report on where we sit on the overall carbon budget in the state. We have no idea how much every year we're storing in wood. So, if you think about trees suck carbon dioxide of the air, they turn it into carbon in the wood. We take a portion of that wood and it goes into flooring or tables or building timbers, right? That's going to be carbon that's stored for a long period of time. D E C had no idea, they could take a guess, but they really wanted to put a better number. And they contacted us and they said, Can you guys help us? Oh, and we only have four months to an answer because that's when we need to submit it to the state. So, you know, fortunately, we were able to juggle some things and we got a very good grad student and he built a great model. And so that number is in there. That's a that's another one of these places. So, they took that number and they said, well, this is great. Thanks very much. Right. This gives us much more confidence that the numbers we're putting into the model make sense. You know, Colin Beier's here on campus, too. He's building the whole forest carbon model.

Joanie Mahoney: I was just thinking about him while you were talking. The amount of carbon that's stored in our forests in that CAFRI project that he does in partnership and others with CALS, the College for Agriculture and Life Science at Cornell. I'm also thinking about Paul Crovella and how he has this expertise in mass timber construction and the carbon sequestration opportunities there. And it's interesting just sitting here at the table that when I asked you what's one of the most difficult aspects of your research, it's, you know, the man across the table who can do something to affect your research. When I came, people talked about us being in silos, but we're not at all. We are having these interdisciplinary conversations all the time. And I've been able to witness them right here as part of this campus conversation that we're having.

Deepak Kumar: Yeah. No, you're right. I mean, as you have as you just mentioned, I collaborate a lot with Mark also, like again. And they have to develop sustainable building materials. So, they have to look at the economics. So again, I help in the techno-economic analysis part. We have written some grants together and so there's a lot of overlap because we are all working towards ultimately sustainability, environmental sustainability. And that's a good part also because these days, most of research need interdisciplinary collaboration. It's like we can complement each other in research and strengthen the idea.

Joanie Mahoney: And I'm thrilled with our new provost, Dr. Sam Mukasa's focus on these cluster hires. And I know one is in the area where you work with that same idea about

that's where these grants are coming from is to fund this work that crosses disciplines. So, I think he's got us on the forefront of that and those are in the works. So, there is one, right, I think, is it Bob Malmsheimer, who is the point person for the cluster hire that is in this world?

Tim Volk: It's lots of work. Some people, a wide variety of people that get together and put these things together. So, so we're looking to hire five people and we really want to focus in on the bio-economy and pieces and, and parts here where we have gaps, right, in order to move the whole system forward. So, we'll hire a chemical, another chemical engineer, right? And so, Deepak and his colleagues sort of assess the landscape and what the needs are and where could we add value, a strength we don't have here. So, we'll have somebody there. We're going to have we need somebody to look at soil carbon. So, there's huge amounts of carbon in the soil here and we need to look at that. And we have one soil scientist on campus and he's only got so much time. So, we'll bring somebody in to help with that expertise. And I think there's going to be lots of work that has to be done in that field. You mentioned buildings, so we're going to hire somebody in the built carbon in the built environment, so building efficiency, more wooden buildings, more stored carbon. To look at those kind of issues. We need a natural resource economist, we've talked both of us talked about economics, but we need somebody else to sort of in an overarching way to help us look at those, particularly to look at job impacts, which is often a criterion that's used in assessing these things at state and federal level. And then finally, we want somebody to look at the landscape. So, if we if we're going to change what we're growing or how we're managing force on the landscape, to have somebody to look at. Not only is what does that do into common across the landscape, but what's that doing to other things like biodiversity or water quality or soil quality or quality of life in different types of communities. So, those are the folks we'd like to bring in. And it is exciting because we look at it and we think, wow, if we could bring this expertise to the table, we could, E S F could really cover a niche out here and be a leader in this field. We already are in many ways, but with this extra support and extra engagement, the fact that you would really put his stamp on E S F. And if we work together, I think we can actually move the dial, make a difference.

Joanie Mahoney: When I listen to you, the phrase that comes to mind is we're really firing on all cylinders here. We're trying to come at this from a lot of different angles.

Deepak Kumar: To add on, as you're saying, firing cylinders and different angles, although we talk till now talked about mostly bioenergy and bioplastics, but we're looking at some other kind of other sector also, and which is kind of bioactive compounds in terms of, let's say, carotenoids, anthocyanins, which are again from coming from food waste and the food processing waste I'm looking for so those we can extract and which can replace the synthetic dyes used in the food industry. So I'm actively working in that area with the research I was doing at University of Illinois. As I'm continuing year of there, I was working on ed corn and we were trying to extract anthocyanins as natural pigment. Yet I'm working on I use that same concept but integrated again more bioplastic component along with the like. First you extract color and then use the remaining materials for bioplastic production as well as working in collaboration with a colleague in University of Guelph, where we are using carrot rejects like peel which come when peel the carrot and the tape and

the front part of that. So we extracting beta carotene out of it and using the remaining one for biofuel and bioplastic production.

Joanie Mahoney: You know, one of the things that's such a benefit is that the generation coming up now wants those things. They will tell you that their dye is natural in the things that they're wearing. And that's going to be a big boost to the research that we're doing, is just the demand that is coming. The generations ahead maybe didn't have the knowledge that the ones coming up now have and they are going to affect the economy in a way that is going to make this research even more viable.

Deepak Kumar: Right. In the end, another part of this is like, for example, when I was talking color pigments in terms of carotenoids or anthocyanins. So, they are not only going to replace the dye in terms of color, but they are going to give a lot of health benefits also. So that's why we call it bioactive compounds. They have anti-carcinogenic properties. They have a lot more medicinal properties also, which so they're very, very high-value compounds.

Joanie Mahoney: It sounds like you have plenty of work for the new faculty that we're going to be bringing on in this bioeconomy cluster. That's terrific. So, what's the thing that you want people listening here to take away? One of the things I'm thinking about, Tim, is you and I have had the opportunity to talk about how the willow trees can be planted along the sides of the roads to stop the drifting snow, which not only is a safety concern, but if towns in the city of Syracuse don't have to use the gasoline to run the plows to get that snow back off the road, there's an ancillary benefit. And then you're growing the mass strategically in places where it can provide that extra benefit. And then the mass is available to heat our buildings with the combined heat and power plant. I guess is the message just keep your minds open to the possibilities with this technology that's coming?

Tim Volk: Yeah, so, we're actually just getting started. We have a CAFRI, so the Climate and Applied Forest Research Institute that you mentioned that Colin Beier is heading up. So he's got a website that we're all working on and getting started. We did launch here at E S F, this Bioeconomy Development Institute that's really more focused on connecting, as Deepak was talking in this scale-up commercialization. How do we take our ideas, connect with industry, and expand that? So that's got a website that's nascent. There is a willow website right at E S F dot e d u backslash willow. People want to learn about the things that we've done or have been doing with willow.

Joanie Mahoney: I think people would be really interested to see the things that you've done and can do with willow. And we didn't even touch on the remediation aspect of the willow tree. So, yet another benefit of the place where you're planting these masses to use in Deepak's research in our power plant.

Tim Volk: If we do things across the landscape, we should not be doing it for a single purpose, and we should really be talking to the people in those communities and thinking about how do we get multiple benefits. So, snow fences we can plant willow in areas where you've got non-point source runoff from agricultural fields. And they can capture and take up those nutrients, use them to grow before they run off into a stream or lake or the groundwater, right? So, ways to address multiple problems at the same time. And then creative back-end uses. So here's a new one we're working on. Instead of putting concrete sound barriers. When I

think about the I-81 project, I think there's like 32 areas where they've identified they've got to put in sound barriers to minimize the sound with communities. So, there's a company out of Quebec that has designed these willow-based sound barriers with a fiber material in the middle that are just as effective and a much lower carbon footprint. So, let's not use concrete with a high carbon footprint. Let's replace it with a more neutral product. You know, it's like, Deepak, let's stop using fossil-based plastics and plugin biomass-based, renewable, biodegradable plastics. So, I think where people engage in this way, I think just being aware of it right and being supportive, right, when there's an opportunity to buy a biomass-based plastic. And they're out there, the idea that way to be supportive of those ideas. And that makes a difference also in terms of legislation, right? And what's happening, you know, in terms of the political system, people should engage in that. There's this public comment series going on around the C L C P A. And if people have opinions, they should express them. All those things get reviewed. Those comments get looked at. If you don't express your opinion, it's not going to get reviewed. So, people should engage in the process.

Joanie Mahoney: It's so interesting that we're here because this is where our one of our most recent conversations ended. And it was what's the thing when I ask that people can do it's learn about the sustainability priorities of the candidates and vote accordingly. And that's a way to support the work that we're doing. Especially for us, we can draw a straight line because we get a lot of the dollars to conduct the research from the state agencies, and they are overseen by the people that we're putting into office. So, we do have a lot of power when it comes to the ballot box in terms of research dollars for E S F. So, this has been such an interesting conversation. I thank you very much for taking time to explain to those of us outside of your world how it all works. And I'll tell you, my biggest takeaway is that there's so many applications. There's so many benefits that can come from doing research in this area. You know, you just very briefly talked on water quality. You know, the remediation, the snow fences, the emissions, the microplastics that we can avoid in our fish and the food we eat. And, that work is all being done here at E S F and by you and by your colleagues. And I appreciate you taking time to tell us about it. So thank you very much for joining me.

Tim Volk: Great. Thanks for the opportunity.

Deepak Kumar: Thank you. .

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