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COLLECTING INNOVATION TODAY

TRANSCRIPT OF A VIDEO ORAL HISTORY

INTERVIEW WITH

ANN MARIE SASTRY

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ANN ARBOR, MICHIGAN

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BARRY HURD:

01:01:41;22 The name of the company, Sakti3, tell us, some people might not know what that means. I mean, Sakti, I know, but the "three," tell us what that's all about.

ANN MARIE SASTRY:

01:01:48;10 Well, Sakti3 is a bit of an homage to my dad. It's Sanskrit for "power," and three is for lithium, and you know, the atomic number of lithium.

BARRY HURD:

01:01:56;22 And tell us a little bit about, that's the lightest metal? It's the third...

ANN MARIE SASTRY:

01:01:59;27 It is, it is. And so when people have scoured the periodic table for energy storage materials their eyes typically go to the north and the west. The north, because it has very low density, the elements there have very low density, and the west, because the proper electro negativity. And so they make good oxidation reduction materials.

01:02:19;28 And so, people have been chasing, research groups and development groups and industrial groups, have been chasing, making lithium batteries at scale for a long, long time. And it's only in the last, you know, decade or two, that they've really gotten footholds in the market. But it was a natural progression to go to these materials for energy storage.

BARRY HURD:

01:02:37;14 When you think about the battery, and we take it kind of for granted, but it's one of the more amazing innovations. When you start, do you go back and think about the guy with the frog's leg or the galvanic...

ANN MARIE SASTRY:

01:02:46;22 Absolutely.

BARRY HURD:

01:02:47;05 Tell me about how some of that might figure into the way you think about today.

ANN MARIE SASTRY:

01:02:49;24 Well, there was this notion, in Volta's time, that it was a life force. And actually, the frog was just the electrolyte, and the metal pieces were the ones exchanging ions and electrons. So you know, turns out that animals, sometimes non-living, can make pretty good electrolytes, but then the question of how to make an engineered battery still remains. We do use electrolytes now that are mostly salt and water. And different metals comprise the anode and the cathode, but they're made, of course, in much more sophisticated ways. So, going from understanding that putting metals together in an electrolyte, in an ionically conducting, but electronically insulating material, can lead to development of a voltage, turns into a real mass production engineering exercise of, "How do I control that, and get the most efficiency out of that system, and get work out of that system?" And that's taken, literally, hundreds of years.

BARRY HURD:

01:03:43;08 Now, what got you interested in this specific battery endeavor?

ANN MARIE SASTRY:

01:03:48;02 I am an electric vehicle fan, and have been for a long, long time. And my background is in applied mechanics, mechanical engineering. And so, that sort of a background gives you a platform to work on a lot of different things, and a lot of different areas. And my research groups and I have worked on a lot of different kinds of problems, in biology, in mathematics, in engineering physics, in electric chemistry. And the reason we, several of us, always kept working in batteries, even though there was a long period of time where Michigan and batteries didn't exactly go together. Now that's changing, thankfully. But the reason we did that was because several of us saw that as the key challenge, the key opportunity. If you can solve the battery problem, then you have a chance at getting electrification technologies on the road.

01:04:40;10 And now, at this point in time, in 2009, in this era the challenge has become much more important because of climate change, because of livability of cities, and so forth. What we're seeing around the world is that the emerging economies will be huge.

01:04:58;26 And the markets for cars will dwarf those of today's markets, as people join the middle class all over Asia, Brazil, Russia, India, China, the BRIC Nations. So those markets will be prodigious. What that means then, is that there'll be lots and lots of more people driving cars, and it would be great to intercept those markets with electric vehicles, rather than IC engines for all the aforementioned reasons. So, this drives a lot of what we do, and a lot of what our colleagues in the industry do. That said, there are a number of technical and business challenges into making sure that happens. And the third piece of that is the workforce challenge in creating a trained workforce of knowledge workers who can execute these technologies. So, that's what I've worked on my academic life, as well.

BARRY HURD:

01:05:43;08 Give me a little, sort of, a little brief history of you went from, I'm assuming, sort of an academic research, and then let's turn that into a great battery technology, let's start a company, let's get funding, let's commercialize it, that whole, sort of, process. It's probably a ten year story, but, or a several month story, but tell us...

ANN MARIE SASTRY:

01:06:00;04 Yeah, its a couple months story. It's, well, like a lot of things, you know, when an engaged group of people gets together, you know, sometimes lightning strikes. And, I would say for us a terrible thing happened when we tried to make batteries the way we thought they should be made.

01:06:17;05 The first set worked. And so, that's always very dangerous, all right, when the first set of things you try, you think, "Oh, I really oughta go down that path." And the team and I were surprised and delighted. And we were, actually, in a lab late one night, and we don't remember, of the three of us who said it.

01:06:34;22 But one of us said, "Well, we should just start a company." "You wanna start a company?" You know, sure, think about starting a company, and, well, just started listing the people we knew who ran co[mpanies]; "Ahh, how hard could it be?" You know, turns out it's pretty hard, but it's also the most fun we've ever had. But our thought was, we could continue just writing papers about what we thought was important and wait for others to come along and license the technology, or sort of follow the recipes that we laid down. And they would be imperfect, and they would be academic focused. Or, we could understand what the needs, industrially, in the markets were, and try to meet 'em ourselves. And so we decided to spin out a company, and we were quickly connected with a venture capital group who funded us. And that process was very fast. And now we've been up and running for almost two years.

BARRY HURD:

01:07:26;18 And what are some of the challenges of turning, I guess, a scientific breakthrough, if that's the term, we can talk more about that, into a commercial, I mean, you have to have money, you have to have partnership, I mean, that's what you're working on right now, right?

ANN MARIE SASTRY:

01:07:38;13 Yeah, and...

BARRY HURD:

01:07:38;29 Tell me about that.

ANN MARIE SASTRY:

01:07:39;29 Yeah, I think, you know, the most important elements besides the technology are the team and the markets. And you can have a great team, but if the markets aren't there, you know, you won't have anyone to ply your wares to. And if you have the markets, but an inadequate team, you may wind up selecting a lesser technology, because the better one didn't get executed. So, for us the focus is really on getting advanced battery technologies into vehicles, so that we can access those markets and intercept one technology with another. And bringing like minded people to us, to join the company, to become trained in our ways, and also train us in theirs. And I think that's something that every leader has to get very, very comfortable with, very, very quickly. When you really have, as your aim, to work with outstanding people, you have to understand up front, that not only will you acclimatize them, and you know, teach them your culture, your culture will change when you bring them in. And this is very interesting, and it's a good thing. But it means that in high performance environments you have very dynamic cultures.

BARRY HURD:

01:08:58;09 How much of what you were doing was experimenting, and did you accidentally discover some new way of hooking, you know, lithium ion batteries up? I mean, was there a breakthrough moment, that you said, "Hey, we've really got something, maybe we should do somethin' with it"?

ANN MARIE SASTRY:

01:09:10;03 I think whenever anybody has the, usually the quote/unquote "breakthrough" is after a lot of hard work. And a lot of mistakes, and a lot of winnowing of ideas that didn't work. And so, usually when there's a breakthrough or an idea that seems to be generating some traction, even it's because you've eliminated a lot of things that didn't work. In our case, and in, you know, my experience, guided innovation is a good thing. Knowing the physics of the situation and then taking some measured bets is a good thing to do. We use a lot of simulations in our work. We use a lot of math and physics in our modeling, to try to understand, okay, what should we be trying to make? What's plausible? And of course, you take calculated risks when you innovate, but the key idea is that you really need to narrow the design space as much as you can.

BARRY HURD:

01:10:07;21 What about for...

BARRY HURD:

01:10:12;21 What about for the people who aren't who aren't battery experts, they hear this in the paper, they hear the volts coming and this is, can you just sort of give us a little primer on, let's say we have a bunch of high school students here.

ANN MARIE SASTRY:

01:10:22;07 Uh-huh

BARRY HURD:

01:10:22;20 Tell us, you know, how the battery works, and what's the big promise of this lithium ion technology.

ANN MARIE SASTRY:

01:10:29;14 In the last couple of decades, what we've seen is a progressive and dramatic, at some times, increase in energy density. And energy density means how much energy your battery has per kilogram or per pound. Right? So in a car, the thing to keep in mind is that you have to pay to carry around your own power supply. Right, so you really don't want a technology that stores energy and that is very heavy, because then you won't be able to carry it, right? So, energy density ends up being a very critical parameter, and that's usually measured in watt hour per kilogram. Lead acid technology had a relatively low energy density. Nickel metal hydride technology came around and approximately doubled that energy density. Lithium ion technology approximately doubles that energy density. With each doubling of energy density, what you see is the access to a completely new market.

01:11:27;08 Okay, so, lead acid technology is not suitable for hybrid technologies but metal hydrides are. And metal hydride technologies aren't really suitable for full battery electric vehicles, but lithium ion is.

01:11:42;15 And so, every time you have these advances in the technical metrics, in the technical measures, all of a sudden, you find you can do very different things in the marketplace, and really change the way people live. So, the reason that you see teams like ours chasing second generation lithium technologies is precisely so that we can get to the next level. The Volt is interesting and other recent vehicles also are very interesting, because there's this push to electrify the drivetrain. So automobiles have so far, been driven by mechanically coupled drivetrains in the main.

01:12:21;25 And the Volt proposition is, "Okay, let's make the whole drivetrain electric. Let's run this car on electrons, and put a battery as the main power supply. The battery's gonna run out of juice, at some point, about 40 miles, but that's okay, we'll put an engine on to recharge the battery."

01:12:38;22 But now, sorta, the burden of proof is on the battery, not on the engine. And so, that's a real shift. And what that does is creates a little bit of a throw down to the battery community. Okay, how small can you make an engine? Right now commercial vehicles are going to be like the Volt, equipped with a four cylinder engine. Maybe that could be a smaller engine, and ultimately, no engine at all. But the key idea is that when you change the way the drivetrain runs, and make the battery the central power element, then that puts, you know, sort of the technical focus on that technology, which is great.

BARRY HURD:

01:13:15;11 Well, your work here, and you know, don't tell us your top secrets, but you basically have, like, an anode and a cathode, the electrolyte, you've got electrons flowing, and you're trying to change what those materials are made of, to make them more efficient, and make everything smaller.

01:13:28;05 I mean is that really, are you trying to do all those things? Plus, you have to control it, so it charges and discharges, it doesn't blow up, I mean, it's the famous thing is, they blow up in there's a control thing if you make them smaller. Are you doing all those parts, or is it just sort of one specific thing that then you'll partner the other parts of the battery with?

ANN MARIE SASTRY:

01:13:44;09 We're a battery cell manufacturer, and so we're making batteries here, battery cells. I think that, you know, since this is a Ford project, it's very interesting, and you know, sort of thinking about vertical integration, and the way things are now. Technology has changed dramatically. If you look at how many different teams on planet Earth are responsible for building a car, it's staggering.

01:14:07;03 People don't know what goes into a pencil, there's a famous book written about a pencil, where a pencil comes from. But there are logical fences around devices that make sense for one company to work on, and so we think that's the battery cell. We make an anode and cathode and electrolyte, and that's what we're working on. There are lots of people, though, who work on one component. And a lot of innovation occurs at the interfaces. So, at the interface between electric chemistry and material science, you've seen innovations in cathode and anode materials. At the interfaces between fluid mechanics and electric chemistry, and fluids modeling, you've seen improvements in electrolytes, and so forth. So, I wouldn't say that our model is the only model, but that's what we're doing.

BARRY HURD:

01:14:51;09 Well, what are some of the biggest challenges you're facing from a technical, are you up against, like, an electrochemical wall or anything like that you're trying to bust through or materials? Or how are you using nanotechnology? And how's that work? And give me, tell me something from a scientific standpoint, some of the real challenges.

ANN MARIE SASTRY:

01:15:07;22 From a science standpoint, we're not nearly at the theoretical capacities that the periodic table promises us. So that's comforting. I mean, when we look, when we go ahead and calculate, what are the theoretical properties we could get out of a pure material and a pure material cathode, a pure electrolyte, of, sort of, properties that we're pretty sure we can get in the lab.

01:15:28;19 We're not getting close to that in commercial products. The key question is, can we make products cheaply enough so that we can simultaneously get those properties and get markets to accept them?

01:15:40;02 That ends up being a value proposition. I think what's interesting, to me, is that there's a bifurcation in battery technology, it's just like there are in a lot of technology areas. There are always groups trying to make the world's best. And there are groups trying to meet markets. And there are, sometimes, not enough groups trying to do what is in the middle, which is improve the technology, but in a way that you could put it into an engineered product. So, rather than chase a particular nanoarchitecture that might be very difficult to execute and make and deliver, we picked a technology area which was massively replicable, massively scalable, and use computational simulation to optimize that.

01:16:28;06 And we'll see if that approach works. I think the laminate batteries you see now are made, largely, in the same way. So the area is ripe for innovation. And I think there'll be a lot of producers in the space. Some will make batteries at very high cost ways, some will make them in low cost ways, but our belief is that in order to address those markets that are coming, we must stay low cost.

BARRY HURD:

01:16:52;03 You think, eventually, for this electrification of the drivetrain, the battery's gonna have to be standardized? So then you can plug and play, in essence?

ANN MARIE SASTRY:

01:16:59;10 I don't, and I hope not. I think that all the chaos you see in automotive propulsion systems is a very healthy thing. And one of the things that I saw as a young composites researcher couple of decades ago, was that although many of us thought, who were working carbon fiber technologies, many of us thought, "Oh, this is gonna happen. Composites are the future. This is gonna be a tomorrow thing, right? Everybody's gonna pick carbon fiber composites. These materials are great."

01:17:26;19 Well, guess what? Steel got better. And so, that didn't stop steel companies from innovating nor should it have. It would've been a mistake to rule out the older technology, assuming that no innovations would occur. Actually, innovations did occur. Steel got much lighter weight, much cheaper, and so steel, in a lot of cases, beat out composite materials, even though initially carbon fiber composites had much greater gravimetric properties, that is, you know, for example, Young's modulus divided by mass, so the properties divided by mass were actually much better.

01:18:00;25 There's an object lesson there, and that is, if you really care about technology, if you really would like to see the best solutions come forward, you welcome the fight. You welcome the competition. All right? It makes you better. And surely batteries will get better, we're working on that.

01:18:17;12 Surely, fuel cells will get better, too. Surely, capacitors will, too. Surely, engines will, too. And right now, I think you see a competition among bio-fuels, diesel, flywheels, capacitors, fuel cells, and yes, batteries. And what that is gonna mean is that there are lots of ways to get past very emissive IC engines, which is a good thing.

BARRY HURD:

01:18:39;12 And you talk about the fight. To go and get the funding, to get the tax breaks, to get TARP funds, I don't know if you got those or not, but do you have to stand up and really fight for your idea? Or does sometimes the idea's so good, how's that all working for you?

ANN MARIE SASTRY:

01:18:54;02 At the, you know, when the dust settles, although governments are important as an expression of collective will, governments are important as a way of assuring that technology doesn't have unintended consequences. We're seeing, in our era, a lot of unintended consequences of technology. We didn't know the damage carbon dioxide would do in our atmosphere. I mean, and nobody would've executed these technologies if they'd known the profound changes that would occur in our climate potentially, because of our technology. These weren't deliberate choices. But now that we know there's a problem, it takes collective will to solve them. And, you know, that's what government is for. As far as supporting, growing, nurturing, deploying a technology, once the ground rules are leveled up on technology then it should be a competition. My point of view.

01:19:44;29 So, it's very dangerous to pre-select a technology very early. It's very dangerous to over advocate for one technology over another. It's very smart to execute policy that levels the playing field, in terms of harm or benefit to society.

01:20:02;04 So, one of the things that I like to talk about is the cost of the petroleum infrastructure, which is profound. All right? We pay for the Strategic National Oil Reserve, we pay huge geopolitical consequences, because of our dependence on oil. And I don't say dependence on foreign oil, it's just dependence on oil, right? So, we already pay an enormous amount of money for the infrastructure we have. If we level-up that cost against the cost of creating new kinds of infrastructures, I think what we find is that becomes very attractive. So, rather than advocate, you know, just sort of in a hand raising way, say, "Hey, I happen to work on this, why don't you guys put some money down here?"

01:20:41;23 I think it's more thoughtful and more reasonable to say, "What are the portfolio choices?" If we switch to clean vehicle technology, that would also allow us to access clean grid technology.

01:20:54;23 So, a third of the carbon portfolio turns into two thirds, turns into most of it, right? It's a sequential addressing of the problem, which I think is really good. Right now, you know, governments around the world, including our own, are talking about carbon cap and trade and different kinds of policy instruments to make sure that we're pricing the cost of technology on society appropriately. I'm not an expert in that area, but as an engineer, I look at these discussions that I'm gratified to see that we can try to attach costs, real costs, to our technology choices, which I think is healthy.

BARRY HURD:

01:21:30;20 What about the way you run around here, you wear several hats. I mean, you're a professor, you're cooking your own lunch. You're a CEO, you're a...

ANN MARIE SASTRY:

01:21:38;19 With the help of microwave technology.

BARRY HURD:

01:21:41;00 I mean how do you find yourself torn between all these things? Is it tough to do? Is it pulling you away from your love of the research or the teaching? Or tell me about that.

ANN MARIE SASTRY:

01:21:48;01 I, you know, I've never met anybody that I personally, admired that wasn't engaged at in a lotta different things at the same time. And I think if there's any trick or mystery to it let me, you know, sort of demystify.

01:22:09;24 If you're working on things that you really love, and especially in my case, when I'm working on clean energy technologies, I mean, I work on battery technologies here, at Sakti3 with my colleagues here. I work on research on battery issues and problems in the biosciences and mathematics, in my university work.

01:22:28;06 And I work on education of people to, you know, stream into the workforce and work on clean energy technology. But all of these efforts are really focused on the same set of problems. And so, you know, I feel extraordinarily lucky that the people that I work with, in all of these different venues often know each other. I can often connect people. It makes life very efficient for all of us who are, sort of, like-minded in the same technology area. So, it's really an ecosystem. And I find myself supported by that, and I'm glad to support it. But, in terms of, you know, sort of taking off one hat and putting on another hat, that I would say, I use the metaphor a lot that people should wear more hats.

01:23:06;29 But I'm not sure it's totally accurate, I think that it's actually a lot more facile than that, to move from domain to domain, if you, sort of, have your head screwed on right about what you need to come to work and do today.

BARRY HURD:

01:23:18;03 Little while earlier, you talked about the right team. Tell me how you work with teams. Some of 'em are students, they call them an intern, they come, tell me how that process works, and how things are discovered and implemented.

ANN MARIE SASTRY:

01:23:27;27 Well, I like to say that 'A' people flock to 'A' problems. 'A' people absolutely flock to 'A' problems. If you have an 'A' problem, it will attract 'A' people. Hands down, no question. You have to accept that the most junior person, and the most senior person will come into an organization and change its culture, and that is good.

01:23:51;20 So, one of the things that, one of our tenets around here, at Sakti3, is we not only expect mentorship of, you know, the most senior people chronologically, or in the age of experiment experience in better technologies, whatever, to the most junior people. We also expect the reverse.

01:24:10;11 There are things that young people know about society and technology that the senior people don't. And so our expectation around here is that in this team environment, we expect mentorship up and down the scales. And I think that mentality builds the team. It creates less hierarchy and more collaboration, which is good. Now, clearly, at the end of the day, in any team, somebody has to be appointed the decision maker.

01:24:41;26 Somebody's gotta, you know, sign the form, or be the person to say, "Hey, I'm gonna, you know, if there's a problem with this, it's gonna be my name on it." But in order to attract great people, you have to create an environment where they feel, and it's materially true, that they can change the environment.

01:24:59;21 And so, you know, I'm very privileged to work with everybody from very young students to very senior colleagues who, you know, you attract like-minded people, I suppose, so they buy into that philosophy.

BARRY HURD:

01:25:11;21 How much of what, overall, you're doing you think is, just seein' if you can deal with the curiosity factor, or seein' if you can make a living at it or if you change world? Do all those things...

ANN MARIE SASTRY:

01:25:19;23 Oh, it's, like, 100 percent, right? So, it's like yeah, you know, when one of your kids says, "Well, wait, watch this," and you kinda go, aagh! It's, like, what crazy thing are you gonna do next? I mean, that's sort of the best part of about workin' in technology, right? That's [the] best part about bein' (UNINTEL) like, "I wonder if," you know, and that's the mo[ment] and, you know, the most fun times in the lab, or the most fun times in front of the computer screen, are when something truly unexpected happened. I mean, I said the part about mapping the design space, and that's true. I mean, you wanna pick a technology area to work on, and you wanna pick a realm of math and physics to work in that looks like it could have an impact on people's lives, that looks like it's probably going to bear fruit, it's probably gonna bear something that could, you know, change the way people live, change the products that you make, et cetera, et cetera. But sometimes, you're truly surprised. And those moments are the ones to watch. Those moments are the ones where you pull out the notebook and say, "We better start takin' a lot more notes here." This...

BARRY HURD:

01:26:23;13 Tell me about one. Tell me how you felt.

ANN MARIE SASTRY:

01:26:26;09 There've been lots. We were working on a new manufacturing technology, and we got a surprising, surprisingly good capacity out of a system we built. And you know, a couple of team members' reaction, first, was, "Must be a mistake." And it's, like, "I don't know. Physics didn't break down the lab. Wasn't a mistake." Something is producing this result, all right? I hold these truths to be, you know, irrefutable that physics still works in the lab. So, then with a bunch of really smart people, you start to deconstruct it, you start to take it apart.

01:27:06;29 And say, "Okay, well, what were the steps that led to this?

What were the things that you did?" And sometimes in being methodical, you find that you figure things out with your Ph.D. or your advanced degree, whatever it is, or your years of experience, that really a high school kid could've come in and said, "You know, you forgot to turn the lights on."

01:27:27;24 And there's some extra photons in the room, that screwed up the instrument, yeah, and there are those moments, too. But, as long as you go in armed with a good understanding of math and science, you will work it out. And there is nothing that is inexplicable that happens in laboratory. Maybe surprising to you, but the fun part is deconvolving it, deconstructing it, and figuring out how to replicate it.

BARRY HURD:

01:27:53;04 Was that the spark, when you were, like, three years old, that drew you into this business? Or, you remember when you said, "I wanna be a... " you probably didn't say, "A battery maker," but...

ANN MARIE SASTRY:

01:28:01;06 I, you know, I picked my major kind of out of self defense. I had a lot of interests going to college. I had a scholarship to go to school. It was a full ride, it was a merit scholarship, and I looked at all the descriptions of the majors, and you know, mechanical engineers looked like they did about everything, you know. It's, like, what doesn't a mechanical engineer do? Okay, sign up for that. And, you know, if it's horrible, you can always switch out of it, to an easier major, but, you know, had good GPA requirement to get in, so I figured, if this doesn't work out, do somethin' else. And it worked out. And I loved it. That's not to say I couldn't have picked a different major, and had that major, you know, miraculously work out, too.

01:28:46;06 I think a conserved trait among the people that I've had the good fortune to work with, is that they'll take their credentials, and they'll stretch them to fit around any problem that they wanna work on. And those problems that I have collaborators in very disparate areas, are often the most fun problems.

01:29:04;20 Because when everybody's stretching, you really sort of see the bones of a really smart group. You really sort of see how everybody, dynamically, stretches to get their credentials and their background and their wattage around the new problem. And that's great fun.

BARRY HURD:

01:29:17;22 But were, you said before, the name is, like, a tribute to your father? Is that what you said? Was...

ANN MARIE SASTRY:

01:29:20;29 Well, my...

BARRY HURD:

01:29:21;03 He in the same business? Or...

ANN MARIE SASTRY:

01:29:22;02 No, my dad is Indian and my mother's German. And she's born here. And my dad's from India, and so that's his mother tongue.

BARRY HURD:

01:29:31;14 Okay, but did you have...

BARRY HURD:

02:00:47;25 You earlier mentioned this for us, "guided innovation". Tell us a little bit more about what that means.

ANN MARIE SASTRY:

02:00:53;00 To me, I mean, people have all kinds of ideas about how to innovate and what that means to them. I think that the first thing is to pick a good problem. Pick a problem where you know, you'll make a difference if you solve it. It's better to fail at something that was of some consequence than it is to work on something of no consequence, I mean, and you're just burning effort. And, you know, vehicle electrification's a great problem. So then you sort of drill down and you say, "Well, what's the bottleneck? All right, what's preventing my favorite technology from sorta hitting the road?"

02:01:26;03 There are several. I mean, you know, electric machines aren't as good as they could be. Controls isn't (SIC) as good as it could be. I mean, vehicles don't, you know, they weigh too much, right? They're too heavy to get a reasonable propulsion system. But really, it's about the battery right now. Really, if we had better batteries we could really kind of open up this innovation space.

02:01:45;22 Then you sort of say, "Okay, well, I'm gonna work on the battery." Well, what are you gonna work on? Well, you gotta get some mass out of the system. You gotta get these materials to be lighter weight. You gotta get 'em to live longer, because the emerging economies don't have the dealer networks that we do. You wanna make 'em in a way that's massively replicable to keep cost down. And you wanna take as much of the guesswork out of it as possible, so you might wanna use a high-precision technique to make batteries.

02:02:11;05 And you also don't wanna have design cycles where you're just in constant churn, where you're just kind of looping back in expensive experiments and so forth. You'd like to do this quickly, because a lot of people are about to buy cars. And when I say that, it's sort of an economical time cycle of maybe a decade or so. The whole world's gonna change.

02:02:26;29 So that kinda narrows down the design space a little bit further. And then you say, "Okay, well I can make a really great battery if I use a very expensive technology. I'm not gonna try that, because I know I'll never hit the markets that way. And I can make a short-lived battery, but it's gonna get really hot. Can't tolerate that, so I'm gonna have to look at a different design space and battery stays cool so I don't need an expensive cooling system.

02:02:49;20 "And I can make a pretty good battery in the sense of having a fast discharge if I use a certain type of electrolyte. But it's gonna weigh a lot. And it's gonna be difficult to design with, because it might leak. Okay, so I'll pick something different." So, our process in deciding to work on Solid-state Technology at Sakti 3 was really sort of that cascade of decisions, right?

02:03:15;15 It was first set of decisions is really about how you focus your career and how you focus your training and whom you choose to surround yourself with and where you go for funding and so forth. The next set of decisions is really about, "How am I really gonna make a difference in this field?" And, "Am I really working on the problems that I think are gonna address the markets that are most significant?" And so that was sort of our process.

02:03:36;17 In different areas of clean tech, of clean energy technologies, groups have made similar choices of guided innovation and narrowing the design space, if you like. Wind energy people have divided into groups of people looking at propulsion technology or excuse me, in turbine technologies and lightweighting those materials to have cheaper and more efficient wind turbines. Other groups have looked at controls and load leveling, grid deployment and so forth. Others have looked at policy and sort of the bottleneck.

02:04:09;16 But in each case, I think if you talked to the people innovating they're convinced that they're looking at the bottleneck. And even if they don't enunciate it right away, they picked that technology problem they thought, "Agh, if you could just solve that one, you could, you know, kind of upset the apple cart."

BARRY HURD:

02:04:28;01 So you seem to indicate that you feel that there's sort of a process to innovate that might be that other people could follow it, that it has, sort of, principles? I mean, you...

ANN MARIE SASTRY:

02:04:36;13 I wouldn’t suggest anybody follow me.

BARRY HURD:

02:04:37;23 No, say that they follow you...

BARRY HURD:

02:04:39;22 But you said there's some commonalities that people could follow in teams in trying to put things...

ANN MARIE SASTRY:

02:04:44;15 Yeah. I think that all of the innovators that I've really had the privilege to get to know and have a lotta respect for, have a certain irrational optimism. I think that's a pretty common feature. And you sort of have to, because, you know, you might get 50 percent of the way there on logic. And you're sort of saying, "Well, you know, this is kind of the technology area. This is the barrier. These are the tools I have technologically. These are the simulations tools. These are the physical tools that I have to execute a new material or a new product."

02:05:20;04 And then you have to place a huge bet. Then you have to place a huge bet that you're gonna put in enormous amounts of your own time and convince people you like and respect to put in enormous amounts of their time and get the buy-in of their families and loved ones and so forth to follow you on the merry path to go and try to make the change.

02:05:41;01 And so I think everybody you talk to who really innovates has that, you know, conserved experience of, "Well, I was about halfway sure I could get this far, and then we placed this gigantic bet." And just about every entrepreneur you talk to not only has had that sensation but likes that sensation, likes that sensation of placing a bet and seeing if he can get a really great team together to chase a really great problem.

BARRY HURD:

02:06:06;26 And you mentioned all the innovators you've known. Did you have inspirational people that sorta motivated you when you were younger making decisions? I mean, some of the historical innovators or current people, family members? Can you tell us about that?

ANN MARIE SASTRY:

02:06:18;15 Oh, yeah. Absolutely, my parents. My parents were both educators. My dad's a math professor. He's retired. My mother was a first grade teacher. Then she worked for the IRS and had other jobs as well. And they really gave my brother and me a lot of opportunity to explore when we were kids and, you know, sort of took the attitude with us that nothing is ever wrong. It's just, you know, on the path to something else.

02:06:44;14 And I was always a tinkerer. And my parents gave me lotsa room to do that. I had great teachers in school. I had great mentors in college. I've learned to some extent things from CEOs and things from technicians hired yesterday that were profound. The, I think, one of the most valuable things that I could tell anybody else is, "Never overlook an opportunity to learn from someone."

02:07:18;00 Everyone has axis of excellence. But there are different kinds of intelligence, right? And so although you have people who are wildly successful in a lotta spheres there are some people you interact with that do one thing really, really well. And it benefits you to study them and learn from them as well. But never overlook an opportunity to be mentored by someone unexpected. I think that's a major life lesson.

02:07:43;28 Now, in terms of attitude I, again, I've never been disappointed in talking with someone who I consider to be really, you know, doing great things and really interesting. A hundred percent optimists. Always the case. Always has. You know, optimism to the point of a little daring-do. And that's not a bad thing. And what goes along with that is a willingness to fail, which I think is, you know, kind of trite to say it. But you really do have to be willing to fail. You really do have to say, "Okay, I'm gonna place a bet. But I understand it's a bet. And I'm chasing something that's really hard to do. It may fail. And that's okay." And you'll draw others to you like that.

BARRY HURD:

02:08:31;22 But are you ever sitting there, like, you know, 3:00 in the morning, you go, "Why did I get myself into this?" And how do you over, I mean, do you have personal demons that say, "I should've done something else"? Has it ever happened? Or is it...

ANN MARIE SASTRY:

02:08:41;07 No, I really don't. I think, you know, I know some people experience stress in different ways. My training as an engineer makes me a problem-solver. So if there's something that's nagging at me or something I'm worried about, yeah, I just, I view it as a series of concrete steps I have to take to, in sequence to solve it.

BARRY HURD:

02:09:03;11 Why do you think it seems so hard to get people, especially in America, to wanna become engineers like they used to? What's your take on that? You're, I mean, you're turning engineers out.

ANN MARIE SASTRY:

02:09:11;15 Oh, yeah.

BARRY HURD:

02:09:11;29 Have you seen that here? Or is that just something we think on the outside? Or...

ANN MARIE SASTRY:

02:09:15;03 You know, engineers as a whole don't regard it as a professional value, enough of a professional value to replicate our own experience, to replicate ourselves. Other professions regard it as a public good to replicate themselves. Lawyers get together and they say, "How can we make young people wanna become lawyers?" Doctors get together and do that.

02:09:33;10 Engineers don't do enough of that. You're starting to see more engineers do that. And many of us who had academic careers look at the students we get coming in and say, "Hey, where are the rest of you? What happened? I mean, how come only, you know, 30 percent of this high school signed up for calculus? What's happening here?" So, I think the thing we have to get our heads around is that unless we get young, young children interested in science and technology, they'll make a series of decisions which mean they'll be down a different path. We won't get access to 'em.

BARRY HURD:

02:10:06;21 What should we be...

ANN MARIE SASTRY:

02:10:06;29 And...

BARRY HURD:

02:10:07;04 Saying to these young kids...

ANN MARIE SASTRY:

02:10:08;05 Take math. Take your science class. Let's get people who are practitioners in front of them. My colleagues and I do many outreach activities where we go into schools. But one offers, two offers, it's not enough. I mean, children really need to be exposed to math and science, really see it from a public good standpoint.

02:10:28;02 And that's another important point. I mean, often, you know, in science and technology we think, as a society, that there are some people with that sorta bent, that they have "it." They have the knack. They have, you know, the sense, the whatever that the tinkerers, that they like math, that they're good at science.

02:10:47;16 But there are many different kinds of intelligence. And what's interesting to me is that if you can access someone's desire to create change, it's amazing what they can train themselves to do. And there are many, many people who are very gifted in math and science who never execute, who never do anything with their gifts and talents.

02:11:05;18 So, how you begin when you start the problem is not the whole story. Getting access to people's motivation to create change is very important. And what I talk about in my journeys in math and science and technology is really the change that we think we can create, the good things that come out of these devices and products not just the process.

02:11:29;01 And there's a huge percentage of every job that human beings do that's just friction losses, right? There's the, you know, drivin' to work and you know, ordering the new Post-it notes and getting the desk chair fixed and, you know, all these kinda normal human things that take time away from our central professions.

02:11:50;01 But there's a part of everyone's job, they say, "Ohhh, that's the part I love," that "a-ha" moment in the laboratory, that perfectly executed simulation at my life, in your life, having a great interview after an hour of setting up cameras and so forth. I mean, and so, really, it's important to access that part of people and talk to them about technology in that way rather than, you know, just the details of how you get there.

BARRY HURD:

02:12:12;25 And what are some of the ways? You know, you have students, the young, you know, developing as usual. How do you access that? I mean, you said “A” people come to “A” problems. But you still, I mean, you have some innovative philosophy that you try to instill in them? Or how does that work?

ANN MARIE SASTRY:

02:12:26;07 I ask questions. You know, "What do you wanna do with your life," is a cliché, but it's a decent question. Another question I like to ask is, "What do you want people to say about you at your retirement dinner? What do you wanna accomplish?" And there's no right answer, of course. I mean, people want different things. Some people wanna be thought of as a great mentor. Some people wanna be thought of as a great inventor. Some people wanna be thought of as, you know, a very visible executive or what have you.

02:12:50;22 But if you get someone who says, "I really wanna change the world, I really wanna change the way people live for the better," and you drill that back to, "Okay, what are some technology elements that make our lives possible and pleasant now, and can you contribute to that set? Would making cleaner water change the planet? Would making clean energy change the planet? Would giving people access to clean energy change the planet?" You know, you have to not only get to the question in people it's, "What do you wanna change about the world," but you have to provide some answers about how your technology problem could change the world.

02:13:23;18 And then, of course, after that it's a collaborative process. You know, nobody can dictate minute by minute what a smart person does all day. You can put a challenge before smart people. You can give them the tools to execute. You can give them the team to help them execute. But nobody can dictate what a smart person does. You have to access that motivation.

BARRY HURD:

02:13:43;21 What role do you think museums could play in teaching innovation to children, young people, and accessing that desire to change things?

ANN MARIE SASTRY:

02:13:52;05 I think that telling the human stories is really important. I think that people who are the greats in any discipline can seem far away and intimidating and unaccessible and inaccessible. And so I think telling the human stories is very critical.

02:14:10;12 I think, you know, Henry Ford talking about the fact that he was a farm boy in Michigan, this is important. It's important to tell these stories. Because all of a sudden there's a pathway and there's a commonality. I think when children and adults, children of all ages, if you like, have things to do in, you know, a conservatory setting, in a museum setting, that's very powerful.

02:14:35;04 So when people can turn the lever and see something move, people can, you know, stamp out a metal part or see how a holograph appears when you, you know, turn on a laser, these things are very powerful. When people learn by doing, I think that's very helpful.

BARRY HURD:

02:14:51;27 Let's, a little bit of a gear change, no pun intended, to the auto industry. If you were to sorta paint a picture ten years down the road, are you seeing that we're all driving electric cars, and the auto industry in America, in the world is back up at the top? Or just paint that sort of vision you might have of how it looks down there. We got these hybrids now. Are we gonna be all electric? Are we still gonna have the gasoline engines? Just, you know, what are you seeing?

ANN MARIE SASTRY:

02:15:15;01 I think there's going to be a continued massive competition. And I don't think the dust is gonna settle on what the key propulsion systems are in the next decade. I think that'll take 50 years. And that's a good thing. I think that you will see these technologies duking it out in the marketplace, duking it out in the laboratories, duking it out in young companies and existing companies. And that's a good thing.

02:15:39;27 I think that in the immediate future, what you'll see is that the supply chain is going to become upended. You have technologies that are becoming important to the drivetrain that really were not auto technologies. I mean, battery technologies weren't an auto technology up until a few years ago, really. And the portion of the market that batteries served was actually very small you know, less than five percent.

02:16:03;25 Now all of a sudden, that has to be a core competency, right? And so the big companies are changing internally. Other companies are building up around that central truth. Right? And they'll compete. What will be on the road will be much more efficient cars. There's no doubt about that. Really, the emerging economies' entry into motorized travel means that the, you know, combined GDP of the world's nations can't sustain the vehicle use unless vehicles get more efficient and get cheaper. And that's clear.

02:16:42;02 And the North American markets, which have been the practice markets for new technologies may not be the practice markets anymore. People may just practice in the final and the biggest markets in Asia. So you'll definitely see smaller cars. You'll definitely see more efficient cars. You'll continue to see cars with IC engines on them, because that has a lot of inertia. And there's a lot of infrastructure behind that and that doesn't change overnight.

02:17:08;11 You'll see a lot more battery electric cars. Within ten years, I think some market forecasts have been, you know, as high as a quarter to a third of the portfolio that's at least mildly hybrid. I think that's probably right. Because battery technologies and controls technologies have gotten cheap and good enough so that you can hybridize a lot of existing vehicles already.

02:17:30;24 Also, lightweighting is gonna be important in that. Whether you'll see a huge percentage of electric vehicles, I doubt that in ten years. It would require not only leaps in technology, which we hope to be a part of, but also really dramatic policy changes. And I don't know what the tolerance of that is.

02:17:52;18 For example, a gas tax would change things very dramatically. Has in Europe and other countries. But Americans are very loathe to pay a higher gas tax. My hope is that a case can be made to tying the taxes that we pay propulsion technologies to the consequences and the infrastructure. So, I mentioned before the high cost of our petroleum infrastructure. It would be nice to see a logical tying of that to a gas tax, to a petroleum tax, etcetera. But that's about the only thing, I think, that would change it so dramatically.

BARRY HURD:

02:18:29;28 And so what do you see? Do you see yourself becoming this huge company or a smaller supplier? And what's sort of your guided innovative dream of how you're gonna change the world?

ANN MARIE SASTRY:

02:18:41;02 Well, we wanna put solid-state batteries into cars. We think that is inevitable. We're racing to be the company that does it. We may be unsuccessful, maybe successful, I don't know. If we're, you know, there are lots of models. We like, you know, all companies, go through this thought process, right, "Would we grow ourselves? Would we license to partners?"

02:19:10;07 I would say this. The model we pick will be the model for greatest impact. You know, if we can have greater impact by licensing in certain markets or opening subsidiaries in certain markets, that's what we'll do. And I think, you know, it's very, very hard to predict. I wouldn't even speculate. But what I will say is that we're very focused on getting the technology right to the point where it could address the market.

BARRY HURD:

02:19:35;07 So it is really the Holy Grail this energy density, smaller...

ANN MARIE SASTRY:

02:19:37;23 Yeah.

BARRY HURD:

02:19:38;00 ...more power? When you said we haven't reached the theoretical limits, is there, must be a great potential there. There must be a long range that you can...

ANN MARIE SASTRY:

02:19:44;18 There is...

BARRY HURD:

02:19:44;25 ...kind of...

ANN MARIE SASTRY:

02:19:45;10 There is. And you know, what I'm saying, you know, sounds like, "Oh, this is straightforward, this is obvious." But it's amazing sometimes in technology that people don't work on the obvious problems. It's also amazing how often the practical problems drive the science advances.

02:20:05;01 It's a little known fact that Marie Curie was the first really, to execute practical X-rays. She trained her daughter Eve to go out in the field and X-ray soldiers' bones so that they could be set and that so bullets could be removed during the war, when she couldn't return to her beloved Poland. And she, you know, one of history's storied nuclear scientists was going around and renovated army trucks with X-ray equipment. And it's true.

02:20:37;27 Now, it's a great use of her nuclear scientist credentials, actually. And when she returned to the lab, she recommenced innovation at the basic science level as well. But my point there is that the practical problems can often transcribe what the theoretical problems are and vice-versa.

02:20:59;14 And I think it's a mistake to think about these things as completely separate. Alright. When you're mapping the design space, when you're really trying to guide your own innovation. A lotta the things that we choose to work on in science, we choose to work on because they're incredibly practical problems.

BARRY HURD:

02:21:15;23 So theoretically, what you're saying is, you're trying to electrify the drivetrain, but all these other things might happen...

ANN MARIE SASTRY:

02:21:20;24 Yeah...

BARRY HURD:

02:21:21;02 ...as well.

ANN MARIE SASTRY:

02:21:21;25 ...yeah. I mean...

BARRY HURD:

02:21:22;19 Like what?

ANN MARIE SASTRY:

02:21:23;18 Well capacitors get really good. You know, someone could come along and build the world's greatest capacitor and, you know, basically snuff the battery industry. And that's okay. And...

BARRY HURD:

02:21:34;08 So explain...

ANN MARIE SASTRY:

02:21:34;12 ...then, you know...

BARRY HURD:

02:21:34;19 ...about that. It's like a super capacitor, right?

ANN MARIE SASTRY:

02:21:36;13 Yeah.

BARRY HURD:

02:21:36;25 It holds the charge and...

ANN MARIE SASTRY:

02:21:38;11 Well, so lemme talk about the different technologies, right. When a lotta people are working on bio-fuels, which is growing plants that can be used to make fuels that fuel IC engines. And those IC engines would be less emissive. And you could grow fuel rather than dig it outta the ground. And it might even be carbon neutral, because the plants take in carbon dioxide from the atmosphere and push out oxygen. So that looks like a reasonable system to look at.

02:22:05;15 Other people like me are working on battery technologies, which is using metals and ceramics to store ions and generate electrons to drive an electric-mechanical load. Others are, continue to work on petroleum technologies for IC engines, including diesel technologies and even bio-diesel, which is a diesel fuel made out of biological, by plants. Still others are working on capacitors, which is a way of charge, of storing electrons in a dielectric so that they can be used to drive an electric mechanical load. And that's actually a high power system often. But those materials right now are very expensive.

02:22:43;01 Fuel cells ,you've heard of, are really a single electro battery. And they have as their emission only water. So there are a lot of technologies that could potentially come onto the drivetrain. They're not only racing internally within those communities to build the best technologies, but also among. And that's a little bit harder to see.

02:23:04;01 I mean, you can map pretty well what's happening in your immediate area. You can know who your competitors are and what the competitive ideas are within, you know, a group pretty well. It's very difficult to know what's happening in another axis, right? In another line of approach. I hope they're working as hard as they can. It'll make us run faster.

02:23:28;25 But there's really no way of knowing. And I think it, you know, it's my academic training makes me very skeptical of people who would say, "Oh, well, it's absolutely gonna be this," or, "It's absolutely gonna be that." It's very hard to say.

BARRY HURD:

02:23:44;09 One thing that I came across, it said you study the energy systems in living organisms?

ANN MARIE SASTRY:

02:23:48;15 Yes.

BARRY HURD:

02:23:48;23 And try to apply those to battery technology? Is, what's, how does that work, if you were trying to explain that to a class a kids or something? What's that all about?

ANN MARIE SASTRY:

02:23:59;05 One of the things that we looked at early on in microelectronic devices was the potential of using different energy sources in the same system to create a more efficient system. And so a couple of graduate students and I had looked at a couple systems where it's like, "Okay, well, instead of using one battery that has maybe really good power but doesn't last very long, maybe we can use several batteries where one has really good energy characteristics, it lasts a long time, but you can't discharge it very fast so it doesn't give high power. And then for power spikes," like this system happened to be experiencing "we can use a different battery technology. And if we can figure out how to control this system, we can actually solve the problem with a hybrid solution rather than a single solution."

02:24:42;11 So systems thinking is often very helpful in complicated engineering systems like power systems. The grid technologies that you're seeing coming online now are absolutely exemplars of that. When you think about, okay, well, wind that is, you know, a very powerful technology, but it's not very energy dense. A coal plant, even though you may not wanna use it, is pretty energy dense.

02:25:06;27 And maybe you could use a solar installation which has, you know, maybe low overall energy but it gives you a base load of power or base load of energy. So maybe if I combine those elements and I get smart about how I combine them, I actually don't have to innovate in one technology area and live with all of its limits. Maybe I can get the advantages of all of the technology areas.

02:25:28;19 So in the batteries that we work on, we think about that very carefully. You know, "How can I combine technologies in a way that, you know, doesn't take us outta the box in terms of physics?" One of the things that you have to differentiate is whether or not the problem you've selected is a physics or chemistry problem or whether it's an engineering problem. And one of the things that I find very heartening right now in batteries is this thing I mentioned is the element that I mentioned, which is the theoretical capacities are actually still substantially higher than the actual capacities we're getting.

02:26:01;05 So there are no physical reasons, no chemical reasons, you know, no laws of physics saying that we can't get there. What we need is good engineering. What we need is to figure out how to entrain electrons and ions in materials that are cheap enough and good enough and last long enough so that we can achieve closer to those theoretical values.

02:26:23;28 And, you know, there's risk. There's always risk that you won't find a manufacturing technique or you won't be able to make material thick or thin enough or that for some reason of engineering practicality, you can't scale it, that you can execute it in a little device but you can't make it really big. So there are always things like that that happen. But those are engineering risks rather than, you know, physics risks at this point.

BARRY HURD:

02:26:48;19 Tell me a little about, we're here in Ann Arbor, University of Michigan. How does, how's the university what role do they play in what you do? I mean, you teach there, but you got a private company, I assume. But do they help incubate the idea? Are they part of it? And, I mean, what's that whole process...

ANN MARIE SASTRY:

02:27:01;17 Yeah. The university was extremely helpful when we spun the company out. I think universities are starting to view commercialization of technology as part of their role as a public good. And so, our university has been very clear that part of its mission as a public good is to make sure that the technologies, the inventions that we work on at the university make it into the marketplace and change people's lives.

02:27:27;03 And we have an Office of Technology Transfer that was incredibly helpful when we decided to start a company. Ken Nisbet is the director of that office. And we sat down with the university attorneys and worked out an agreement. The university has a small stake in the company and, you know, was incredibly helpful in connecting us with business people, attorneys and so forth.

02:27:51;22 I think what is important to understand is that a good relationship between a university and its spinouts is absolutely essential. It's essential to ensuring that more spinouts get out. And it's also absolutely essential to recognize the fact that universities were the origin of a lot of invention and really housed all the innovators and innovations in their earliest days. And so you know, I've been asked the question, "Oh, well, do you have to pay the university," or this, that or the other just presuming there's some resentment there now.

02:28:24;09 I mean, I'm very grateful that the university, you know, housed all of our research for many years, helped us get smarter about the technology we're working on and then, you know, helped us segue part of that effort into a commercial effort. So this is normal.

BARRY HURD:

02:28:39;28 How much competition is there in this battery business, I mean, with what you're doing? There's...

ANN MARIE SASTRY:

02:28:43;06 Oh, lots. It's marvelous. Yeah. Lots and lots of competition. Lots and lots of people starting battery companies every day. It's marvelous. Yeah.

BARRY HURD:

02:28:49;24 And is there any, are these breakthroughs and the innovations, like shared? Or is it so commercially potentially great that people don't wanna share their ideas? Or is there, there's this idea we have that the scientists all share their...

ANN MARIE SASTRY:

02:29:01;10 Yeah.

BARRY HURD:

02:29:01;15 ...ideas. Is it, is that...

ANN MARIE SASTRY:

02:29:02;29 No.

BARRY HURD:

02:29:03;06 ...what.

ANN MARIE SASTRY:

02:29:03;08 Scientists are human, too. And, you know, so there are parts of things that people share when it's prudent to do so. So, a problem that someone is having with their technology that they're pretty sure everybody else is having, they might share that in order to get people talking to share a solution.

02:29:21;17 I would say my experience is that scientists and technologists, in general, are much more collaborative. You know, what we like to do is solve problems. And solving problems is faster in teams of smart people. And so whenever you get a group of engineers together they wind up talking about common issues and solving problems. I mean, it's just, you know, part of the DNA, if ya like. That said, of course, there are things everybody's holding back about their technologies. And they should.

02:29:52;17 You know, there have to be some rules in innovation in the marketplace, otherwise nobody's gonna do it. I mean, if every time you invent something, you get your lunch money stolen and you can't, you get so you can make the device and it can't be profitable, then who's gonna do it, right? So there are rules about, you know, intellectual property. There are rules about patents. And different countries have different rules. And, you know, they have to be followed.

BARRY HURD:

02:30:17;23 Is this battery cap...

ANN MARIE SASTRY:

03:00:42;04 I guess, I mean, you know, people can run their lives however they want. I mean, if you decide that you want to be, you know super cutthroat, and, you know, use shark practices, and so forth, you can do that in any field you want to. But...

BARRY HURD:

03:00:51;03 Right. Well, that's what I mean. It's not just engineers. It's...

ANN MARIE SASTRY:

03:00:53;09 But yeah. But I would say, you know, my experience is by and large engineering has less of that. And technology fields have less of that.

BARRY HURD:

03:01:01;25 You know, speaking about the competition, I think what I was going to ask you and then, I got a few follow-ups from outside, was is this battery industry, I mean, it's developed. And you see it as it'll be shared around the world? Or will there be a source, where it'll be Asia will be the battery makers? Or the US? Or it'll be, you know, like we tend to sort of think of industries gathering in one place. What's your thought on that?

ANN MARIE SASTRY:

03:01:20;18 Oh, we don't share anything. We compete for every last point of market share globally, both within markets and, you know, in other countries markets, et cetera. And I think one of the things that is very interesting in the present era is that it's hard to differentiate the markets based on national origin.

03:01:41;09 When you look at engineered products now, the teams that build them are truly global. And the supply chain is, you know, this is not the era of the Rouge, right? It, you know, for the Ford focus here. I mean, this is not the era of vertical integration. This is the era of horizontal integration.

03:02:02;09 And that's also true in markets, and who forms flash mobs to go in and form teams to go and create products that address those markets. And there's a lot, there's a great deal of advantage in heterogeneity. And one you know, one of the things I love about my country, about our country is the heterogeneity.

03:02:21;02 You know, people come from all over. And they have that sort of daring-do. And they plant feet here. And they`, "America is the club you can join," is what I like to say. And that's also true in forming technical teams. Heterogeneity is very good and very powerful.

03:02:38;02 So although every country, for its own economic health, has to have a clean energy sector there's no doubt about that, right, there's no doubt that governments will require, that the collective will require, that clean energies form the basis of our power technologies for our energy technologies. It's also true that in order to compete economically, nations will have to make investments.

01:03:05;10 So that not only they're making the right technologies, but also that they have the economic market share to be competitive. It's going to be very difficult for countries that predicate their economy on emissive technologies, on polluting technologies. It's going to be very difficult for them to compete.

BARRY HURD:

03:03:20;00 Do you think there's still something about America and the American character experience that gives us an edge in innovation?

ANN MARIE SASTRY:

03:03:25;20 Oh, yes.

BARRY HURD:

03:03:26;10 Tell me about that.

ANN MARIE SASTRY:

03:03:27;07 Well I have the privilege of working with people from all over the planet. And they come here, people come here from all over the planet because they like how we live. They like the rules. The rules are you get to do pretty much whatever you want. Right? It's America. Right?

03:03:45;17 So you're allowed to fail. Actually, failure is often a badge of honor. If you look at the histories of great innovators, they're often pockmarked with failure. That's often a point of pride. In this country, coming from humble beginnings or inauspicious beginnings, or you know, puzzling beginnings based on where you wind up, this is a badge of honor in this country.

03:04:13;00 There are no social strata. There are no presumptions. There's no expectation that you should stay in your box or your bin or your stratum. In fact, it's a point of pride for people to that delta, that gap of where you start and where you wind up.

03:04:28;07 And it really doesn't matter whether you got your degrees, whether you read physics at Oxford or whether you got your technical degree from DeVrys, if you wind up a billionaire because you make a product that everybody wants. In this country, that's what's valued. And so I think that's very heartening for people from all over the planet. They sort of look at people in America, and they say, "Well, you know, you can do anything in that country." Very improbable people have done very improbable things in America. And so, what it does is it attracts that person and those people who have that ambition and daring-do, and, really, a desire to change things. So absolutely, I think we're advantaged.

BARRY HURD:

03:05:07;20 Do you think that's a message maybe that we should get out to our young people more as they're coming up, to inspire them? I mean, how would you inspire if you were trying to inspire people? And, you know, think about it. That what words would you say to them about how there's no rules here; you can do what you want; you'll be honored if you achieve.

ANN MARIE SASTRY:

03:05:22;09 I think you just said it very well, Barry.

ANN MARIE SASTRY:

03:05:31;07 "You get to do whatever you want, kid." You know, it's like, you know, that's like, don't say that at my house please.

BARRY HURD:

03:05:40;08 I mean, if you tried, that's such an inspirational message. I mean, do you sort of try to inspire your students with that?

ANN MARIE SASTRY:

03:05:44;22 Well, sure. I mean, you know, it's like, if you want to go into a technology area, you know, sort of, metaphorically, guns blazing, and really make change, boy, arming yourself with math and physics is a really good way to go. All right? Arming yourself with a very good understanding with a very good science background, with a very good mathematics background, with strong engineering skills, those skills give you a platform to do really interesting things with your career.

03:06:17;24 And teaching, you know, telling young people about what you can do if you continue your education in these areas, about the power that that affords you to create change and create new processes and products to change people's life, I think that's very important, you know.

BARRY HURD:

03:06:34;13 So the rewards of understanding math and science go beyond just money?

ANN MARIE SASTRY:

03:06:39;02 Oh, yeah. And you know it's certainly true that people who are technologists can earn a good living. There's no question about that. But that is part and parcel of creating change. If you're doing something which profoundly changes people's lives, which change what they buy, which change what they have access to, which really change what people, how they live, you're bound to economically do well. But the key thing is to focus on the problems that matter to people. And all that other stuff will follow.

BARRY HURD:

03:07:18;00 So if we were telling some people, you know, the wisdom of what they should be really looking for in their career, I mean, what will you tell them?

ANN MARIE SASTRY:

03:07:27;02 Well, you know, I talk to a lot of students and younger colleagues who, very passionately want to work in clean energy technologies and want to make change and so forth. And a lot of young people have the notion of if government only understood what the needs were, if the average, you know, person walking around only understood how important efficiency is, if people really only understood climate change, then that would create change.

03:07:54;17 I'm, and I actually don't believe that. I think what creates change is people executing technologies and policies that make change. And so, it's one thing to sort of say, "Well, if I were at a job where I could, you know, put people together," and sort of have a nebulous idea of, you know, "If I could just tell people or put people together, or create an organization or a non-profit or something..."

03:08:16;25 You know, you actually have to have the product there. At the end of the day, there actually has to be a device there that allows people to live differently than they did before. And, of course, you'll need people around that device to market it, to sell it, to create policy that allows it to get to the marketplace.

03:08:32;05 But you need to build it. And the people who build it are the people who are able to complete their education and complete their training and arm themselves with the right tools to build it. And then, also develop the people skills to develop the right teams to build it. So those are important elements. And that's what I try to convey.

BARRY HURD:

03:08:52;21 Let me jump back. We were talking about how the university supports, they're almost an incubator of innovation. Then a small company starts; maybe it grows big; government's involved. But the public doesn't seem to know about these things for a long time. It's like hard to get the word out. Do you think it would be better overall if the public was more involved and they knew what you guys were doing here? Would that help in any way? Or?

ANN MARIE SASTRY:

03:09:13;13 I don't know. I mean, I don't know how much the public wants to know about, you know, how hard people are working at their own companies and so forth. I think what the public really wants is better products. And clean energy. And good regulation. And livable cities.

03:09:35;10 And so the details of what company is doing what or what university is spinning out what are probably less important than the cumulative totals that can, you know, be aggregated and conveyed. Universities are absolutely an economic engine. And they're absolutely innovative engines.

03:09:58;14 But it's not obvious to me whether it's best to tell the story in the smaller settings or whether it's to tell them in aggregate. As an engineer, I sort of like to look at the aggregate data and say, "Okay, well, if I sort of look at the macroeconomics of the X billion dollars put into research universities and the product of that, and then I'm convinced that there's a story about value there. There's a story about, you know, numbers of patents and numbers of companies, and new products, and so forth. But for other people, maybe it helps to hear the individual stories. I don't know.

BARRY HURD:

03:10:31;23 Well, let me ask you this. I mean, this is one of those tricky questions we always ask. It's about you don't normally don't think of women being in engineering jobs that much. And I know you've been asked this a hundred times. Give me a little riffing on that. What's your opinion? That it's like a non-question nowadays? Is it still important? Is it, they said, well, in school, you know, that still the boys are favored in math and science and the girls aren't encouraged. What's your whole sense of that whole situation?

ANN MARIE SASTRY:

03:10:55;04 Engineering's gotta get more diverse. All disciplines have to get, we need all the talented people we can get. And my feeling about that is that you need people from all economic walks of life. You need both genders. You need all races, whatever that means anymore. Engineering's gotta get a whole lot more diverse.

03:11:15;16 And the reason is really simple. The reason that, I think, our nation is really good at producing innovators and innovations is because we get the whole audience here. We have this tendency to be able to attract people from all over planet earth. We can engage anybody from any socioeconomic level, from any walk of life. That's totally normal in our country.

03:11:42;07 And so, what it means is that our teams, when we decide to look at something, whatever the domain is, whether it's entertainment, whether it's engineering, whether it's policy, tend to be very heterogeneous. We tend to bring in a lot of viewpoints. That makes for better solutions. And so, that clearly, in technology, it's very important to have a lot of different voices.

03:12:05;11 One of the key reasons for that is because some of the technology problems that we need to solve are up and down the socioeconomic scale, involve both genders, involve a lot of races, whatever that is, involve a lot of countries. And so, having heterogeneous teams to pose the problem is probably about half the work. Once you pose the problem about right, then you can start to execute. But it's a real mistake to talk yourself out of inclusion of any group.

BARRY HURD:

03:12:30;23 So, like the scales of justice, innovation should be blind, and we'd be better off, eh?

ANN MARIE SASTRY:

03:12:34;25 I think sometimes you have to make a decision that you're going to create an environment where you bring improbable people in. In some ways, that's the American value proposition. And we love the Horatio Alger story. We love the improbable person becoming very successful. Actually, that's a conserve story that's treasured. And so you know, in technology we need to do the same thing.

BARRY HURD:

03:13:00;18 I have a final, I think, a final question for you that somebody gave me a little earlier today. And I'm really interested in this answer. What do you want people to say about you at your retirement dinner?

ANN MARIE SASTRY:

03:13:08;20 Oh I'm, I don't know that I'm going to retire.

BARRY HURD:

03:13:14;23 Oh, you're not allowed to answer.

ANN MARIE SASTRY:

03:13:15;20 I'm having too much fun. It's...

BARRY HURD:

03:13:16;21 No, you must answer the question. It's your question.

ANN MARIE SASTRY:

03:13:21;18 I don't know. I really haven't thought about retiring to be honest. Nobody's ever turned my question around on me before. But I, that's a first. I have a hard time thinking about myself retiring. I got the advice early on in my career that, you know, it's kind of an old saw "If you love what you do, you never work a day in your life."

03:13:43;09 And that's more or less how I feel. So to the thought of somebody throwing a dinner which says I have to stop working is pretty horrifying to me, actually. So I guess, "Okay, after this dinner, Sastry, you're out." I'd say, "Well, wait a second. You're gonna take away my key?" I mean, you know, that sounds, that's pretty horrifying to me.

BARRY HURD:

03:13:58;03 But, I mean, don't you hope that, you know, whenever you let's say, and let's say you don't retire, but you just take a vacation that they'll say you did something? I mean, are you looking for any kind of, you know, there's some pride in something? Or is it, I mean, I know it's a tough question.

ANN MARIE SASTRY:

03:14:11;00 Well, I feel a lot of pride in my students and people I've mentored. When, because it means that something we've done has some legs. It has some permanence. You've changed somebody's life. They're going to execute. There's a smart person out there that not only is going to carry on what you might have done together, but also think of 100 new things and impact hundreds of lives after that interaction has quelled.

03:14:39;15 And so I take a lot of pride in that. I take a lot of pride in individual experiments and things that work. It's really cool when a code is working, or when an experiment starts to work, or when you were right about something. Also, really cool when you were spectacularly wrong, but you put together a team of people where somebody in the room is right.

03:14:59;03 So there are a lot of times when a group of us are working together and one person has sort of thrown the problem on the table and said, "I think this is gonna happen," and that person is so wrong. And that's very good. Because there are enough, you know, bright people there to work through it. So building teams, people that I've mentored, and you know, absolutely getting things working, those are those are things I take a lot of pride in.

ANN MARIE SASTRY:

We do scanning electron microscopy and tunneling electron microscopy to understand how these particles are put together. And then we make samples that we put under an atomic force microscope to understand what the three-dimensional morphology is.

And then we make batteries out of them so that when we discharge the batteries and see how the batteries behave, we can take that all the way back to what kind of crystal structure produced what kind of behavior. And then when we can make those correlations, we can create simulations which take the parameters that we generate about these batteries' materials, like, you know, what was the size of the crystal, what was the surface area, what was its composition. And then we use the models to link these two things, to link how the batteries behave to what the material was made out of. Does that make sense, what I just said?

BARRY HURD:

To you it does.

ANN MARIE SASTRY:

Sorry. I'll try harder. See, these are close-up pictures of some battery materials. And the people in this laboratory, the graduate students and the post-docs and the faculty members and the engineers who work here at the center, work on all of these different scales.

So we have some people who specialize in what the, understanding what the materials are made out of, some other people who specialize in understanding how the materials change as they're discharged in batteries over time, other people who develop simulations technologies to model what happens to batteries' materials as the batteries charge and discharge.

And all of those teams work together to try to develop improvements in battery technology so we can get 'em into vehicles and they'll last longer and most importantly, get them into lots of different kinds of vehicles, so lots of people can have an electric vehicle.

I think you know, it's interesting from, you know, this being a Henry Ford project, that, you know, Henry Ford is credited with democratization of the automobile. And what we think we're working on is democratization of the electric vehicle, right?

ANN MARIE SASTRY:

So Henry Ford is really credited with democratization of the automobile. And what our team would like to see is democratization of the electric vehicle. And that requires some technology solutions, just like democratization of the car did.

In order to make the technology accessible to a lot of people in a lot of markets, you have to make it good enough and cheap enough so lots of people can buy it. It's really simple. And the reason that people are so competitive in this space is because you want to be able to make technologies that are low-cost and very profitable so that they'll be sustained, so that markets will pick them and people won't pick emissive technologies. They'll pick electric vehicles. And that's really important.

So although demonstrations are nice and science is great and it's great to write papers and about specific elements we're taking a team approach here because we really wanna put the pieces together so that, when we get performance out as an output in our models, we feed that back to the very fundamental scales of, "What did we make that out of and did that work well?" And it takes people of a lot of different expertise working together to do that.

BARRY HURD:

So tell what this machinery we're looking at, what happens here?

ANN MARIE SASTRY:

This is what they say, this is where the magic happens, right? This is a drive glove box. And it's in an inert environment. This is actually filled with argon, which is a noble gas. And it doesn't react with the materials inside the glove box. So you don't have to worry about materials getting oxidized as you're working on them. This is also a glove box over here. And inside of this instrument is an atomic force microscope that we use to look at, we use to look at structural changes in materials, okay.

ANN MARIE SASTRY:

We use to look at structural changes in materials as they're being discharged. And so, you know, again, the idea is to really understand what's happening at a very fundamental scale to materials and feed that all the way up to how the vehicle behaves. And, as you can imagine, there are lots of steps in the technologies and a lot of different pieces of expertise that have to come together for that.

You know, the people who know a lot about how materials are made and how they change is not the same group of people, necessarily, that knows how to do vehicle controls or how to integrate technologies into vehicles. And that, again, is a different group than the group of people who know a lot about how to simulate batteries and how to use lots of equations put together to describe the multiple elements of physics that go into making a battery work.

BARRY HURD:

How important is, commercially, getting it where you can get those ions to get back to that cathode so it recharges fast? Is that like one of the holy grails of...

ANN MARIE SASTRY:

That is absolutely critical, getting what we call cycle life out of a battery is very, very important. And, again what we'd like to see, what a lot of us in the industry would like to see and in academics would like to see is very long cycle life so that we can get to those markets where people don't have dense dealer networks and we don't have to build that infrastructure in order to get them to buy electric vehicles.

I like to give this example of cell phone usage in the Dominican Republic, which exceeded American cell phone usage on a per capita basis for a brief period of time. And the reason is, they skipped land lines. They just skipped it. They just said, "You know, I don't think we actually need that infrastructure. I think we can talk to each other without land lines, because we've got really good, cheap cell phones." Well, it would be great to have really great, long-lived batteries so we can skip a very dense service network that's an infrastructure barrier to seeing people buy electric vehicles. And of course...

BARRY HURD:

So we'd never build super-charging electrical stations is what you're saying, right?

ANN MARIE SASTRY:

That may be part of the answer. I don't know. But as much of the infrastructure as you can skip by making better batteries and better technologies, the likelier it is that people buy EVs. And so the easier you make it, by making the technology better, the likelier it is that people will pick your technology. So that's why we're runnin' so fast.

BARRY HURD:

How much is the oil industry fighting you battery people?

ANN MARIE SASTRY:

I don't know. You know, I don't hang with those guys. I don't know what they're doin'. I suppose, you know...

BARRY HURD:

They're very powerful here.

ANN MARIE SASTRY:

So I've heard tell. I think that every industry that's been around for a long time has the benefit of an infrastructure that supports it. The oil infrastructure is prodigious. All nations on planet earth pay an enormous amount of money to sustain the oil infrastructure.

I think it's time that, as we look at climate change, as we look at livability in mega-cities, as we look at the profound changes in consumption of energy as people in Asia and the emerging economies enter the middle class, we gotta rethink that infrastructure. We gotta think whether, "Okay, is this really sustainable?" And it's not. And it requires us to think about different tax structures and policy structures and ways of penalizing pollutants and so forth. But that's totally normal.

I mean, human history, I mean, the history of technology, really, is filled with examples of how we made mistakes on the way to technologies and how we had unintended consequences of the technologies that we developed. That's totally normal. Part of the fix is different technology. But part of the fix that also must be acknowledged is different policy as well.

BARRY HURD:

You know, I was gonna ask, I don't know if this has anything to do with the interview, when you say solid-state, your electrolyte, it's not a liquid or a paste, it's actually solid?

ANN MARIE SASTRY:

Yes.

BARRY HURD:

And that's one of the big things that makes that...

ANN MARIE SASTRY:

Differentiated.

BARRY HURD:

That differentia...

ANN MARIE SASTRY:

Yes.

BARRY HURD:

My research, I was a little, not sure what that was all about.