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ENERGY COMMISSION

ENERGY RESEARCH AND DEVELOPMENT DIVISION

TRANSCRIPTION OF RECORDED PUBLIC MEETING

OCTOBER 25, 2018

SACRAMENTO, CALIFORNIA

Present: RIZALDO ALDAS, California Energy Commission

SILVIA PALMA-ROJAS, California Energy Commission

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TRANSCRIBED RECORDED PUBLIC MEETING

October 25, 2018

MR. ALDAS: All right. Good afternoon, everyone. I think we're ready to start. Thank you all for coming, and welcome to our workshop. This is called the Next-Generation Wind Energy Technologies and their Environmental Implications.

My name is Rizaldo Aldas. I am the program manager for the Renewable Energy and Advanced Generation Research here at the Energy Commission.

Before we move forward, I would like to mention a few housekeeping items, especially for our participants who are here in the room right now. First of all, our facilities, if anybody will need to use the bathroom, we have one out this door. You go out of the glass door and to your right. And there's another one to the left. There are filtered drinking fountains along that side, both sides of the building if you need to get water.

Emergency exits are located outside this door, both to the right and the main door where you came in. There's another door at the back of the room over here that we can also use.

Now, in case of emergency, you will hear a really loud sound. It's annoying. It'll ask you to go out of the building. And I will ask everyone to move out of the building, follow the staff. Our convening area is across the street in a park. So hopefully that will not happen today during our workshop, right?

And lastly, we do have a sign-in sheet by the door. If you didn't sign in, I'll ask you to sign in, your name. And there are a couple of brochures out there, agenda and the workshop notice, if you would like to get some.

All right, with that, before I proceed I would like to mention a few words just to kind of preview a little bit our workshop this afternoon. So we know that the state had a good wind energy resources, and at the same time we also have high renewable goals.

At the moment, they estimate about thirty-two percent of our energy's coming from renewable resources. And wind energy is contributing about thirty percent of that in terms of the capacity and thirty-one percent in terms of energy generation. That's in megawatt hour.

And recently we know that our goal is to increase to one hundred percent clean energy and one hundred percent carbon neutrality by 2045, right? So wind energy, in my view, will play an important role in achieving those goals. And we'd like to ensure that wind energy will continue to play that critical role.

Now, one of the questions that -- have we maxed out our wind energy resources? Is there room for further development for increasing our capacity? There are estimates that there's the potential. They lack about 24,700 square miles with 120 gigawatt of wind energy. We have advanced technologies like taller tower, longer blades.

So in order to realize that potential and harness those resources, we will need technological advances, manufacturing innovations over what we currently have.

And so we organized this workshop to contribute to that discussion. You will see that we have a lot of questions. We're hoping to get feedback from our experts, analysts, stakeholders, basically from everyone. Questions like do we really need to go forward with those strategies. Is it feasible to construct tall tower in California and those kind of questions. So it will be important for us to hear those feedback from you.

And then there is the offshore wind energy resources. There's an estimated potential of 159 gigawatt from our offshore wind energy resources. It's something emerging in California. There's a lot of work that's going on in the East Coast and other countries.

But recently -- you may know -- there's also a lot of work that has been going on in California, too, so -- and we will hear some of those during our afternoon panel. And we would like to use this workshop to contribute to those discussions.

So lastly, instrumentation, monitoring systems on environmental (indiscernible) responses technology performance. We view that as a kind of -- will help improve the efficiency, cost competiveness of wind farms. And so we would also like to get feedback from our experts and from everyone on that area.

All right. And so with that, let me move forward with the next slide. Just to give you an overview what's going to be discussed this afternoon, my colleague here, Silvia, will provide an overview of the research initiative that we have under the 2018-2020 EPIC Investment Plan.

That will be followed by a presentation from Mike Derby. Thank you so much for coming here and being available to share with us the research and development efforts going on on wind energy technologies at the Department of Energy. We are looking forward to that.

And then we will have a panel discussion on research needs and opportunities for next-generation wind energy technologies. We are fortunate to have four experts here from the industry and academe, and they will be sharing with us their thoughts or insight on this topic.

And then after this panel, actually, we will open it to a short public comments. We'll encourage everyone that have comments to be specific to that particular panel only. But if there will be general comments, we will have opportunity for that after the second panel.

So the second panel will be on the risk to sensitive species and habitats from offshore wind energy projects in California. So that's where we will have a lot of discussion on the offshore wind.

So after that we'll open it again for public comments. We will ask folks who will be providing comments to limit their comment to three minutes. The first set of comments should be directed towards the immediate panel, and then afterwards we will open for any general comments.

All right. So just a few more additional housekeeping notes. First of all, I'd like to use this opportunity to thank everyone who have already submitted their comments through our docket. We received those. And we will also thank everyone who will be providing their comments today.

And I would like to inform everyone that this is being recorded via Webex, and the presentations will be available after the workshop. And so with that, I would like to call my colleague, Dr. Silvia Rojas to start her presentation. Thank you.

MS. PALMA-ROJAS: Thank you, Rizaldo. And good afternoon, everyone. And we are very happy to have you here in via Webex for all the participants that are in Webex.

And just to mention -- like, just to repeat what Rizaldo said previously, this workshop is to gather information and feedback from the stakeholders, the experts about the challenges associated with the next-generation wind energy technologies real-time monitoring system for proactive maintenance in offshore and land-based wind energy projects and research gaps. It's a way they monitor environmental responses of offshore wind energy projects in California.

Before moving to the expert presentations and the panel discussion, I would like to give an overview about our Electric Program Investment Charge, known as the EPIC program, just so everybody has the same level of understanding.

So our EPIC program aims to benefit direct payers of the three largest electric investor utilities and by funding clean energy technologies projects that promote greater electricity availability, lower cost, and increased safety. And also EPIC encourages technological advancements and breakthroughs to overcome the (indiscernible) that prevent the achievement of the state statutory energy goals.

In our previous investment plans, our EPIC program also funded some projects, and all of them were addressing -- they all are addressing because they're still active, some of them -- some of the challenges that we identified in the following initiative.

The first one was more related to wind energy forecasting. And the other initiative was related to recovering wind energy.

Okay. So this is some of our projects in our current wind portfolio. So we have one project that is with UC Davis that is in the purple. We titled it Powering Wind Energies.

So we are trying with that project to develop inexpensive standardized turbine upgrades that will allow legacy turbines to behave more similarly to modern turbines, but these patches aren't enough when is unofficial.

The project doing right now is installing the (indiscernible) power in eight turbines. And also the project team is collecting data from the hardware.

And also we have some projects that work in the wind energy impact on wildlife, such as birds and bats. And also we have a project with RCAM Technologies that works on tall wind towers built onsite. And that project aims to develop -- demonstrate -- it says a 3-D concrete printed technology for building low-cost tall wind turbine towers.

So right now the project team is working on the structural performance characteristics for a baseline concrete fabrication process, and continue improving the principal concrete at this time.

And also, like I mentioned before, we have an initiative focus on forecasting wind energy. So we have also another project with UC Davis that was working in improving a currency of production offshore wind ramp.

Our EPIC (indiscernible) environment plan was approved last year in 2017, and we have two initiatives under the same developed technologies that enable increased wind capacity in California.

And that team we have two initiatives, like I mentioned before. One is the advancement of manufacturing install approach for 3D -scaling-based wind turbine components. And they are trying to address the challenges of larger and taller wind turbines.

And the other one is a real-time remote monitoring system for offshore and land-based wind technologies. And we try to address with that initiative the development of system for proactive maintenance in wind energy projects.

So for our first panel we prepared a set of questions that we will try to bring the discussion on onsite manufacturing of hybrid solution for wind energy and try to understand the challenges that California has to develop this type of approach, and of course the research needs to overcome those challenges. Also we have a couple of questions more related to the area of material finds, where we also are going to discuss the lifecycle aspects of those new approaches.

And also the last question is more related to the monitoring systems for offshore and land-based wind energy projects. And also we are going to have a discussion on the future development and implementation of offshore wind energy in California.

Like Rizaldo mentioned, we are going to receive comments related to these questions. And also I have some questions that I call the key questions, that also if you can provide feedback. And those ones will help us to understand better the context of taller and larger wind turbines.

And I'll just do three of the questions. They are like what is the current state of next-generation wind energy technologies and real-time monitoring systems in terms of benchmark performance, cost, and technical characteristics? What are the costs and technical targets that need to be met to drive adoption of the targeted technologies? Aside from cost, what new features and capabilities are needed to improve the valued proposition of next-generation wind energy technologies and real-time monitoring systems?

So like Rizaldo mentioned, we are going to keep mention that we are going to receive comments until this November 1st, 2018. And if you can comment for the questions that we include in the panel, also the key questions, would be great to have your feedback.

Now I'm pleased to introduce the next speaker, Michael Derby. Michael Derby is the head of the Research, Development, Demonstration, and Testing for the Wind Energy Technologies Office in the Office of Energy Efficiency and Renewal Energy in the U.S. Department of Energy.

Michael leads the offshore land-based and distributed wind (indiscernible) portfolio and DOE. Directing research in the national laboratories to address critical technological (indiscernible) to wind plant performance reliability and maintenance. Mr. Derby has been with the Department of Energy since 2009. Yeah.

Just to mention that the Energy Commission always wants to ensure that our initiatives are not duplicating DOE efforts, but leveraging them. Now the floor is yours. Thank you.

MR. DERBY: Thank you, Silvia. And I want to thank you for inviting me to speak today. I'm going to cover real quick the research portfolio that we're doing through the Department of Energy's Wind Technologies Office. I'm the head of research there. Our office is basically in a fight (ph.) research program.

A lot of what we touch on is --

FEMALE SPEAKER: Michael, you're going to have to speak up.

FEMALE SPEAKER: There's a lot of fan noise in here. If you could speak up a little bit.

MR. ALDAS: You can pull the mic.

DR. PALMA-ROJAS: I see -- no.

FEMALE SPEAKER: You can sit down. Thank you.

MR. DERBY: Is that better? Okay. The Department of Energy looks at land-based wind, offshore wind, and distributed wind. And the way we define distributed wind is basically two point of views. It's wind power that's attached to the distribution grid or point of use as opposed to being on the transmission side, so it can be utility-scaled turbines. It's not necessarily small wind.

We look in basically three different areas, reducing technology, costs, and risks, though. This is our research program for technology. But that's not enough, right? We also need to look at what it takes to be good stewards of energy. So wildlife concerns, the human-use conflicts, integrating onto a grid.

And the last area that we work in is really in cost analysis. A lot of techno-economic analysis goes on to understand what technologies we have are really going to be efficient.

So if you consider how the wind industry has progressed over time, cost of energy has come down. And you kind of see a tipping point where deployment starts to take off. And a lot of this is due to the fundamental R&D that's taken place over the years.

You know, the early turbines had a few challenges. And as we got smarter, learned more, the technology got better and better, and costs kept coming down. And once that happened, you know, it became an economical way to do business.

We think there's a lot more to be had. NREL recently did a study that shows if we continue to do R&D, we can probably drive the cost of land-based energy down by another fifty percent.

And that continued decrease in cost is really important. If you look at the graph here on the right, this is projections of continued wind deployment in the

U.S. based on a few scenarios. And if you look at the dark red curve, that's really kind of if we don't continue to innovate, wind doesn’t deploy past 2020 until you reach out to about 2040. You know, other forms of energy are going to deploy, but we just don't see that wind has a place there.

If we continue to innovate, we could achieve that blue curve and wind deploys. It kind of levels off a bit. But if we really pursue aggressive R&D, we think we can reduce that cost by half. Wind continues to deploy pretty much at the historical rate.

So what's DOE doing to look at this? We've got a program that we call Tall Wind. It's primarily focused around taller towers, bigger blades. And we also consider the weight of the drivetrains, lightweight generators.

One of the initiatives we have under here is called a Big Adaptor Rotor Initiative. And it's specifically looking at what it takes to do low specific power rotors.

So what's a low-specific power rotor? Basically, if you take any given machine size and increase the rotor diameter, you're decreasing the specific power of the rotor. That directly impacts the capacity factor that you'll get from that machine.

We're also looking at what can we do to get taller towers? Now, taller towers exist. They've been deployed in Europe for some time. And the challenge is making it cost effective in the U.S.

Another area that we focus on is wind plant optimization. So in our opinion the wind turbine OEMs have done a really good job of optimizing individual wind turbines. But those wind turbines act only thinking about themselves. There's opportunities by analyzing an entire plant and working on how these turbines work together collaboratively to improve the energy production from the entire plant.

We're also looking at offshore wind. There's a tremendous resource off our coast. It's close to where the load centers are. And there's a huge opportunity there.

And if you look at the trends in Europe, the price of offshore wind energy has come down tremendously. It's getting to the point where it's extremely competitive with any other source of generation. And our goals are to help accelerate that same transition into the U.S.

And we also look at the distributive wind technologies. I think there's some real opportunities with distributed wind to not only make a more resilient, robust grid. But there's also in small wind space, there's the opportunity to do real economic development in rural America.

So if you look at technology trends over time, you know, we started out in the '80s with very small turbines, fifty to a hundred kilowatts. Over time, up to about 2005, there was this continuous growth. But then you start to see land-based wind taper off. The growth kind of slows down. We've continued to innovate, continued to get big, but there's definitely a mean curve there.

In offshore wind, the turbines are getting larger and larger. Vestas has a nine and a half megawatt machine for sale today. GE is working on a twelve megawatt machine. And we expect that to continue to grow.

This plot comes from the market report from 2017. And part of the information on here that I wanted to point out is the red line is towers, the height of towers. So the height of towers increased, and then it kind of leveled off at just a little over 80 meters. And that's really due to transportation challenges with towers.

In order to make a tower cost effective, you need to increase the base diameter. But there's limits on how big of a base diameter you can transport. It's typically around 4.3 meters in the U.S. If you need to go taller, you have to increase the thickness of the steel in the tower. It becomes not cost effective.

Rotor blades have continued to increase in size, and it's the blue line there. You know, we keep coming up close to what we think are transportation limits as far as how big a blade we can ship. But the transportation industry has continued to innovate and continues to find solutions to keep transporting blades.

We think that's going to become a bigger and bigger challenge unless we do some technology innovations ourselves to help facilitate that.

So this graph kind of shows some of the technology development that's taken place over the few years in regards to tall wind. And this includes work both DOE's done and other entities.

So DOE's been looking at tall towers since 2002. We started with the Washaws Wind (ph.) is a space frame towers, multi connections. And that technology was actually acquired by GE in 2013 -- I'm sorry, 2011. And GE turned that into a commercial product, but I don't believe they've actually been able to deploy any of those to date.

We also funded Native American Technologies to build what they call the Ultra Tower. This was kind of a telescoping-type tower. And again, interesting technologies never made it to commercial deployment.

We've done work in big blades. GE worked on a fabric-skinned blade. Keystone Towers has designed a spiral welded tower. Gamesa had a commercial product, segmented blades, that they called the Innoblades. Those are no longer commercially available. Hexcrete Towers, these are towers that are made from modular concrete pieces that can be transported to the site and assembled.

We worked on modular blades with Wetzel Engineering. We've also done work in superconducting generators and different hybrids. All of these things are targeted towards, you know, how do we get cost effective tall wind.

Currently we have what we call the Big Adaptor Rotor Initiative. This one is very intentionally taking advantage of some of the things that we've learned about wind plant optimization.

And one of those things is how you can steer wakes. And it looks like working collaboratively, if we steer a wake from one turbine, you can increase the power production from a wave turbine by up to fifteen percent. It's particularly effective if, instead of yawing the turbine, you could actually pitch it. If you pitch it, you run into blade clearance issues with the tower. But you could entrain flow from above the wind plant into the downwind turbines. So it's got future potential.

So part of what we're doing in the Big Adaptor Rotor Initiative is stepping back, looking at turbines to see is a three-bladed upwind turbine the right solution? Maybe it should be a two-bladed turbine. Maybe it should be a downwind turbine.

Also we'd like to go to a much bigger rotor size. That allows you to capture more energy, increase capacity factor of a turbine. And if you look here, current technology has been following this trend for some time. Today turbines are down around 200 watts per square meter. They started up around 400 watts per square meter, so almost twice the energy.

We’re targeting 150 watts per square meter, and if you coupled that with a tall tower, say 140-meter tower -- if you look at the map of the United States, those orange areas, those are areas that are currently places where you cannot get a high enough capacity factor to make wind economical today. And with this low specific power rotor and a tall tower, it opens up the entire southeast of the United States for wind energy development.

Now, you can question whether or not a thirty-five percent capacity factor's going to be cost effective in those areas with these new technologies, because the cost of the technology's going to go up. You build a taller tower, you build a bigger blade, it's going to cost more. So you still have to consider the economics of this.

Transporting large blades, this is getting to be a real problem, you know. So we recently ran a workshop called the Supersize Blades Workshop, where we were looking at how can you transport up to 115-meter blade over the U.S. railroad network. And we considered several different options.

One of the things we looked at was onsite manufacturing. Could you actually just build the blades where you're installing them? We looked at segmented blades. Could you build them in two pieces, transport them where you want them? Modular blades, multiple pieces that get assembled onsite.

And I think my colleagues are probably going to talk about this in the next session, so I'm not going to go into too much detail about the findings. But there's some possibilities there that look reasonable, but they're going to require some additional R&D to take place.

You know, so we look at tall towers. This is another way to look at it. Going from eighty meters to 140 meters opens up a huge amount of area in the United States that potentially could be cost effective.

Again, what we're talking about here is achieving a certain capacity factor. There's several different technologies out there that are competing right now. I mentioned the spiral welded towers -- that's an onsite manufacturing use of steel -- the modular concrete. There's also additive manufacturing concrete projects that are underway. And Silvia mentioned one that California is funding itself. DOE is funding a similar project.

The areas here, you know, 140 meters has been done today. GE currently has a machine for sale that can go to 160 meters. It's available for sale in Europe. So the technology exists. Again, it all gets back to cost. What's the cost it's going to take to do this and make it cost effective?

Our atmospherics to electron program, this is really our one-plant optimization idea. Again, what we're looking at is how do we make the wind turbines talk to one another, increase power production in the entire plant. This includes looking at the atmospheric resource. We have an atmospheric science program, where we're trying to understand what our field really looks like. Taking global weather systems and trying to forecast what the power production per plant would be on a twenty-four-hour basis, ten-hour basis, the half-hour basis. Trying to be able to predict ramps and decays.

It also gets into if you're going to model the plant itself, you have to understand the turbulence that's in the atmosphere and scaling the turbulence from the big scale weather models down to what you need to understand for wind plants, a challenge that we haven't solved yet.

If you consider -- if you understand what the flow is to the plant, then you can understand what that flow's doing to individual turbines. You can understand what the loads are. You can better design your turbines. You can reduce the margins required to come up with better standards. You can also use the knowledge of what the flow's doing to inform a turbine downwind. So if a turbine upwind sees the wind change, you can tell the turbine behind you, hey, the wind's shifting; you should shift too and be ready for it.

See, the last thing that I talked about earlier was steering the wakes, being able to manipulate the wake. So once you understand the flow, you can design the plant better. You might decide that turbines don't all need to be the same height, position, different heights. And you can steer the wake. If a turbine behind says, hey, your wake's impinging on me; tell the upwind turbine to move, by shifting that wake over you can actually increase the power production of both turbines.

The opportunity there -- typically, a wake turbine produces about sixty to forty percent of the energy that an unwake turbine produces. So there's a large margin to be had there.

Moving to offshore wind, you know, Europe's been very successful with offshore wind. So one of the things that we're interested in doing is leveraging as much of that information as possible. So our intent is to focus on those challenges that are unique to United States. The United States has different subsoil conditions under the ocean. We experience hurricanes, which don't happen in Europe. And much of our resource is in deep water, so those are considerations that we need to take on account.

But there's a huge opportunity here. If you look at the chart that's on the right here, that big yellow bar is what we see as the need for additional electricity generation as we go forward in time. Now, not all of this is going to be accounted for by wind energy, either land-based or offshore. But that is the opportunity space for new electrical generation. So there is a lot there. And as I said, the offshore wind is a much steadier resource that tends to have a wind profile that better matches the load distribution. And it's close to the load centers, so we don't require as much new transmission.

Our current efforts in the space, we're just launching the Offshore Wind R&D Consortium. There's forty-one million in total funding available for this. NYSERDA is the implementing agent for the Department of Energy. They're administrator of this work. And there's three technology areas that they're going to be concentrating on.

The first is wind plant technology advancement. So what are those things that we need in the U.S. to accelerate floating foundations that are going to be necessary for deep water? What kind of controls, electrical subsystems, all the basic technology pieces we need to make wind cost-effective in the U.S.

Next area is on resource and site characterization. Again, our subsea structures are a little bit different than what's in Europe. It's expensive to do those surveys, and we don't have a good data set for what the actual winds are offshore. We know the models that we have for weather forecasting don't get the winds right at turbine heights. They do well near the surface, but it's that transition to the boundary layer, to the point that we're interested in, that they're not working well.

And last, we're going to be thinking about installation challenges for the U.S. O&M and building supply chain that we need in the U.S. There's something called the Jones Act that requires vessels that come in and out of a port of the U.S. to be U.S. flagged vessels, crewed by U.S. crews. So the U.S. doesn't have these installation vessels that Europe has today, so there's a huge investment cost to come up with those vessels, or we need to come up with different solutions for how we're going to install these turbines.

The other project we have is our offshore wind technology demonstration projects. There's two. There's one in the Great Lakes that's trying to demonstrate exsuction buction (ph.) -- excuse me, suction bucket tower technology. Basically, this is a foundation that can be installed and removed without leaving any traces. It literally is what it sounds like. You set it down; you suck the water out of this cup; it embeds itself in the subsea floor. And when you want to remove the turbine, you just pump the air back in, extract the whole thing.

The other project we have is a floating foundation with the University of Maine. This technology uses a concrete semisubmersible foundation. Both of these projects are trying to demonstrate innovative technologies in the foundations.

Offshore wind plant optimization, you know, this is part of our A2e program. And that optimization is much more critical for offshore because of the way those turbines are typically installed. They're usually installed in a very tight matrix. They try to get the turbines as close together as they can to reduce the balance of (indiscernible) cost. So the waking of those turbines is a bigger concern offshore than it is for the land-based turbines.

And, of course, we have to consider wildlife concerns as well. There's right whales that we need to understand how to mitigate the impacts on those when we're installing the foundations, and also understanding what the birds and whatever other species may be out there, what impacts we're going to have on those offshore.

Distributed wind -- there's big market potential for distributed wind. Currently, there's just about a gigawatt of distributed wind deployed across the United States. Small wind is a huge exporter. We're the number one exporter in the world for small wind turbines.

The emphasis that we have in our program for small wind focuses on a couple of various -- one, small wind is challenged by doing good resource characterization. A lot of small wind turbines get installed in areas that don't perform the way they anticipated. So we're looking at ways to improve the resource forecasting for small wind, which is a much more difficult challenge than it is for utility scale wind.

We're also looking at how the small turbines can be more easily integrated into rural co-op electrical distribution systems. You know, the rural co-ops have been working with solar for a number of years. Our solar program has worked with them to establish how they work with that, but small winds not as much. And something you're not familiar with is scary. So what we're trying to do is educate and come up with kind of standardized designs that they can leverage, in order to make it easier for them to integrate those things into their grids.

None of this matters if you can't deploy. And so you have to consider what's the impact on our world. So other parts of our program include -- you know, it's citing and environmental research, so better understanding the impacts on birds and bats, other species, and also what are the impacts to things like radar, TV. All of those things are things that people are concerned about.

In our radar program, we've been working with several other agencies, including DoD, the FAA, NOAA, Department of Homeland Security. Wind turbines impact our security radars, our weather radars, our air traffic control radars. And so we've been working with these groups to understand what those impacts are and how we can mitigate those. And we've made significant progress.

Several years ago, the military had a basic answer of, if you're within a certain distance of a military installation with a radar, you cannot deploy a wind turbine here. The answer was just plain no. Today, those turbines that want to be deployed there are evaluated, and solutions are developed that can potentially permit them to be installed, where ten years ago it wasn't even possible.

There's more work to do here. We've been working several different sites. Travis Air Force Base here in California is one of the areas that we've been working on.

We also have a bunch of tools and resources that we've developed. And this slide really has links to several of these.

The Working Together to Resolve Environmental Effects of Wind Energy is an international collaboration that we're involved with.

The WINDExchange is kind of a resource for people to get fact-based information about wind.

The U.S. Wind Turbine Database is something that we just launched earlier this year. This database has geographical information for every turbine installed in the United States. You can go in and get the latitude, the longitude, the heights of the turbine, the make of the turbine. It's all there.

The DoD screening tool, again, this gets back to the radar interference. It's a asset for developers to go in and understand if they're going to have an issue trying to put in a wind turbine.

We're also doing workforce development. We've got our Wind for Schools program, where we're trying to introduce wind energy to K-12. And hopefully it equips college students for them to understand wind energy.

We're also running what we call the Collegiate Wind Competition. This is where teams of college students get together, design wind turbines for specific applications that they've identified. And then they get to do a competition with the other teams, using wind tunnels to assess the performance. They also get to build a business case and present, you know, why their technology is a good solution.

What I want to leave you with is there's huge potential for wind energy still in United States. We're not done. There's lots of untapped areas that we can go into, off our coasts, throughout the entire U.S. And it's going to take a mix of technology. It's going to be land-based; it's going to be offshore; it's going to be distributed wind applications.

But those barriers that we need to address include, you know, new technologies for wind turbines that are cost-effective for offshore, cost-effective for tall wind. And we've really got to drive the cost down.

I didn't speak to the grid much today, but that's another area that we have to understand, right? We can't be bad citizens on the grid. So we need to come up with ways to integrate with other renewable technologies, with storage, improve our capacity factor so that we can reduce requirements for spending reserves, and, last but by no means least, mitigation of any environmental impacts and human use concerns. Those are fundamental. As I said, if you can't deploy, it doesn't matter what we do in any of these other areas.

And with that, I'll conclude. Thank you very much.

MR. ALDAS: Thank you, Michael.

I guess while we're transitioning to the first panel, I would like to see if we have one or two question, at the most, in the room for Michael?

(No audible response)

MR. ALDAS: No? If no question, then -- well, thank you.

MR. DERBY: All right. Thank you.

MR. ALDAS: Appreciate that.

Well, at this point, I would like to call our moderator for the first panel. We're fortunate to have Professor Case van Dam to moderate the first panel, and I'd like him to call and introduce the panelists. Thank you.

FEMALE SPEAKER: (Indiscernible).

MALE SPEAKER: (Indiscernible).

FEMALE SPEAKER: (Indiscernible).

MALE SPEAKER: (Indiscernible).

MR. VAN DAM: First or second? Okay.

FEMALE SPEAKER: (Indiscernible).

MR. VAN DAM: Okay. Okay. I'll get this.

FEMALE SPEAKER: Maybe if we can (indiscernible).

MR. VAN DAM: Yeah. Okay.

FEMALE SPEAKER: I'll start it. Are you (indiscernible).

MR. VAN DAM: Uh-oh. Can I get up there with this? Okay. Thank you.

Welcome, everybody. My name is Case van Dam. I'm a faculty member at UC Davis and a longtime interest and researcher in wind energy. So it is my pleasure to moderate this panel discussion this afternoon. I think we have about an hour for that. And then I have, at the end of this, some time for some questions.

And we have four terrific panelists, people from academia, national labs, and as well as some industry. So let me introduce the four panelists, and then I'll get started with the questions.

So the first -- the first person I would like to introduce is Mo Li. She's a faculty member in the Department of Civil Environmental Engineering at UC, Irvine. And she has also joint appointments in the Department of Chemical Engineering and Material Science at UC, Irvine. Her expertise is in advanced construction materials and structures and additive manufacturing methods. She directs state-of-the-art infrastructure materials research in advanced manufacturing laboratory at UCI, and is an active user of the structural engineering testing hall there. She also works on developing innovative concrete technologies, advanced manufacturing and monitoring methods for energy-related applications. And she will comment on some of that, her thoughts on that today.

The second person I'd like to introduce is Jason Cotrell, and he is the founder and CEO of a startup company, RCAM Technologies. Before that, Jason worked twenty-two years at NREL in Golden, Colorado, where he was a senior engineer and manager in the wind turbine technology innovation group. Jason's primary responsibilities at NREL included activities in gearbox and generator research, and testing advanced controls, distributed wind turbines, and manufacturing supply-chain issues.

Third person there on the panel is Walt Musial, and he's a principal engineer and a manager of Offshore Winds (sic) at the National Renewable Energy Lab, where he has worked for thirty years. And his contributions, especially in Offshore Wind, are greatly appreciated. He really has been one of the mainstays there in that area. In 2003 he initiated to this, the Offshore Wind energy research program at NREL, which he has left since then. Walt also developed and ran National -- NREL's full-scale blade and drivetrain testing facilities for fifteen years. And before that, he spent five years in the commercial wind-energy industry in California.

And last but not least, I'd like to introduce Kevin Smith. He's the director at DNV GL, the wind and solar operating asset services. He is responsible for leading DNV GL's advisory services that support asset management and operation phase of renewable energy projects. His team provides turbine engineering, inspections, operating data analysis, SCADA, asset organization (ph.), and power forecasting services.

It is really -- it's great to have these four folks here today, kind of giving their thoughts, ideas, inputs on some of these questions. And I think these questions kind of address a broad range of opportunities and hurdles that I think we face in wind energy, especially focused on California.

So with that, let's get -- maybe let's get started. And that is the first question. I think the questions are there --

FEMALE SPEAKER: Yeah.

MR. VAN DAM: -- too?

MALE SPEAKER: Yeah.

MR. VAN DAM: Okay. All right. Though there are neither new or existing wind turbine manufacturing facilities located in California -- and I think Mike Derby brought up the 2017 Wind Technologies Market Report by Ryan Wiser and Mark Bolinger earlier. And that actually -- I really want to make a plug for that annual report. It provides an terrific update on the state of the art, but also provides a very nice historical perspective. So anybody's interested in wind, I highly recommend looking up that report and spending an evening reading that.

And there in that report, you find there's no manufacturing facilities located in California, not much on the entire, I think, west of Colorado, actually.

There's not much listed there.

So how critical is it, and are the opportunities for -- are there opportunities for advanced manufacturing technologies in California? How can the evolution in next-generation wind energy technologies support the advancement of manufacturing in the state? So that is -- I think is a very important question. And like maybe to start, maybe -- Jason Cotrell to maybe start out to maybe commenting on that, and then the other panel members can join in.

So I think, Jason, you have prepared some, I think --

FEMALE SPEAKER: (Indiscernible) --

MR. VAN DAM: He --

FEMALE SPEAKER: -- thing change.

MR. VAN DAM: (Indiscernible).

MR. COTRELL: How does this work?

FEMALE SPEAKER: (Indiscernible).

MR. COTRELL: Okay.

FEMALE SPEAKER: (Indiscernible).

MR. VAN DAM: There --

FEMALE SPEAKER: (Indiscernible).

MR. VAN DAM: I can otherwise run up to -- let's see.

MR. COTRELL: So this is a laser pointer?

MALE SPEAKER: It's for weather.

FEMALE SPEAKER: No, no. This is --

MR. COTRELL: Oh.

FEMALE SPEAKER: -- (indiscernible) change.

MR. COTRELL: Okay.

FEMALE SPEAKER: And these are in case the people don't catch --

MR. COTRELL: So I don't need that one?

FEMALE SPEAKER: No. No, you need that because when you (indiscernible) touch the --

MR. COTRELL: Okay. The microphone for Webex?

FEMALE SPEAKER: Yeah.

MR. COTRELL: Okay. Okay. But I should talk into this then?

FEMALE SPEAKER: Yes, for the (indiscernible).

MR. COTRELL: Can you hear me?

FEMALE SPEAKER: Yes.

FEMALE SPEAKER: Yes.

MR. COTRELL: Okay. And it's loud enough?

(No audible response)

MR. COTRELL: Okay. So I've put some thought and queried some of my colleagues about actually both of the questions, question number 1 and question number 2. And the questions have changed a little bit. This was an earlier draft of the questions, but they're essentially the same.

And the first question -- actually, the questions have been updated here. You know, the key there is the question is basically stating that there are few, if any, wind turbine manufacturers in California. This came from the DOE-funded market study, 2017. In fact, if you look at that report, there are only three wind turbine component or manufacturers west of Denver. Then there's a clump in Denver, and a clump of -- clump in Texas. So is that a problem or not? My initial response is that's a very large missed opportunity, because every gigawatt of wind turbines is worth about a billion dollars of capital investment. So it's a missed opportunity.

And so let's see. So maybe we should go to the next slide.

FEMALE SPEAKER: You --

MR. COTRELL: Oh, and that's me.

FEMALE SPEAKER: Yeah.

MR. COTRELL: Sorry. Oh, now I'm probably going backwards. No?

FEMALE SPEAKER: Oh, the other one. The other one.

MR. COTRELL: This one?

FEMALE SPEAKER: Yeah.

MR. COTRELL: Okay.

FEMALE SPEAKER: Big one, yeah. That one.

MR. COTRELL: Okay. So it is a missed opportunity. And then there's a second maybe data point or observation that indicates that it is indeed a problem, because last year California, according to the -- I think it's the 2017 market report again, installed only 50 megawatts of new turbines. That's about twenty-five or less modern turbines in 2017 in new capacity. Not sure if that includes repowering. But to put it in perspective, if you look at that same data, Texas installed 2,300 megawatts. And pretty sure California's economy is bigger than Texas. So it shows what can be done.

So I would consider it a problem. And that's in light of wind turbine prices being at all-time lows. So something is not working. And I believe we can affect that problem.

So this first slide here -- and I'll try to make this as fast as possible, because I know we're time-constrained. But it shows maybe the state of the art of turbines that were just announced by GE within the last month. It's a five-megawatt class turbine. It has 78-meter-long blades in two pieces, 160-meter-tall concrete tower. Along with that, you're going to need a foundation that's going to require at least a hundred concrete trucks worth of concrete.

They don't sell that in the U.S., and I don't know if they will sell that. And it goes back to Mike Derby's concept, since it is a more expensive machines in a lot of cases. In fact, that tower is a one-and-a-half-million-dollar tower, and it costs almost, if not more than, the entire rotor on the top of the machine. So the tower is a very expensive portion.

In addition, the wind turbine manufacturer or the tower manufacturer doesn't even exist, or they don't sell into the U.S. market. It's a German manufacturer of that tower.

That brings along with it a number of other problems if you want to try and take advantage of a machine like that. And in the lower left-hand corner, you can see the cranes. That's how they would install the nacelle head on a machine like that. We don't necessarily have those specific cranes in the U.S. And any other cranes -- I was told there's about five of them, by some -- by a gentleman at a construction firm.

So right now we can't install those here, at least in a cost-effective manner. And so I think what I should have pointed out at the beginning, I am one of the recipients of a previous EPIC award to develop concrete printing solutions, 3D printing with concrete, for the tower. So I wanted to make sure -- want to make sure that folks were aware of that.

So -- oh, that's the wrong computer. Here we go.

FEMALE SPEAKER: Yeah.

MR. COTRELL: So the question becomes, well, does a tower like that -- does a machine like that make sense in California? And there's data provided by the National Renewable Energy Labs, funded by DOE, that indicates there is. And that's this data on the left-hand side. And I won't spend much time on it, other than it's -- than kind of cutting to the chase and saying the current technology is this black technology, this black line on the bottom. And if these new turbines start to be installed into California, these land areas on the left-hand graph are what become possible for every particular capacity factor.

And the bottom line is that you can increase the land -- deployable land with sufficient capacity factor, the availability of that, to -- by about a factor of twenty times. And that's with this 140-meter-tall near-future turbine. You might be able to double that again with a five-megawatt turbine. So there's clearly an opportunity there.

But along with that comes some substantial problems in terms of how do you get the tower there, how do you build it, those sort of issues.

In addition to the economic benefits from those wind installations, there's also operations and maintenance installations. And that's what's represented in the right-hand corner, which is a whole another source of revenue. So there's near-term job potential, near-term economic development, and long-term for the life of the turbine, which is probably twenty to twenty-five years. But we can't get there yet.

So I just have -- maybe I should pause there, because the next slide gets into the next question, which is how do we -- gets into site-specific design. So let me pause there.

MR. VAN DAM: Okay. So any -- maybe Kevin or any additional comments?

MR. SMITH: That was a good presentation, Jason. Thank you.

I think for manufacturing in California, we've been -- my company's been working with studying supersized blades, so the next generation of blades that are magnified to 115 meters, as Michael mentioned earlier.

And one of the interesting logistic things that you talked about, Jason, is moving these large blades around becomes a big challenge. And if you looked at a map of the U.S. where the blade manufacturing is, it's in right down the center of the U.S., and that's right where all the deployment of wind is in the nation. So I think California has an opportunity to put manufacturing in this state for really large, large blades that I would say serve the offshore market, because that's where those blades are extremely valuable and needed for offshore wind.

But those same size blades could also be deployed on land, so that those same factories could also be servicing super-large turbines that -- what Michael Derby was talking about, with the really large rotor, tall tower, so you can do two things at once. But the trick there is needing -- these are large objects to move around the state of California. And you can also serve basically the western half of the country because, let's face it, the Rocky Mountains are a pretty big obstacle to move really large objects over and through. So that's an impediment that we noticed with these large blades is that you -- kind of moving them over the Rockies is going to be a trick.

So I think that for focusing on manufacturing, like why you need more -- what's the opportunity for manufacturing in California? The tall towers is a clear area to get access to the taller, higher wind resource that's available. And I think whoever can try to figure out a blade manufacturing facility on the West Coast of the U.S. will have some valuable onshore and offshore.

I think, given the recent announcements and -- well, you can basically walk us -- and speak to this too, but off -- floating offshore, offshore off the coast of California, seems to be the real, real ripe spot to spur that economic development that you were mentioning.

MR. VAN DAM: Walt, maybe? Any thoughts on this, yeah?

MR. MUSIAL: Sure. Would you like me to --

MR. VAN DAM: Yeah.

MR. MUSIAL: -- just --

MR. VAN DAM: Yeah.

MR. MUSIAL: -- do a -- so good afternoon. So I'm Walt Musial. My focus is really on the offshore wind questions. And just if you haven't been following this as closely as I have, California has recently gained interest in this area because of a lot of -- lot because of the policies, but because recognizing a trajectory toward zero carbon. Offshore wind provides a significant resource, and the question is how significant is that going to be and what's the time line or trajectories of introducing that technology?

So we've seen two to three years -- in the last two to three years, we've seen a lot of interest increasing. The government formed a taskforce. And just, I think, in the -- within the last week, the Bureau of Ocean Energy Management announced three call areas in California, which should really be embryonic beginnings of what they would consider lease areas. And so this is a -- this is a technology and a industry that's moving right now in California, so it's a really good time to be addressing this question of, you know, what can California do to intersect with the momentum that's happening right now.

And I can tell you that Europe is on this right now. They've just kind of transitioned, I think, from strictly a fixed-bottom focus, you know, where they have a lot of shallow water in the North Sea, and they've deployed over 16,000 megawatts of offshore wind. Now there's a big push to develop this technology.

And so question that's, you know, becoming apparent is when the developers who claim they can commercialize this technology in California, somewhere in the 2025/2026 time frame, when that -- when these projects begin to arrive, you know, what will the local content be, and what will the role of California be? Is its technology going to be delivered as an export market for the Europeans, or can -- how can California get involved in that? And I think that's the question that I want to try to help you answer.

And I'm not -- of course, I'm kind of learning as I go, as well, but I think there's a lot of -- I kind of divide this into two areas, the technology questions and then kind of the siting and supply chain infrastructure questions that are necessary. And I think technologically there's going to have to be some differences between the technology that gets deployed in Europe and in California, because of water ducts, and maybe certain interactions with species, and perhaps the -- just the way the grid is structured here. So I think those need to be considered.

In particular, I'm thinking about systems to address deep water moorings. And those are technology questions that probably haven't been adequately addressed at a really deep level.

Keeping in mind that this whole -- what we're observing right now is a dynamic industry. Turbines are growing in size. So whatever changes that are made or investments that are made to the infrastructure need to anticipate that growth, so that what will the technology look like not now, but what will it look like in 2025 or 2030 when this industry really kind of hits this state and becomes something that the state is and needs to participate in, in order for it to be successful? So I think that that's something we need to look at.

There's some of the questions that may get answered globally, and I'm thinking plat -- the scaling of a floating platform, and what's it going to be made of? It would help if the materials that those platforms are made of were indigenous and could be accessed and fabricated here in the state. That requires some knowledge of the technology and then an investment in the infrastructure, because they're big. These are big parts that need to be put together and assembled.

And, frankly, optimally the technology needs to be integrated with the infrastructure. It can't be separated really, especially at the sizes that they're going to right now. So the ports and infrastructures have to be designed for the parts that are going to be built. So getting on that wagon has to be done, I think, now versus when the first projects start getting put in.

So from a siting and an infrastructure standpoint -- it's been said, I think, earlier, the resource and what we considered a resource assessment is -- was good to understand the average windspeeds and the average, perhaps, energy output of the capacity of the resource area. But when we get into grid value and resource adequacy, integration with other renewables, like the duck curve that everybody's probably familiar with, you need to have more high-resolution resource data in order to understand if you can deal with the ramp rates, and deal with the seasonal, and, frankly, the hourly variations that come with that.

And the data that we have is -- hasn't been fully validated. There needs to be measurements made, at least a few places so that we can anchor the resource assessments that have been done to what's been -- what we're going to need to do.

And then dealing with -- on my list, one of the things I think is -- that's important is understanding the sea states that are in the Pacific. The sea states are higher. The wave climates are -- it's higher than in the Atlantic. So the experience from the Atlantic is not going to transfer to the Pacific. It's something that has to be done here and/or, I think, to some extent, to leverage what's happening in Europe. So higher -- just innovations on high sea state crew transfers, for once the turbines get built, to install them, to lay the cables, to repair them.

And then look -- just looking at detailed studies of the ports and facilities that are already here and what's going to be needed to upgrade them, to make them accessible for the manufacturing and for the pre-commissioning of the turbines before they go out.

So I'll stop there.

MR. VAN DAM: Yeah. Clearly, lots of opportunities and, at this point, lots of hurdles as well.

So that gets us to question 2, kind of -- it kind of ties into that. What are the research needs to enable on-site manufacturing or hybrid solutions for wind energy technologies? What are the main on-site manufacturing challenges in California, and what are needed to address those challenges?

And maybe, Jason, I think you had some ideas for that, so let me come to your slide.

MALE SPEAKER: The areas that --

FEMALE SPEAKER: (Indiscernible).

MR. COTRELL: Yeah, so this is when I queried about ten colleagues, each with ten to thirty years of experience, and said, you know, what really should we be doing in California? And I got about five responses back. And in true engineering style, they all came back with more questions than I asked. I asked two, and they came back with seven. And so, I mean, we can go through the questions. You know, the first ones probably will help. Let's go through just a couple.

You know, they wanted to know, well, what is the actual deployment potential for large turbines? Yes, the NREL-derived data shows it's quite substantial, but, you know, that was a very high-level study. It was an average type result. You know, and how much would it really cost, you know, in California? We have estimates. We have general estimates with brackets, but how much would it cost in California?

So I -- and then the third one, let me -- that's a very important one. This is a similar theme as what you're hearing from Walt and Offshore is what are the actual wind shears, because these tall towers make the most sense when the wind shears are large and positive. We know in some regions in California they're not large and positive. Some regions they can be negative during parts of the day. But it varies. That's the point.

So there's a general theme here, in that, in general, one of the things we need to do -- and this gets to the next slide -- is have a much better understanding of how these technologies fit specifically in California, because, in many ways, California is not like the rest of the country, in terms of geography, and deployment barriers, and so on.

And so that made me think that that need for understanding, much better understanding than these high-level studies that we presently have, made me think back to some of the most impactful works that I have seen DOE do in my career, and that I still use today. So for example, this study on the left, there's whole theories of these WindPACT studies.

And one of them, coincidentally, happens to be authored by Kevin Smith, who's sitting here. So although I don't use that study still today, some of the other ones are still used. That study is twenty years old, but has, you know, had a life of about probably ten or fifteen years. And that basically looked at the logistics of transporting and installing large turbines, back when a one-and-a-half-megawatt turbine was a big machine.

So a study like that -- but the problem with a study like that, even if it were updated, is it's not necessarily specific to California. They will pick a site. I think maybe they picked -- I don't know -- somewhere in the Midwest or North Dakota. I was going to say North Dakota. There's a big difference between North Dakota and California, for sure.

And then the one on the right is actually an offshore wind study, performed by University of Delaware five years ago. And basically, what they did is they looked at how they could -- we call it industrializing offshore wind. They picked a abandoned port in Delaware, and they did detailed studies about, well, if we change the process, how much levelized cost of energy reduction would we see? And they saw quite substantial, you know, between five and thirty percent type numbers.

But the key there is in both of these, everything is tied to logistics, which makes it regionally very specific. And so the -- there's a whole bunch of topics listed on the right-hand side that we could go through, some of the same ones that you saw previously with wind resource assessment, a large wind workshop. Actually, I would -- this is an important point. I would actually -- originally had a tall tower workshop, something I've been looking for for a very long time. But I wrote large wind because I was trying to be maybe more fair and not biased, since I work in tall towers.

But the one thing I wanted to point out that I'm very excited about is that DOE has this big, adaptive rotor project ongoing. So I feel like DOE has the rotors covered. There's certainly things California can do. And one of those things that California can do is take the results from those studies and apply them in California with very specific data. So pick a port, whether it's Long Beach port or some other port, Humboldt County, and actually take those data, perform the logistics models, and come up with the cost specific to California.

And that might -- you know, as a first step, you would want to have some sort of workshop. Right now, that workshop doesn't exist in the United States. And if

California -- if there's indeed a market for that, it's a great place to have it.

The next bullet, and I kind of prioritized these as terms of my wish list, but open-source reference turbines. So presently a five-megawatt 150-meter rotor turbine, reference turbine, doesn't exist in the U.S. There's three megawatt we can draw off of. But if you had one, and you said, okay, well, we're going to install that at these promising locations, whether they're repowering other locations, a valley in California, if that makes sense, and came up with the actual cost, I think that would be tremendously important to smaller companies, universities, but most importantly, investors, because once you can prove that there's a market and that those -- that is a promising solution for California, then the rest of the dollars, commercialization dollars, flow.

So I'll pause it. I'll stop there.

MR. VAN DAM: Kevin, because your name was mentioned, any --

MR. SMITH: Thank you, Jason. There was no -- there's --

FEMALE SPEAKER: Yeah.

MR. SMITH: Appreciate the recognition there. But I think also the recognition goes back to the original DOE and NREL for having the vision to do studies that are far-reaching and looking forward, at the time when, you know, the industry really was -- has a lot of -- had a lot of challenges ahead of it. So I think that I want to echo what you said, Jason, was about, like, having more California-specific analysis of the situation here is then going to be much more valuable to try to help decision makers and local jurisdictions have a good understanding of what the opportunity is, to then figure out where they want to start putting their efforts in, because I think there is a lack of awareness still on what the wind conditions are, what the infrastructure can handle in terms of moving large objects, like, say, the rail infrastructure, and the road infrastructure, and things like that.

And then you throw in this burgeoning offshore, you know, wind opportunity out there. And that's a huge space that can -- needs a lot of attention and study. So I think that type of research that the CEC can at least foster, that's really specific into the opportunities and the challenges for this state, is -- should be a real centerpiece.

The on-site manufacturing question, I want to take us back to that because that's an interesting topic. And it's ripe for conversation right now because the scale of the towers and the scale of the blades -- primarily, let's -- we'll just focus on towers and blades because the rest of the drivetrain is largely, relatively compact and you can move those on the ground with rail, and truck, and things like that.

So -- but just the blades and the towers are an area that on-site manufacturing really -- there is no parallel to on-site manufacturing of a wind turbine blade today. I think that, at least in tower world, you can look at concrete batch plans and concrete, you know, pours and things like that, that you can see parallels between how you can do an on-site manufacturing of a -- like, a 3D-printed tower element that then could be assembled into a tall tower. Like, that -- the material science and that technology, it's out there. It still needs effort, and research, and to come to fruition.

But on the blade side, blades are really unique objects and structures. And they are really large, but they're also incredibly lightweight for their size. They're complex internally. I don't think you really can appreciate the different layers and the fibers and the orientation of all the internal components that get put into a blade, because it's all hidden from you on the outside. It just looks like a white -- a white wing. But they're very complex internally, and so it takes a lot of control, takes a lot of quality processes. It takes -- ironically, it's a lot of people just physically moving fabric, if you will, into a blade mold. Like, it's a manual process, but it's incredible how efficient humans are at moving a large amount of material into a blade mold.

And so any time you start looking at on-site manufacturing, especially for blades, I think we -- in recent work, we think you have to -- it does need more study. It's a big question about whether you can be efficient, cost-competitive with a blade manufactured on site versus a blade that is manufactured off-site and transported.

There are three key parameters of the -- of on-site manufacturing that you have to kind of work on. It's the stiffness of the material; it's the resins; and it's the materials that go into the blade, so how stiff can that be, especially if you're trying to do additive manufacturing, or printing, or using some type of injection, resins, and things like that. That does not exist right now at any scale that is necessary to produce blades as fast as the wind industry needs blades produced.

So you -- it takes R&D into the material science, on the materials that go into that type of blade, and it would need R&D on the equipment, the machines themselves, the extruders, the tape-laying machines, and everything else, to be able to apply the material as fast as it can, orders of magnitude faster than what current 3D-printing machines can do. The current technology is interesting, but it's so far from the production rates that are needed to make big blades within a -- basically, a twenty-four-hour mold cycle.

And then the third element that on-site manufacturing has to balance is the actual cost, the finished cost out of that entire process. So, you know, moving -- if you have a mobile blade factory, blade factories are very effective when they can work 24/7, 365 days a year. If you're going to move a blade factory around from site to site to site, you're going to spend a lot of time with that factory not in production. And when it's not in production, your utilization plummets, and then your costs go extremely high for the equipment that you've just invested in.

So there's the stiffness of the material. The material science has to come together, the production rate of the equipment has to come into play, and the combination of all of the labor cost and the cost of the finished blade have to come together to make on-site manufacturing even kind of in the conversation.

At the same time, you need to go back to logistics, because at the same time you're trying to advance technologies to make blades on-site, you have to ask yourself, well, can I still just move them? And there are really still a lot of innovations in the transportation world that still have yet to be kind of really realized, that you're going to have to know what that landscape looks like. So studying the transportation side, as long as -- as well as studying the on-site manufacturing need to go hand-in-hand because they're in competition with each other.

So there are airships. Lockheed Martin in this state is -- has developed and will be deploying large cargo airships. They're in certification now with FAA. I'm not paid by Lockheed Martin to mention this, but they have machines on the drawing boards that can move blades that are 115 meters long without a problem because the blades are so light.

So you need to -- my guidance is you need to look hard at the transportation and logistics world, because that might upset the applecart if you invest all your money into some other on-site manufacturing or something like that. You have to look at both worlds the same time and keep pushing on both, so --

MR. VAN DAM: So to be sure that we stay on time, so let's move on to the question number 3. And we already -- some of us already alluded to -- so what are the research needs, for instance, in the area of material science, to make the next generation of wind energy technologies, such as super-size blades and concrete or hybrid wind towers, feasible?

And I think maybe, Walt, you want to take a first stab at it? Yeah?

MR. MUSIAL: I could. I think I might have touched on that, but I think --

MR. VAN DAM: Okay.

MR. MUSIAL: -- that might belong to someone else, if you want to --

MR. SMITH: I have a -- I had a couple thoughts.

MR. VAN DAM: Okay.

MR. SMITH: Just to the --

MR. VAN DAM: Yeah, go ahead, yeah.

MR. SMITH: Sorry. I'll go quick, and then we can listen to someone else talk too.

But the science seems to be telling us longer and slender blades that you can -- that you can spin as -- the faster you can spin them through the air, you can make your blades longer and slender is very effective. It's an effective design, and it actually has some advantages for transportation, lightweight and other things.

The challenge with a long, slender blade is how do you keep those loads in control? But in the material science side, there's a world of thermal -- so you need materials that are high in stiffness, so -- but have relatively low weight, so fibrous materials. They need to be high enough in stiffness. They don't have to be extremely super-strong, special aerospace-type grade fibers. But right now, thermoplastics would be really interesting material, but it -- the stiffness is really not there right now. So -- but they might have some interesting other properties in terms of field repairability. You may be able to put them into more of a additive manufacturing process than other types of material.

So I think the R&D, the laboratories and the universities in California, I would think, would have a good material science group that would be looking at resins, and fibrous thermoplastics, and thermosets that are high in fatigue, high stiffness, low cost. So that's the trick. I think people can find really strong fibers, but making them low cost for the wind industry is really the trick. So --

MR. VAN DAM: Mo, you -- you want to --

MS. LI: Yeah. I agree with what you just said, in terms of the materials for wind turbine structures. I can see the future research is going to the direction of higher performance, like stiff -- higher stiffness, higher durability, more damage tolerance, and also lower environmental impacts because next question is related to environmental impact, especially when the wind turbines, there will be more and more of them. And there has been a lot in the past. Some of them, probably most of them in the past, have reached the end of their life. How do we deal with them and the environmental impact when the whole market is growing larger, and we have to think about that.

So a third one would be can we come up with newer material innovations to accommodate advanced manufacturing methods? If you want to do modular construction, we need to think about how do we connect those modules using, probably, stronger materials, more durable materials. And you would talk about on-site manufacturing, like additive manufacturing, how do we design the materials, for example, 3D printing concrete, that can really work with this process, that will be very different from a normally constructed concrete that you have, a form where you have sufficient curing time but you now are talking about using a robot handling the concrete. Probably we don't give it much curing.

There's no form work. Then the concrete should be totally different from the concrete before.

So with that three major topics in mind, you could look at turbine structure. We have three major parts. We have the turbine blade, and we have the tower, and we have the foundation.

For the turbine blades, currently people are using carbon fiber reinforced plastic or glass fiber reinforced plastics. And how do we make those materials better to achieve the three major goals?

Now, in terms of towers, right now most of the towers are using steel. But we are going to bigger turbine blades and taller towers. The steel towers need to increase the diameters, and they might not be cost-effective. So should we look into high-performance concrete with reinforcement to replace -- I mean, to be alternative, cost-effective alternative, of steel towers? And can we use conventional concrete, or should we pursue, like, ultra-high performance, higher durability concrete, higher-strength concrete? How would that influence reinforcement design? Can we use fiber-reinforced concrete? I think those are all very interesting research questions to look into in the future.

Now, in terms of foundation, we are mostly using concrete, right? So how do we improve the performance of the foundation? How can we do additive manufacturing of foundation using 3D printing concrete? Can we make the concrete foundation more durable and without having to worry about damage, especially for offshore structures? And these are the thoughts I have.

MR. VAN DAM: Fatigue. Concrete fatigue.

MS. LI: Fatigue, right. Cracking.

MALE SPEAKER: Cracking.

MS. LI: Because concrete is a brittle material, cracking is a issue.

MR. VAN DAM: And go ahead, Walt, yeah.

MR. MUSIAL: You know, and I'll just add on the offshore side, when we look at the development of offshore substructures, this is a very likely component that could be locally manufactured. And the fabrication, currently, of most substructures are -- is steel, and -- but steel is very subject to corrosion.

MS. LI: Um-hum.

MR. MUSIAL: And we're worried about that because it's a long-term O&M topic. And I think there's been several examples of concrete substructures that are on the drawing boards now or have been demonstrated. And that's an area that could be maybe localized a little bit more. It's something that I think is worth looking into, at least.

MS. LI: Um-hum.

MR. COTRELL: Could I --

MR. VAN DAM: Yeah, yeah. Go ahead, Jason.

MR. COTRELL: So one thing, one very important global effect that we're witnessing is the effects of automation on manufacturing. And especially here in California, I think, you have -- at least in Southern California there's some -- there's quite a bit of robotics being used. There's robotic manufacturers and just a lot of software that goes into that robotics, which is another California specialty.

The importance of automation, you know, can extend through the wind turbine supply chain. At least in our case, what we're doing is effectively using automation with a very low-cost material, so we're effectively using robots to apply concrete in ways that you normally -- you can't do with traditional methods. And that combination of relatively low labor but 24/7 operation, like you heard Kevin say, is very important.

And very low-cost materials. You know, it's a very powerful combination in terms of reducing costs and enabling new designs. And you can do it on site, as well. And so you see that -- kind of, that theme of onsite automation. In fact, it's actually on the verge of transforming the entire construction industry. And if you start looking into it, you know, people are talking about the third industrial revolution or industry 4.0. And if you -- if you're interested in those things, you can actually see that happening through the application of automation to construction. I mean, that's where you'll probably see it first.

But I just wanted to really make sure that that automation component of it, which clearly has applications to concrete, but also, your standard concrete -- you can't just go to your hardware store, and pick up a bag of Sakrete, and put it in the robot. It takes material design. It takes a mix specialist in research to modify that formulation in many different ways, whether it's additives, or reinforcement, or what have you.

There's a lot of research going on in that, and we're doing some of that in our CEC funded project. But we're drawing on research from across the rest of the world, and then applying it here in California and trying to enable taller, more cost-effective wind turbines.

MS. LI: Yeah, (indiscernible) and automation, material science

MR. MUSIAL: It's green.

MS. LI: Yeah. Automation and material science --

we really need to talk to each other and work together to achieve this goal.

MR. VAN DAM: Okay. Thank you. That gets us to the next question. And again, some of it was already alluded to in the previous Q and A. Are the environmental life cycle aspects of the new composite materials and technology innovation being evaluated in the design and development of next-generation, land-based, and offshore wind technology? Maybe, Mo, maybe you want to start off with it?

MS. LI: Yeah, I'm going to stand here so I don't hurt my neck. Can I have the --

DR. PALMA-ROJAS: The control.

MS. LI: All right, so this is the question about the environmental life cycle impacts of wind turbine structure. Because the first-generation wind turbine blades are reaching the end of the life, and most waste is sent to landfill. So we really need to consider the environmental impact of those waste of those already build wind turbines.

But also, we need to consider in future, when we are building taller, bigger turbine blades and taller towers, what would be the environmental impacts of these?

In the past, there has been some limited studies about the environment life cycle impacts of wind turbine blades. For example, macroscopic quantitative analysis of environmental life cycle impacts of a typical 45.2 meter 1.5 megawatts blade has been analyzed. In the analysis -- so first, we look at the global data to calculate the amount of wind turbine blade materials consumed in the past, up to date. And then they consider the equal data for different stages here in the life cycle.

So the stages includes the raw material production stage, the tower -- the turbine blade manufacturing stage, transportation, operations, and maintenances. And the major findings are for the typical 45.2 meter blade, the carbon footprint is about 795 gigajoules and mainly gets dominated by the manufacturing processes and raw materials. In both of them, the first two stages occupies ninety-six percent of the total carbon footprint and also energy consumption. The total mass is also calculated. And there are some numbers here about the consumption of the energy and also a carbon footprint.

The analysis also considered the major different materials, carbon fiber, glass fiber, and resin, and the other type of materials. For the material use and the energy consumption of this 1.5 megawatts blade, the energy consumption is dominated by carbon fiber or glass fiber fabric and then the resin and adhesive. The first one is 38.6 percent. The second one is 56.7 percent. The other type of materials on the blades, they occupy a smaller amount of percentage. And here we are only looking at the blade.

And now this one is comparing two different materials for the blades. One is glass fiber reinforced plastics. The other is carbon fiber reinforced plastics. So this here is what I want you to focus on. Compared with glass fiber reinforced plastics, carbon fiber reinforced plastics has higher performance, and also higher energy consumption, and higher carbon footprint, and also higher total water consumption. And those numbers are very specific for this specific wind turbine blade. But if we look at different wind turbine blades, onshore versus offshore, larger ones -- those numbers can be totally different.

Now here, there is also study of the wind turbine -- the entire structure, not just the blade. So here you look at the different components of the structure including the tower structure, the blade structure, the foundation structure. I highlighted those are the important components. You can see the weight of different components. The tower structure probably is the second heaviest. The foundation is highest weight. And then the third is the blade. You can see the difference between the mass of the blade and the tower structures and also the foundation structures.

The results of the life cycle analysis in terms of energy consumption and carbon footprint -- the landfill side is assuming everything will be landfilled -- the waste will be landfilled. The second one is considered recycling. The main message here is first, again, if we look at the entire structure, also the material stage -- production stage and manufacturing stage dominate in terms of the energy consumption and the carbon footprint. Now if we compare landfill and recycling, of course, if we can recycle most of the materials, then the total energy consumption carbon footprint will become lesser.

So here is your current disposal and recycling strategies. For iron, ninety percent are recycled. For concrete, 100 percent goes to landfill. Fiberglass, 100 percent goes to landfill. Aluminum, about half recycling.

Now, to summarize, I think that it's very important to evaluate how new materials, new blades, taller towers, different foundation designs, and the manufacturing processes are going to affect the life cycle environmental impacts of wind turbine tower structures. It's also important to come up with new strategies to reduce environmental impact, especially during the material production and also manufacturing processes, because these two stages really dominate. For example, if we can come up with materials like concrete materials or composite materials that can be easily -- more easily recycled, also last longer, consumes less energy to produce, then we can reduce energy consumption during the material production stage. And if can come up with manufacturing processes that can make the process have less environmental impact, that would also help.

MR. VAN DAM: Kevin, any questions?

MR. SMITH: I'm curious, is any of the fiberglass or reinforced materials being used in concrete or other, like, secondary uses like --

MS. LI: They are used for retro phasing purposes -- repair and retro phasing purposes.

MR. SMITH: Okay.

MS. LI: Yeah.

MR. SMITH: But like, I'm saying, like, having the crushed materials, like, once you make a blade, the resin that triggers like a one-way chemical process.

MS. LI: Um-hum.

MR. SMITH: That's why I think recycling a blade is so difficult. That once you bind that resin and stuff like that, it's kind of done. So but is there an application for that material and a secondary application because those fibers still have value. And there's reinforcement value, and it could be mixed with other materials --

MS. LI: Um-hum.

MR. SMITH: -- or --

MR. MUSIAL: As an aggregate.

MR. SMITH: As an aggregate. I think that's where I'm going. I don't know if that's possible.

MS. LI: Yeah. It has not been done, but in theory, that can be done. People should get used to it.

MR. SMITH: That should be done.

MS. LI: Yeah.

MR. VAN DAM: Okay. We will move on to the next question. But I just want to be sure that we finish up (indiscernible) we have time. And have also some time for some more questions from the public. So the -- let's see, where do we go?

So the question five, I'll rephrase it a little bit maybe. The question is, really, what was, clearly, with these turbines onshore and those offshore, we have to get better monitoring techniques of the systems there. So what technology is out there to keep us informed about potential in the chemical issues, structural defects, and potential damage, and those new onshore as well as offshore turbines? And you know, are, kind of, these robotic systems useful in that talk -- a lot of talk about using drones for inspections, autotype of robotic systems for monitoring and maintenance. So what is -- what do you see -- what are the research opportunities? What are the hurdles there when we come to -- when it comes to these kind of technologies?

And maybe, Mo, could I ask you to talk a little about that first?

MS. LI: Sure. Okay, so this is the fifth question. Okay, the format got messed up a little bit. That's fine.

Here we are looking at a wind turbine structure, and it shows examples of the health monitoring systems installed. For example, accelerometers are installed to measure acceleration during operation. Seismic accelerometers from surface centers installed to the surface of the tower and also the blade to measure displacement or a strain, for example, or even temperature.

The current approaches -- here, it shows current approaches. A visual inspection is most straightforward approach typically by examining the surface of the structure and see if we see any flaws, any damage, delamination, and so on.

For the future, for the tower structures, it's very difficult to do visual inspection especially considering the safety issue. Now if we consider those offshore structures or those turbines in very remote area, it's also extremely difficult to do visual inspections.

Some new developments, they include the videoscopes and our flying remote visual inspection device, like drones to go there -- example here -- to get closer, take pictures, and kind of replacing visual inspection without really many people there.

So this is -- another approach is based on the vibration analysis. For example, you compare the mode shape between the reference and an inspection stage to see if there is any difference.

The third category, we will use point-based strain measurements like strain gauges attached to the surface or optical fiber sensors to see if there is some larger strain or there is some larger deformation at a certain location where the sensors are installed.

Acoustic emission method is another method, and then also, ultrasonic testing techniques, radiographic inspection, and thermal imaging methods.

So here I summarized the major challenges related to each method. First one is visual inspection including using a drone. The method works well for surface (indiscernible), or damage, or information. But it does not collect information that is below the surface. If there is delamination -- there is some internal damage, we cannot see it.

Vibration analysis requires deployment of many sensors and also requires computationally intense analysis techniques. It focuses more on the global behavior but does not really focus here on the local damage. This method is affected by the environmental change like such as weather change. The weather change can change the modal behavior.

Point-based strain measurements, they collect data where the sensors are installed. But if the damage is away from the sensor, the sensor cannot really get the information. So it's not sensitive to the damage away from the location. It's only sensitive to the surface strain change. If there is some damage, cracking inside below the surface, the sensor cannot pick up the information.

For concrete monitoring, for example, for the towers or for the foundation, it's very -- almost impossible to use strain sensors to collect information about concrete cracking.

The sensors are not cheap, either. So if you want to get more distributed information, we need to install lots of sensors, and that becomes really, really expensive.

Acoustic emission method -- more suitable to be used for blade monitoring and steel tower monitoring. They need to be near damage source to be accurate. Their measurement can be high costs, and also data contamination can be due to the noise and secondary source. But that contamination issue is more severe for concrete structure monitoring like tower monitoring because concrete has very heterogeneous structure compared to metal -- compared to a carbon-based composite. The signal passing through concrete will be highly attenuated. So analyzing the data, trying to guess what is really happening in concrete has been a major challenge in the research field. And noise and secondary sources can also contaminate the data.

Now, ultrasonic testing method requires power hungry instrumentation. Again, it is susceptible to environmental conditions. Environmental conditions can influence the test quality, especially for concrete structures like foundation and towers.

Radiographic inspection is sensitive to cracks and voids. So these advantages, but they do not evaluate the structural performance like global performance. It's also labor intensive to conduct because we need to send experts to carry the equipment out there to do this kind of inspection.

Thermal imaging method has lower resolution, labor intensive, and not very appropriate for early fault detection because the temperature develops more slowly in the early stage.

So here are some facts. The size of the wind turbine has increased over the years. It's very difficult to perform inspection maintenance due to the height, remote, and offshore locations. However, continued or real time monitoring is extremely important to improve the safety, minimize downtime, and provide reliable power generation, and also lower costs related to maintenance and logistics, especially the turbine price is going to increase with higher capacity. So we do not want to have any failure or safety issues or interruption for those larger turbines.

Research is needed having reliable -- or developing reliable, low-cost, continued, and most importantly, distributed damage sensing approach. Not just at the sensor point, but it can give us a distributed information. Things happening on the surface will also enter the surface.

If desired, the system can be integrated into the wind turbine system. That's going to benefit the wind industry by reducing the life cycle costs and make the wind energy more affordable.

Any comments?

MR. VAN DAM: Walt, any more thoughts, especially focused on the offshore part?

MR. MUSIAL: Yes. Yeah, I'd like to maybe add a few things. That was a very good list of nondestructive capabilities. And you know, a lot of that gets implemented well in the laboratory and some, you know, especially during testing. And some of it's very useful, especially some of the sensor technologies.

What we've found is that a lot of that type of health monitoring has to be done in conjunction with the turbine manufacturer because to know -- you have to know what's normal. And so that has to be implemented first, and then you measure the deviations based on a deviation from a normal state. And so we -- that's been -- and that, I think, is what's happening.

In offshore wind, the value proposition for all this technology is much greater --

MS. LI: Um-hum.

MR. MUSIAL: -- because it takes a lot of -- it's very expensive just to send someone out to see what's happening.

So I totally agree that the drones going to be very important as a first stage of inspection to see if -- see what's going on, and you can do that very quickly now. And the resolution of the cameras has gotten so good. So you can really see if there's defects on the exterior. But as you said, it's really hard to see what's going on inside, so you need more. You need cameras inside in the cell. You need other sensors on the critical components that you can bring that data through either the SCADA system or an independent, more high-speed data system to shore. And I think one of the -- this emerging capability -- or the emerging area of the field in O&M is this advanced data analytics that people are starting to look at in terms of, you know, prophesying multiple data streams and interpreting that. And the interpretations is the key --

MS. LI: Um-hum.

MR. MUSIAL: -- being able to look at that and understand there's something going on, or is something -- or are systems normal? So that's really an emerging area that every -- that's being looked at, especially in offshore wind. And I think it's going to become an important piece.

And it's just -- I mean, just to get a sense, you know, a ten-megawatt wind turbine, which is say, the top of the spectrum right now, is going to be a forty-million-dollar investment for these projects. So it's --

the percentage that goes into the monitoring equipment is smaller and smaller as the turbines get bigger. So it pays -- it's going to pay off in the long run.

MR. VAN DAM: Kevin, do you have any comments?

MR. SMITH: Yeah, I think great of both of you. I totally agree with all your thoughts. What I would add is from firsthand experience, we're flying drones, we've been sending, like, remote robots down into blades to look at inspections, to look on the inside because our whole thing is what's the effect of a defect?

MS. LI: Um-hum.

MR. SMITH: Which that whole topic is ripe for more R&D. Like, you see a crack in a blade or something in a foundation, so what.

MS. LI: Um-hum.

MR. SMITH: You have to ask that interpretation. And that's where you need to understand where is the crack, how deep is it, what is the structure around it, how long could you operate the machine or -- with that condition in place. Maybe you don't have to stop it. So I want to build on what -- I call it more of, like, a -- there's a lot of all these different ways of getting, like, status or they're kind of like different pieces of a puzzle.

MS. LI: Um-hum.

MR. SMITH: You know, they all -- these different senses give you a different out -- different view of the picture, but you -- there's this -- still a holistic picture that maybe is artificial intelligence, maybe it's other forms of how you process all these discrete signals coming into the turbine controller. Then you know what the turbine condition is -- what the wind is doing and what the turbine is trying to do.

I think there's a whole higher level health monitoring and decision making that is needed in these machines. Offshore is the sharp end of that spear because that's when it's going to pay off the most. But that's also where you're going to lower the cost of wind because you can run these machines probably much longer with known issues. Like you know your knee hurts, but you can still go for a walk. Okay, that you know your machine has maybe an issue, but you can still produce some energy as opposed to just letting it fault and sit there and do nothing. I think that's the next level the industry needs to get to.

You're right. The OEM's, Walt, they've put their arms around all of this data, and they call it proprietary. And it's even hard for the owners to get access to their own data. And so I think other parties pushing on this or developing other technologies that can bring in these different sensor streams and provide a different view for the owner would be extremely valuable for the industry.

MR. VAN DAM: Okay. Thank you. Yeah, this kind of ties into a -- really, like we just commented on, big data which is of course the analytics of big data and that's one of the big research areas in many fields, so I think this is the time -- that getting access to that data, I think that is the Achilles heel of the industry right now, I think. Anyway.

Let's just move on to the last question. I want to be sure that we wrap things up in a timely manner. So what research are needed into the environmental and technology (indiscernible) development and implementation of offshore wind energy in California?

And with that, I ask Walt, maybe, to comment on that.

MR. MUSIAL: Sure. I don't want to repeat myself because I think I actually went through a lot of this earlier.

So I think that just to kind of end this, I think that you know, if I had to pick a few, I think that investing in the local -- the technology for the local infrastructure high seas state crew transfers, a statewide coastal grid access and expansion study to understand how the power is going to get delivered into the load centers. You know, it's not necessarily a foregone conclusion in my mind, at least, that there's going to be these lateral transmission lines inland. Maybe there's going to be a more effective way of distributing it in a sub seeded backbone that goes along the coast.

So those kinds of tradeoffs should be looked at, the port studies are necessary. So if there's going to be manufacturing installation commissioning and deployment from specific ports, what's going to be needed right now to upgrade those ports so that they're ready in time for the projects to be built?

And so -- and then I think focusing on the resource, focusing on the quality of the data that we need to make accurate grid value studies and understanding the integration of offshore wind. How much can be delivered, and how will it play with solar and land-based wind as you get toward the hundred percent goal? So I think those are key questions.

And then I guess on the technology side, I'd focus on things like the deep-water mooring systems and flushing out those technical issues that probably haven't really been worked very hard yet.

MR. VAN DAM: Jason, any thoughts?

MR. COTRELL: Yeah, I would like to add something, and it's related to concrete and materials. You know, we have the opportunity -- we have a small DOE funded project to look at the application of 3-D printed concrete and offshore. And that's been a real eye opener because I'm learning more about offshore. I'm learning more about concrete and marine applications.

And I'm seeing this battle -- this classic battle between steel and concrete about who's going to win out. And traditionally, they started with steel because they put steel piles into the ground. But you quickly run into scalability issues with that and other steel structures.

And concrete is, you know, you look at this building and you look at other large structures, gymnasium sized structures, concrete scales well. And it can be -- it was made -- designed to be built on site. And so those are some of the key features about both offshore and land -- tall, land based, big turbines.

So, you know, I think there's a new interest in concrete. I would -- I'm seeing it pretty much across the globe. And it's not just because of 3-D concrete printing, but it's also some of these emerging industries.

And then one key point about concrete that I like to point out is its simple cost effectiveness. If you look at the cost of a truck's offshore structure made from steel, the finished cost is 3,000 dollars a ton for that structure. For concrete, the raw materials -- now you still have to form it, but you're looking at something like a hundred dollars a ton. So there's a factor of thirty in cost difference. Now there's a lot of other things that will inflate that cost. But at the end of the day, that raw material is what affects cost.

And then the other really important thing -- so cost and then jobs. You know, the bottom line is you don't ship concrete structures over land very often. It's just too heavy and too expensive. And that's why we have -- across the U.S. and across the world, we have concrete plants everywhere. It makes sense. It's inherently a local process which means local jobs. You effectively cannot outsource it. So that's another, perhaps, very attractive thing for California to consider in its material design. It's possibly, in some ways, a way -- a path of the future. It needs a lot of research and development especially in sustainability.

And just one final thing that I've seen recently in California is, it's amazing how much concrete expertise exists in California. UCLA, UCI, UC San Diego, USC, you know. And why is that? Well, look at the -- look at transportation, look at our strengths. So it's a strength that California has. It's a potential in that strength place with its offshore resources. So I think, really, it could be a world leader. And those technologies that California develops can then be an export to the rest of the world, therefore affecting climate change. And you effectively end up selling those technologies to the rest of the world for the benefit of us all.

MR. VAN DAM: And like those (indiscernible) down here. And I maybe opening up for a few more questions. Maybe first let's start here in the room maybe? That's right. So if anybody has a comment in the room, we can start here, and then we will open up to our online participants. Just so everyone in the room knows, we have about -- we had about fifty-two people online. It looks like we still have those.

FEMALE SPEAKER: And we have some questions.

MR. VAN DAM: Right. So, okay, let's see. Is there anyone who have a comment or question specific to this panel? In other words, if it's a general comment, we prefer to entertain that at the end.

MALE SPEAKER: Yes, I'd like to hear more about the idea of 3-D printing onsite offshore. It sounds like your research is just concrete. I'm wondering if there's also a similar type idea about resin and how that might possibly be done offshore, like, on barges or vessels. Has that all been thought through, or is that just a -- is that just too far away to think about?

MR. VAN DAM: I'm going to give that to you.

MR. COTRELL: So --

MR. VAN DAM: Is that loud enough?

MR. COTRELL: -- I guess I would say, when I think about and have thought some about, additive manufacturing of large structures using polymers, normally, it's in the context of, well, it might be too slow with the 3-D printing processes that we're using. That's a research topic that we're exploring now. And if we're not able to solve those problems, then what we want to do, and some of this has already been done already, is we want to print the molds. And then we want to fill those with concrete. And Oak Ridge National Labs has already done this for wind turbine blades, effectively. And that research can be quickly -- relatively quickly -- research isn't fast -- can be relatively quickly done and applied to wind turbine towers, to offshore foundations for those sorts of things. And you can do that at a port. In fact, there's precedence for all of this.

The Army Corps of engineers has been exploring 3-D printing of buildings, and they do it in a tent. They do it in a big tent. So if they're doing it out in the field in a big tent, there's other ways to enclose these structures, then you can do it at a port.

Now nothing -- I just want to make clear, nothing that we're proposing would be printed you know, fifty miles offshore or ten miles offshore where you might install the wind turbines, but I'm not ruling it out.

MR. MUSIAL: Can I just make a -- sorry. I just want to make a general comment because I'm not sure of the nature of your question, but you don't want to push anything offshore that you can do onshore, right, so because the labor just goes up incredibly. It'll make it not economical. So I assume you meant, maybe, at quayside or in the harbor someplace. But that's where you'd want to do it. In fact, that'd be the optimum --

MALE SPEAKER: (Indiscernible)

MR. MUSIAL: Yeah.

MALE SPEAKER: And I was thinking about the idea of manufact -- I was also thinking about your comment about manufacturing and moving manufacturing is costly the whole plant if you had something on a boat you could move it up and down the coast.

MR. MUSIAL: Yeah, I --

MALE SPEAKER: That sounds like that doesn't --

MR. MUSIAL: I think you wouldn't want to do that.

I think the goal is to get as much of the labor at quayside or onshore as possible and just do the simple stuff out at sea.

MR. VAN DAM: Right. We will entertain one more question in the room, and then we'll move to --

KEVIN WOLF: Thank you. Yeah, I'm -- name's Kevin Wolf. I work with the Wind Harvest International.

One of the things I thought was great in the beginning of this conversation was looking at the wind resource and looking at how large the market is because if you're going to do manufacturing, you need to show a big market. And all that simulates investment in. So if you don't know, really, what your resource is, do these tall -- super tall turbines -- are they going to impact birds in areas? Does that take them out of consideration in large windy areas of the state? If you don't know that, it's hard to get anybody to come in and say this is the product. So it seems a baseline research needs to be done on impacts on birds.

And the other one is the wind resource. So I'm glad to see you've mentioned wind shear. The state shows that there's a great deal of near ground wind resource because the wind shear is so upside down in the wind resource areas in California. So that means that maybe one of the things you should be looking at is shorter turbines under the taller turbines if the wind is really at fifteen to eighteen miles an hour right there in the San Gorgonio Pass that's fifteen meters above the ground, that's a tremendously valuable resource. New research is showing that you can just put small horizontals under tall horizontals. If you're going to go to super tall, maybe you'd put the shorter ones underneath.

Are there any interests or movement in the direction of really evaluating California's wind resources for figuring out what the future market should be?

MR. MUSIAL: It's a -- there's a comment. I would agree. We were talking over lunch that we think that the shear is -- the shear extrapolation question is really still -- there's some questions around the state as to where do you actually have higher shear values because you might have opportunities in the valleys north of here in the central valley. But maybe the characterization needs to be a little more refined because the topography and the weather missions around California are so unique and so microclimatey.

MR. VAN DAM: Okay, so we're really -- go ahead.

MALE SPEAKER: I would just add that, you know, wind shear is complex, not only because it varies from region to region, but it also varies throughout the day. And so that's why it's hard to -- that's why it's hard to make generic statements. And that's why it would make sense to do a more thorough characterization as far as possible. And then I just would add that if you are going to measure -- if you're interested in the winds at 200 meters high, well, you're probably going to have a tower that's also measuring at ten meters high. So --

MR. MUSIAL: Not necessarily. A lot of -- some of them are only measured forty meters and above. So if you need (indiscernible) wind shear.

MALE SPEAKER: Okay. But I do think -- I guess the point is is that there would be value in -- if you're going to characterize the site, do a thorough job at that site is my point. And that I won't use the two birds with one stone analogy.

MR. VAN DAM: All right. I apologize to the next panel, I guess. I promise we will hear someone from the our online participants. Maybe you'll entertain one question from the online, and then we'll move on to the panel. After that panel, there is another time to provide comments and we can continue our questions and answers at that.

MALE SPEAKER: Okay, we have a question from Brandon Pitchett (ph.).

Yes, a couple folks have mentioned being a good grid citizen and the duck curve in California. Is there a good map of existing wind generation diurnal patterns in different locations in California and how that typically integrates with generation mix like number 4 on the screen, and this was a while ago? So I don't know what screen he was talking about.

MALE SPEAKER: Is that a land-based question or an offshore question, do you know for Brandon?

MR. VAN DAM: Well, I guess I don't if I would like to comment on that, but we will keep that question in our set of information collected here.

MR. MUSIAL: I think -- I mean, I think, if I were -- sorry. It seemed like -- I believe the answer is not good enough. And I think I understand what Brandon's saying, so I -- but I think that there needs to be more information generated on our hourly site-specific resource. And I would say that's true for offshore. It's probably true for a land based if we don't have good assessments of wind shear and that sort of thing. I think that seems to have come out on his conversation.

MR. VAN DAM: All right. Will you please join me in thanking our panel here? Thank you.

At this point I would like to call Doctor David Stoms to kick off the second panel.

(Pause)

MR. STOMS: Good afternoon. Welcome. My name's

David Stoms. I'm also from the research division of the Energy Commission. And I'm very pleased and excited to introduce this panel -- final panel of the day. We've heard from Michael Derby and several of the other speakers about the very large potential for offshore wind.

Is this loud enough or do we need to raise it up a little more?

About the potential for offshore wind in California and its importance or potential importance for meeting California's energy and climate goals. And we've also, as Michael and other pointed out, there may be environmental constraints on some of that deployment. And so knowing what those potential constraints are and if -- and how to mitigate those could be a very important part of an EPIC research program as well as complementing the programs of other agencies and groups.

So we've put together a panel of some of our colleagues from both federal and state agencies and from the private sector to talk about the research in this area -- the research needs. This is sort of -- the outer continental shelf is kind of like a new ecosystem for us in terms of the kind of environmental research we've typically done.

And so this session is going to help us understand what the -- what research is already being done or has been done, what the research needs are -- the gaps, and help us sort of look at what the priorities that maybe the EPIC program could play a role in.

So I'm going to just, very briefly, give a high-level introduction to the session, here. Since this is a new area, we've only had a very few studies in the past. And the three that I've listed here are actually all what we consider small grants where they were sort of unsolicited topics. We just put out a general call for a general area, and people proposed applications. And these three happened to be in the area of offshore.

The first was one by UCLA looking at modeling the effects -- atmospheric effects of a large offshore wind farm and the effects on the downstream wind field and cloud formation. The second was looking at a way to monitor harbor porpoise using a passive acoustic system rather than the more conventional methods of -- so it was really, kind of, a monitoring technology approach. And the third one is one -- the only one actually funded under EPIC which is a -- using machine learning to interpret video imagery you know, from submersible vehicles to identify species -- number and types of species in the video instead of having highly trained biologists sitting there for many, many hours so hopefully, reducing the costs of those kind of surveys. So an example of that is the project from Cal Poly.

So we do have this in the EPIC investment plan that Silvia mentioned. We have an initiative on environmental land use solutions to facilitate the transition to a decarbonized electricity system. That does include marine environmental research and lists some of the potential topics. It was intentionally very high level and very general to be responsive to the information needs identified by the task force and kind of as this topic emerges. But we wanted to get it in there as a place holder. And so this workshop's going to help us you know, fill in some of that information about what those opportunities should be.

Unlike Silvia, I only had two discussion questions. But they're much more high level because it's still a fairly new area. So it's not like next steps where we can talk about you know, things as specific as manufacturing.

So the first is just the you know, trying to get from the speakers and from comments from you, what are the priority topics that we ought to consider for an EPIC program you know, that would really leverage probably a relatively small amount of funding that we could apply to this and not duplicate the work of others. But I put the word unnecessarily in there and emphasized it because we also recognize that for new science there's also a need to replicate studies for validation as well as investigate things from you know, different lines of evidence. So duplication is not off the table entirely because of that.

Second question then is you know, general focus in EPIC is to identify you know, what are the barriers to meeting our energy and climate goals. And in terms of the knowledge gaps, there could be several causes of those as we don't have enough information. Do we have the information, but we don't have you know, the sophisticated enough risk assessment methods? Or do we not have the data because we don't have adequate you know, technology to monitor and survey in offshore environments for a particular biological resource?

So I'm going to stop there and turn it over to our first speaker who's on WebEx, hopefully. And if we can turn it over to Jeremy Potter from the Bureau of Ocean Energy Management.

MR. POTTER: Can you hear me?

MR. STOMS: Yeah, we can. Great.

MR. POTTER: All right. I'm looking for the share screen.

MR. STOMS: Yeah. Have you made (indiscernible)?

(Pause)

MR. STOMS: All right. There we go. You should be able to --

MR. POTTER: You can see my screen now?

MR. STOMS: -- share your screen now. Not yet.

MR. POTTER: Not yet. All right.

MR. STOMS: Okay, here it comes.

MR. POTTER: Did that work?

MR. STOMS: Yes. It did.

MR. POTTER: All right. Thanks, David. I want to say thank you for the Energy Commission for organizing the workshop and inviting BOEM to participate. We are very excited when we saw the workshop announcement and that you all were considering a future solicitation for next generation wind energy technology as well as monitoring system development.

My name is Jeremy Potter. I'm the environmental sciences section chief in the BOEM Pacific Region. There's about five of us total in the room. So I'm sure if I misstate anything, I will be corrected pretty quickly. You may know some of the others, Netsa Sumai (ph.) Dave Pereksta, Jean Thurston, Dave Panzer are joining me.

So the charge of my talk was to provide an overview of the latest in environmental research and remaining gaps research needs to advance understanding of potential environmental impacts of offshore wind off of California. So I have three primary objectives for the next fifteen minutes or so. One is provide an update on the California offshore wind energy call areas. Two, briefly highlight the BOEM environmental studies program and the strategic approach that we're working to implement in the pacific region. And then three, to note several specific research areas of interest that might be worth the Energy Commission's consideration.

So as many of you know, BOEM State of California, through the leadership of the California Energy Commission, has been engaged in a collaborative offshore wind energy planning process to foster coordinated and informed decisions about California's shared ocean resources and many of the users who depend on them. The big news last Friday, October 19th was that BOEM published a call for information nominations to identify companies interested in wind energy leases. This is the first step to offering a location for wind leasing. The call included three potential lease areas, two off the Central Coast, that's the Morro Bay and Diablo Canyon and one off of Northern California, Humboldt.   In total, that's about 1100 square miles.

The call and the 100-day public comment are seeking two things. One is to gauge specific industry interest in acquiring commercial wind leases in some or all of the call areas. And then two, to obtain public input on the potential for wind energy development in the call areas. That could include site conditions, resources, multiple uses in close proximity to the call areas that might be relevant to BOEM decision making.

In the top right of the slide you see a URL, www.boem.gov\california. If anybody has more interest and more information about the call or if you want to get really quickly to how to put in public comments, I would suggest going to that link. That would probably be the easiest way to get there quickly.

So it's kind of perfect timing for you to set up the workshop today. I'm not going to go to an obligatory BOEM organizational slide, but I do want to highlight the two major divisions of BOEM's environmental arm which are both tasked with supporting and informing management decisions. One is the environmental science program.

MR. STOMS: Excuse me, Jeremy. Jeremy, can I interrupt for just one second?

MR. POTTER: Yeah.

MR. STOMS: Could you make your screen full-screen?

MR. POTTER: It should be. It looks full-screen on mine.

MR. STOMS: Okay, let's just go on then.

MR. POTTER: It might be the ratio of the slide. That could be the issue -- I'm wondering. Can you see the entire slide?

DR. PALMA-ROJAS: Yes.

MR. STOMS: Yeah.

MR. POTTER: Okay.

MR. STOMS: And we see the participants and other things.

MR. POTTER: Oh, let's see. I don't see that. I think that might be on your end. You can play with that for the most part. Shall I keep going, David?

MR. STOMS: Yeah, definitely Let's just keep moving on.

MR. POTTER: Okay.

Two environmental arms -- environmental sciences division is really tasked with providing the environmental information needed to make the management decisions about offshore energy in federal waters. So that's anywhere from three to 200 nautical miles offshore. That includes the environmental studies program, which is the primary mechanism that BOEM uses to fund scientists to fulfill or fill in our data gaps. That being -- could be academic, private sector, or other federal scientists.

The second arm of the environmental analysis division, which is focused on developing the environmental documents required under NEPA. So the environmental analysis group is using information from environmental sciences to inform and developing those environmental documentations. Worth noting that identification of research gaps or data gaps can be provided by either group. Certainly in the Pacific Region, it's interesting that our scientist are dual hatted. So basically, everyone has one foot in each division. This helps ensure that the environmental analysis are using the latest and best available data and information. As long as -- making sure that we're identifying what are the best data gaps or data gaps that we need to fill, priority data gaps.

Sorry. Adjusting. Okay.

During numerous state quarter meetings over the past several years, there's really three topics that seem to be coming up in many and most of the comments. Those being generally birds, marine mammals, and fish. And BOEM takes those comments and those concerns very seriously. Here, the ecological information for renewable energy -- I'm not going to go through each of these bullets. But I want to, at least, flag what are many of the eight major issues that we're considering.

These are really a lot of the information needs that we're trying to use to assess environmental energy projects based on the potential effects to marine resources.

What is really important to note is placement right at the very beginning -- the importance of placement. Location is exceedingly important. Beyond that, there are limited opportunities for a minimization and mitigation other than really operational adjustments. And at the bottom of the slide, you'll note how difficult it is to obtain information in some of the areas that we're working in, whether that's weather, remoteness, or even research vessel availability. It's worth noting that just last month we had 28-day crews just north of Point Conception, and at least over half of that was impacted by weather. So this work is expensive and sometimes hard to accomplish.

Approaching goals -- really dividing this up in terms of broad scale assessment and site-specific assessments, you'll note the second bullet on each really broad scale assessments is where BOEM feels that its niche is, whereas the site-specific assessments are what rely on industry for. Broad scale assessments include large area surveys, data centrist modeling, vulnerability assessments. And the site-specific assessments are needed more as a project level of planning and assessment such as preconstruction surveys to be able to assess the effects of construction in the operational phases of leasing and development. As I said before, the site-specific assessments are funded by the lessee.

The goal of all of these are really threefold. One, to understand the baseline conditions; two, be in a position to actually understand what the anthropogenics -- or be able to measure what the anthropogenic effects would be; and then three, ensure that design and implementation is done in a manner that minimizes the adverse effects.

This is a really short and sweet slide. But in my mind, it's perhaps the most important one in this presentation. It's a process that we're using in the Pacific Region for collecting the environmental information informed management decisions. Synthesizing existing data, collecting new data, only a small subset is technology development, BOEM doesn't really fund that very much, assessing risk, and then monitoring. In an ideal world, this is a very straightforward process. In reality, it's very complicated and iterative in many respects.

In the next couple of slides, what I want to do is explain some of the current and recent projects that we've got ongoing but do it in a way that ties right back to what this process is. So first, synthesizing existing data, and of course the first slide I show is one that's happening thousands of miles from California. But it's really just an example slide. This is at its core, synthesizing existing information. Solely collect -- it's not solely collecting and summarizing existing information and how that can hopefully inform management decisions. In this respect there were three primary questions that this project tried to answer. Each of which are listed on this slide. But I guess what I want to highlight is this was kind of an ideal case for doing this work around the main Hawaiian islands. There have been lots of groups that have been collecting data around there, but nobody had gone back to put all that information in one place and try to assess the implications of that data as well as identify what the remaining gaps are specifically in a relation to renewable energy.

In of itself, these are -- these assessment projects are powerful tools to inform management decisions. But they're also very helpful in informing future investments -- scientific investments. On this slide, it's just an example, this is a map that showed locations for cetaceans. Point, we identified distribution and mapped distribution of twenty-two different cetacean species. But more than that, we use this information to predict -- for predictive models of where distribution might take place. And in this case, because of the information gleaned from those models and the predictions, we were able to then better target research investments on future projects. For instance, right now, we have got an investment -- or a project going on with Navy and NOAA, as well, to look at marine mammal distributions around the main Hawaiian islands in the winter seasons. I can say that there is no single product like this that is ongoing off the west coast that's directly relevant to California. BOEM and others have funded small pieces of these types of biogeographical assessments, but not broad brush over the entire west coast. Is there a need for something like that in the future? Well, it is a priority that BOEM has been discussing, but it hasn't been funded to date. But the information is very relevant to try to best assess what the existing data and information tell us.

Second, collection of new data and information. Sea floor mapping is used to predict distribution of fish in sensitive habitats. This is just a picture and an image of a project that was done 2010-2012 in the outer continental shelf of Washington, Oregon, and Northern

California, a collaboration between the State of Oregon, BOEM, and multiple other federal agencies. The mapping data that was collected with this just didn't stop there. They collected, also, biological information on the sea floor for more than 400 sample stations and the used data was then turned into to projects and products to provide a regional understanding sea floor and invertebrate populations.

MR. POTTER: So using habitat, and characterization, and ground truthing to develop predictors efficient vertebrates. There is a lot -- it's interesting timing, as there is a lot of related work like this going off of California right now. Just in the past three months there have been three major sea floor mapping efforts off of California, two that are directly relevant to the potential for California offshore wind.

In August, USGS and NOAA spent essentially the entire month mapping a portion of the Cascadia Margin. A subset of that cruise was focused on the vicinity of Humboldt, including a subset of the Northern California call areas. During September, USGS, NOAA, and BOEM were working in and around what are the two Central California call areas. This is the cruise that I mentioned that was severely impacted by weather.

Vector is generally mapped south of the Monterey Bay

National Marine Sanctuary north of Point Conception. Right now, NOAA ship Shimada probably just pulled into Alameda for a short port call. It's following up on a lot of the mapping work done in the past several months, and taking a first step into habitat characterization effort, largely focused on sensitive communities, including deep corals and seep communities in the area. A subset of that work is in all three of those call areas, so it wasn't designed that way to start with.

Moving on to the third topic, which is assessing risk. I'm not going to tread too far into what Scott will likely discuss, but this is a major bird project, which we're very happy with and is a great example of looking at vulnerability or potential vulnerability of species. In short, not all birds are created equal. Vulnerability varies. This is a recently completed assessment of collision and displacement vulnerability among birds in the California current system.

It's a major collaboration with USGS, take home methods being that vulnerability is driven by species specific parameters. This is a graph of population displacement vulnerability on the X-axis, and population collision vulnerability on the Y. It highlights the differences in risk among various bird types. Some are at higher risk than others due to a variety of factors, including behavior, natural history elements, and conservation status.

Right now, I'm just highlighting the pelicans because they are perhaps the most vulnerable to collision based on this assessment. They can and they do fly high, but they are not very maneuverable. Not going to go through the rest of the various bird groups, but you can get an idea of their groupings on the graph.

This is taking the same data and looking at it for helping with marine spatial planning. Vulnerability scores can be mapped using distributions to inform spatial planning. On the left, you have collision vulnerability. And on the right, you have displacement vulnerability.

Jumping to monitoring, BOEM does have significant experiences that relates to managing large-scale and monitoring efforts with a variety of participating entities. The Multi-Agency Rocky Intertidal Network, more affectionately known as MARINe, is a long-term monitoring effort for rocky intertidal species on the West Coast.

BOEM was particularly interested in it in the beginning due to oil and gas development off of Southern California, but over the years it's grown into an incredible partnership effort. Worth noting, never underestimate how much time and money organizing these types of efforts takes. It's incredible on a geographic scope, number, and diversity of partners.

Despite the organization work, it's been incredibly successful and has provided numerous unanticipated benefits. This map shows mortality associated with sea star wasting disease, which is something that was not anticipated when the network was put into place, but the fact that it was established has allowed us to get a look on how it has grown and changed. It's helped document widespread patterns, which can infer factors contributing to the outbreak, such as water temperature.

Proposed Pacific seabird monitoring program. This is an effort that BOEM has been considering for the last several years. Whether or not -- it's not yet any decision to fund a major effort moving forward, but to me, this slide is a great example of a project that's trying to take all the steps that I've just gone through. Whether it's synthesizing existing data, collecting new dated information, assessing risk and a monitoring effort, and puts it all into one. It shows how they all fit together.

Whether or not this moves forward, we might know more in a year or so. But we are committed to this being important, especially given all of the stakeholder concerns that have been brought up as it relates to bird species.

As far as a quick wrap-up, a few research topics that we do think it's important for the Energy Commission to consider. These relate to comments that we submitted approximately two years ago, I believe. Near-shore and onshore, just (indiscernible) that BOEM particularly -- if funds work, primarily the Outer Continental Shelf, so more than three miles out. But there are, of course, implications for offshore energy development in the near-shore, whether that's actually in the water or onshore. And I'm sure the Energy Commission is considering that.

Marine mammal entanglement is an issue that many stakeholders are concerned about and that we've been working to address to some degree already in a partnership with PNNL. Also, remote monitoring technology for installations is something that definitely needs to be considered, and I think that provides a great lead in for Scott's presentation. Things like bird-strike -- we're still years out from having steel on the water, but these are topics that we need to be considering now.

And then ensuring complementarity with the Energy Commission and BOEM efforts. We are primarily a funder, not a doer of science, so we are in a position where if there are opportunities for the Energy Commission and BOEM to partner, we think that would be a fantastic effort. At a minimum, I do believe it would be helpful for us to share additional information about our past and ongoing environmental studies.

We've only highlighted a very small number of them today, and further discussions about remaining gaps and research needs. We are always open and welcome to that. We have a number of subject (indiscernible) are experts, which I think would be quite helpful. Any way to leverage, with respect to funding opportunities, we'd be very supportive of. That's what I have for you.

MR. STOMS: Great. Thank you, Jeremy. While we're transitioning to the next speaker, we probably have time for one question. Scott, you want to come up?

MR. TERRILL: Is it on? Okay. I --

MR. STOMS: Let me do an introduction, then. Okay. We didn't have any questions, apparently. So our next speaker, then, is Scott Terrill from H.T. Harvey & Associates, and he's going to drill down -- so Jeremy gave kind of a very high level kind of overview and focus on what BOEM particularly is doing, and Scott's going to drill down more on the bird species, and what's known, and what the gaps are, and what the differences are between West Coast and other places where people know more.

MR. TERRILL: All right. Yes. Thank you, David (ph.). I appreciate that. I'm going to get some place where I can see. Anyway, as Dave said, I'm Scott Terrill. I'm a senior ornithologist with H.T. Harvey & Associates, and we're a consulting firm, but we also do basic research. Much of it funded by NSF and NOAA, and that's primarily marine research. And one of our lead scientists has been doing marine research in the California Current for over three decades, so we have a lot of experience with birds and other marine associated life.

Okay. Well, we've -- everybody in this room and probably online has seen the resource map, but obviously there's a tremendous resource off the coast for offshore wind. And I think it's important to point out that although there are a number of projects in the Atlantic, primarily off Europe, these projects are in relatively shallow water, and they're near shore. And the projects off California that are currently being considered are -- primarily involve floating platforms in deeper water, so they're moving farther offshore, obviously, as opposed to the existing -- most of the existing offshore wind projects, which are in the shallow, near-shore water.

So the Outer Continental Shelf off the West Coast is quite different than the offshore regions in Europe and off the East Coast of North America. The shelf is relatively close, and quite steep, and provides a lot of topographic relief, and that topography creates highly productive waters, so the California Current is one of the most productive currents in the world. It's an East/West current and it -- as it runs into the shelf, it causes upwelling, which causes a lot of productivity.

And that topography is associated with hotspots, which we call hotspots for birds and other animals. So getting off of the shelf and putting windfarms out there is, of course, a challenge for many reasons, not least of which is the topographic (indiscernible).

Okay. All right. Thank you. So as Jeremy --

FEMALE SPEAKER: (Indiscernible).

MR. TERRILL: Yeah, yeah. Thank you very much. -- Pointed out, there are several considerations for potential impacts to marine birds. And those involve collision, displacement, the birds going around the windfarms, and lighting.

Lighting is an issue for both terrestrial and marine birds, and terrestrial migrants offshore presents an issue for some areas. But as I'll tell you in a minute, I don't think offshore California is one of the areas of intense concern.

So let's talk about those first. Migrant terrestrial birds. Many of these species migrate at night. They're susceptible to lighting if there's lighting associated with the offshore turbines, and the lighting can create disorientation, cause collisions, attraction due to inclement weather.

But the reason I mention that I don't think land bird migration is going to be the same caliber of issue that it is in the North Sea and elsewhere is that the land bird migrants do not -- part of their normal migratory pathway is not offshore because in the fall the birds are going from the Northwest to the Southeast, and in the spring they want to go up the coast. So whereas the North Sea, and the Gulf of Mexico, and even the Western Atlantic provide migratory pathways. And so in those cases, land birds are an issue, but probably not a major issue off California, especially for offshore.

So let's go ahead and move on, then, to marine birds. And we discussed collision displacement, and dysfunction of displacement, habitat loss if the birds go around the windfarms. Are they going to lose valuable habitat? And I mentioned lighting. There's lighting issues for marine birds. Some of which are photostatic, and they respond to light. And of course, you've already got spills with maintenance with the platforms themselves. Things like that, so we need to avoid spills.

So there's been a lot of studies on birds in the Atlantic, and as I've mentioned a couple of times, those windfarms are very near-shore. And those studies are applicable to some of the near-shore species off of California, but as you get to the Outer Continental Shelf, we're dealing with a whole different suite of species than our near-shore or the Atlantic. And I'm going to go into some of those differences because those differences are highly relevant to analyzing potential impacts.

And I'll also point out that the California Current has one of the highest abundances and diversity of seabirds of any places on the planet. And that's true for what we call tubenoses, which are albatrosses, and shearwaters, and petrels. And these represent some of the birds that we need to learn a little bit more about with respect to potential impacts over the Outer Continental Shelf.

Most of these birds are farther offshore than the near-shore species. A few of them are near-shore. And sort of the overall -- some of the overall differences that are relevant are the near-shore species, which are on the right side of the slide, are typically birds that fly low, except during some periods of migration. And they are broad-winged, and they're considered flappers, and so they flap rapidly. They have quite a bit of maneuverability, and they're typically low to the water.

Whereas offshore, what we call gliders, typically fly close to the water under low wind speeds. But as the wind speed increases, the flight height of these birds increases. And so this just gives you an idea of what I'm talking about. The albatross, which is a classic dynamic soarer -- and they tack, basically, against the wind. So as the wind increases, they basically glide in a high arc and drop down. And so the stronger the wind, typically the higher they go.

These birds are built to utilize the wind to save energy. They exploit highly dispersed and clumped food resources. And a lot of times when you're out in the pelagic zone, it's a long ways from one food resource to another. And the way they find and exploit food resources is using the wind. And the more wind, the less energy they expend to traverse the ocean.

And I just want to mention, too, that many of these tubenoses -- well, the vast majority of them don't breed in the California Current. They breed in the Southern Hemisphere or North of California, but they converge on the California Current when they're not breeding because of the incredibly high productivity.

So they've tasked me with highlighting, or presenting, or proposing some of the areas of research priorities that might be important to advancing offshore wind, and the permitting of offshore wind. And Jeremy mentioned risk modelling, and the report that he showed you -- the modelling is a really good start on that, and I'll get back to that in a minute.

And also, to expand a little bit on what Jeremy said, what's really probably critical is development of and implementation of remote monitoring technologies because of all the difficulties that Walt mentioned about getting out into the ocean, the expense, and the logistic difficulties, etcetera.

And this is the BOEM model that Jeremy mentioned, and it examined population vulnerability based on collision and displacement, as well as the overall population vulnerability of each species examined. And so what we're identifying as one of the important next steps is modelling using the species distribution and abundance, and we have thirty years of data -- there exists thirty years of data of height as a function of wind speed for these species. And then creating a three-dimensional model using the windscape, which is the data on wind, the information of flight height and direction by species, and the distribution and abundance, and creating a 3D model. That model could be used, as Jeremy indicated, for a broad scale examination up and down the coast, or it can be used for site-specific examinations, too. We have enough data probably, at this point, to be able to do that. At least at the broad scale.

So I think it's important to point out that we need the risk models. We need to develop monitoring technology, but at this point we have no apriority information about how these dynamic soaring birds are going to response to offshore wind turbines. It's a totally novel thing in the environment for these birds, and so finding out how they respond is going to be critical.

And that leads me to monitoring. So how do we get a handle on behavioral response to these offshore wind turbines? Well, observational monitoring is one way, and there's a fair amount of observational monitoring in the near-shore environment, and there's also radar, etcetera. But you can do that from shore. But we're faced with all of those issues that were raised earlier with respect to access to the OCS, the expense of a boat-based platform for observations, weather. You know, especially during the late fall and winter when you just aren't going to be able to get out there. So there're a lot of issues with monitoring.

And that leads to the -- I think a really important funding opportunity is to fund the advance of technology to do remote monitoring. And currently in that vein there are instrumentation technologies under development right now. Radar, of course, exists, but developing algorithms to put a radar unit out on the open ocean to try to compensate promotion would be really important, and apparently, it's possible. Optimal monitoring, acoustic, and accelerometers. So these would be instrumentation placed on the blades themselves which would record an event, simultaneously take a picture of that event, and hopefully ultimately determine what species was involved.

And some of the consideration with doing any of the instrumentation monitoring out there would be platform stability, data streams, reams and reams of data that would be collected, and getting this remote monitoring to the point where you can identify species. That's a challenge, too.

But just to give you a couple of examples right now, Shari Matzner of PNNL has been working on a stereo thermal video imagining system which can be used to detect and following birds and bats in pretty much all conditions because it's thermal. Right? So it detects heat, so you can do this in fog, or drizzle, or what have you. And the lab is working on developing a processing algorithm so that we can classify the image to species, hopefully. There's been some tested or done that's based on mass, size, wingspan, wingbeat frequency, etcetera. And so that definitely shows a lot of promise at this point.

And going back to the vibration sensors on the blades, etcetera, to actually detect and record a strike. That's being done by Roberto Albertani, and Robert Suryan, and Dr. Brian Polagye. Roberto's at OSU at the Mechanical, Industrial, Manufacturing Engineering group. Rob is at the Hatfield Marine Science Center, and Brian is at the Northwest National Lab Marine Renewable Energy Center.

So in summary, I think the most sophisticated development of risk models on both a broad scale and can be applied on a project scale, as well. And the development of some of this remote monitoring technology is quite important in terms of priority. I think that's it.

MR. STOMS: All right. Thank you, Scott. That was great. Great summary. And thank you, also, for making the trip over here to present in person.

So now, hopefully our last speaker is Chris Potter from the Ocean Protection Council, and they actually had a council meeting in Santa Cruz today to vote on some new research projects. The council was approving -- presumably presuming some new research projects, and he was going to give us an update on that and kind of their strategic thinking moving forward. And so it's going to be a little challenge. You were able to find him?

MALE SPEAKER: (Indiscernible).

MALE SPEAKER: Oh, okay.

MR. POTTER: I'm here.

MR. STOMS: All right, Chris. Great. So I'll turn it over to you, and you can give us an update.

MR. POTTER: Can you hear me?

MR. STOMS: Yeah. Yeah, you're good.

MR. POTTER: Oh, excellent. Okay. Well, good afternoon, everybody. This is Chris Potter, and I'm the marine renewable energy program manager for the California Ocean Protection Council (indiscernible) coastal policy arm of the California Natural Resources Agency.

The Natural Resources Agency is a superagency in California government consisting of (indiscernible) boards, councils and conservancies managing California's natural and cultural resources. Some of the departments include the Energy Commission, Department of Fish and

Wildlife, State Parks, State Lands Commission, and the California Coastal Commission. The OPC was created in state law in 2010 to coordinate ocean and coastal policy development for all of California state agencies.

So research priorities for the OPC, in the area of marine renewable energy and especially wind, revolve around tradeoffs or compatibility in environmental impact considerations that will have to be weighed during the planning for offshore wind in supporting infrastructure development.

These tradeoffs and environmental considerations include but are not limited to the loss of commercial fishing grounds, especially for trawlers. California's fishing communities and fishing fleets have been in steady decline for decades. As such, we're concerned about ocean-based energy projects that may place additional stressors on fishermen, fishing grounds, and fishing communities.

Proximity to state and federal marine protected areas (indiscernible) is another consideration. Starting in 2005 and ending in 2012, the state went through an exhaustive (indiscernible) process to redesign California's system of marine protected areas. The function of the network in order to increase coherence and effectiveness in protecting the state's marine life and habitat may (indiscernible) recreational, educational, and steady opportunities provided by marine ecosystems (indiscernible). (Indiscernible) investigation.

The whole (indiscernible) is foundational and emblematic to our identity as Californians. (Indiscernible) California from around the world to enjoy its beaches and take in its sweeping coastal views. So I wanted to note that coastal (indiscernible) 2016.

Compatibility with shipping is another major concern. California is home to three of the largest ports in the nation. The Ports of Los Angeles -- the Port of Los Angeles is the busiest port in the U.S., followed closely by the Port of Long Beach, and the Port of Oakland is the fifth busiest port in the nation.

And finally, compatibility with military operations, research, and development. California is home to the largest share of our country's military, a fact that is largely lost behind perceptions of California as America's bread basket, and a tourist paradise, a leader in high-tech development and manufacturing, and an international mecca for film and television. Department of Defense, Homeland Security, and Veterans Affairs collectively spent 47,000,000,000 in fiscal year 2016 and directly employed 295 residents of California.

So there are significant challenges facing offshore wind development in California. The number one challenge is cost. Specifically, offshore wind will need to compete in the market, and that includes photovoltaic with solar. As we know, there's no caveat in the state's RPS for offshore wind, and there's no official state decision for or against offshore wind technology. In the coming months and years, the state will undoubtedly need to determine under what scenarios offshore wind and other marine renewables will be needed to meet the renewable energy targets set forth in SB-100, which was just signed by the governor.

The technology risks off offshore wind are relatively unknown on the West Coast environment. For example, the sea floor off of California has a different profile than that found in Europe and the East Coast. In other words, it drops off quickly, meaning that flooding technology will be required. Environmental concerns are also some of the unknowns. For example, what is the impact of offshore wind on avian and marine life water quality? How loud will construction or operation be? Will there be any navigation hazards? We're also just beginning to understand the potential impact of climate change in ocean de-acidification on ocean conditions.

California has a complex regulatory regime that includes state and federal agencies with overlapping jurisdictions and responsibilities. Specifically, there are seven state agencies and seven federal entities that would be involved in permitting an offshore wind development, as well as cities and counties with local jurisdictions. There are also tribal entities who may be involved. There are 184 in California, of which 150 are federally recognized, and about a third are located on the coast.

Last, local governments may have permitting authority under the California Coastal Act and the California Environmental Quality Act. Transmission summaries to the state is a major impediment in bringing electricity generated by renewables to market. The greatest offshore wind resource in California are off the North Coast. The region of the state is not in close proximity to major load centers, nor does it have the transmission capability to accommodate large commercial-scale projects.

And last but not least, grid regionalization certainly has implications for marine renewables. AB-813, a bill that sought to expand California's electric grid and integrate it with the transmission systems of neighboring states, was rejected on August 31st by the California Legislature. It's highly likely that the

Legislature will take up this issue again next year during the new legislative session.

So in closing, I just wanted to talk about -- to the studies that were funded by the OPC today. The first is a research project entitled the California Offshore Wind Workforce and Wind Integration Analysis. It'll be conducted by UC Berkeley, and the time frame for completing it is approximately nine months. This project will produce and disseminate research about potential job gain, quality of jobs, and employment impact on underserved communities under various offshore wind scenarios. It will also model and analyze degrees to which offshore wind supply could address California's grid balancing and resource adequacy issues, and how offshore wind would integrate with other renewable energy resources. We'll also analyze various scenarios of offshore wind development to better understand the impact of offshore wind on the state's renewable energy portfolio.

And the second project is an offshore wind study -- is a North Coast offshore wind feasibility analysis. This project consists of seven modules, four of which will be funded by the OPC. Specifically, the OPC will fund modules that investigate on the following areas: likely and potential environmental impacts of offshore wind development on the North Coast, coastal infrastructure modifications and their impact on ocean environment climate resiliency in local stakeholders, three, stakeholder benefits and impacts, and four, implications of federal, state, and local policy in regulatory decisions under consideration that relate to the development of offshore wind energy in California. And I think I failed to mention that the North Coast offshore wind feasibility analysis will be conducted by Humboldt State University.

So that is the extent of my comments. I hope it came across well enough. I'm sitting on a bench here in Santa Cruz. (Indiscernible) less ideal situation.

MR. STOMS: Yeah. Thank you, Chris. You did fade in and out a little bit, but we appreciate the effort to be able to contact us today.

I have just one quick follow up question. Are the -- you talked at the end there about the two projects. Is that a one-time only kind of funding opportunity at OPC --

MR. POTTER: No --

MR. STOMS: -- or do you see that as ongoing?

MR. POTTER: Right. Yeah. If I had to prepare my comments over again, I would talk about what we're thinking about in the immediate future, and that is doing some type of tradeoff analysis. We are talking to some NGOs about scoping that work out and what make sense in terms of a time frame because I think, you know, there's probably a need for information for the North Coast before other parts of the state.

MR. ALDAS: Okay. Thank you so much. Thank you, David, Jeremy, Scott, and Chris. I think at this point I'd like to open the floor for open discussion, comments, or questions. Preferably starting with questions for this panel, and then any general comments you have to this topic. What I'll do is start from here in the room, and then I'll lead up to online participants. For our Webex participants, you can either type in your questions or use the raise hand button and we will unmute you.

All right. Any comments, questions in the room?

FEMALE SPEAKER: I actually have a question for you on the process of Silvia with the date needed for comments. It's coming up quite quickly, and I have a lot that I would like to offer. How strict are you on that date, and what's driving it, exactly?

MR. ALDAS: We are not very strict on that date, and we will entertain your comments even a few days or several days after that. And what's important for us are your comments and feedback.

MS. MILLS: Hi. Thanks. I'm Danielle Mills with the American Wind Energy Association. I just had a couple of questions. A couple people mentioned transmission constraints, both -- well, specifically with regard to offshore wind, but I also wonder if the commission has considered doing any additional research on transmission cost and availability onshore and regionally, and how that might compare to next generation wind costs in California, including offshore wind. I hope that's clear.

MR. ALDAS: All right. Anybody want to comment on that? What we'll do is we'll take that question, we'll put it as part of the proceedings of this, and we will put it in our summary (indiscernible). Thank you.

Any more questions or comments in the room? Okay. Let's go to our questions from Webex participants.

MALE SPEAKER: This question is from Claire Warshaw. What happens to ocean algae in the area of large-scale wind turbines? Can lighting that algae is not disturbed by be considered? I'm guessing the already existing offshore windfarms show that algae and coral adapt. Some algae, for example, probably significantly contributes more to sea wildlife plus oxygen, and California seaweed farming might be an idea to consider.

MR. ALDAS: Okay. I don't know if anybody from panel would like to respond. Otherwise, it's part of our proceedings, and we'll note the questions.

MALE SPEAKER: Okay. Jilal Abetty (ph.) has a question for the last panel -- previous panel. Any future development for offshore wind energy in state water?

MR. STOMS: So that's really a policy and market question, and so I don't know that we can really comment on that at this workshop or could even provide the correct answer to that question. I haven't seen or heard of any real proposals or push -- well, Walt probably knows of if there was any efforts in state waters, but most of the resource seems to be further offshore.

MR. ALDAS: Thanks, David.

MALE SPEAKER: And Deepak Rajan has a question for the previous panel, as well. Given the explosion of turbine choices, numbers, types, and heights in future large wind sites, what are the challenges in determining the best layout of turbines? How do we even define best?

MR. ALDAS: Looks like that's a question for the previous. I wonder if either Michael or Kevin would like to comment?

FEMALE SPEAKER: Michael.

MR. DERBY: Certainly, that's part of what we've been working on at the Department of Energy under our Atmosphere to Electrons program. We have a effort that's called wisdom. It's really designed to come up with optimum solutions for wind plants considering not only how they're laid out, what height turbines, what size turbines. It all takes in cost into consideration. It's not just the technical potential of the windfarm and how much energy it produces, but what it costs to produce that energy. And our expectation is this model that we've developed is going to be taken up by industry and used for helping to site future wind plants.

MR. ALDAS: Thank you. Do we have any more questions? Any raised hands? Okay. So I think at this point -- do we have any more sides to show? Okay. I think at this point I would say -- I will thank everyone from the first speakers all the way down to the last panel.

So what we'll do -- what we'll do is that we will gather all the comments and feedback. The Webex is recorded, so we'll have somebody to kind of transcribe that to make sure we don't miss any points, or questions, or comments that were raised, and then we will enter the additional read-in comments by our dockets. So we mentioned November 1st, but I also mentioned a while ago that's not a strict deadline. If you have comments that you want to send after that day, we, of course, definitely look into that.

I mentioned that we will pose the presentations after this workshop, so we'll do that. I guess we will touch back our panelist speakers just to make sure that they are okay with all the slides that are submitted to us and give the opportunity to refine or trim down if they want to. Preferably, this is the same presentation that they presented today.

And then I guess any more that we --

DR. PALMA-ROJAS: Also just to add to that, we are planning to pass out a summary of the workshop with the main feedback and comments. And also, if you can use the dockets system to submit your comments, also will be great. It will be easy for us to compile all the comments, so the information is on the screen how we can go and submit the comments.

MR. ALDAS: Okay. And with that, I would like to thank, again, everyone. This is the end of the workshop. I will you all have a safe travel back and have a good rest of the day. Thank you.

(End of Recording)

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