SESSION III. REALIZING THE PROMISE OF BIOFUELS IN DEVELOPMENT

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Moderator: **Ambassador Melinda Kimble**
Speaker: **Birgitte Ahring**

Ambassador Melinda Kimble
Senior Vice President, U.N. Foundation

I'd like now to turn to Dr. Birgitte Ahring from Denmark. Dr. Ahring is actually a private entrepreneur, a researcher, a scientist, and a policy advisor. She works in this very, I would say, much higher-level area where she is looking at how to ensure that bioenergy – in particular, second-generation bioenergy – delivers on its promise. I think she will be a nice contrast to our other speakers, and I'd like to turn the floor over to her.

Birgitte Ahring
Professor, Technical University of Denmark
Head, Danish Center for Biofuels

Thank you; thank you very much, Melinda. And I would like to also thank the organizers for the possibility to come here and talk about my passion in life, which is to create bioenergy. And I'll try to pull together here some general things and also some perspectives about where the technology is actually standing today. And I call the title of this talk, "Can we produce biofuels without affecting food production and the environment?"

There is this statement I always like to point up, which is the unique role of biomass, which actually DOE defined actually a while ago. And it's saying that we can actually produce renewable fuels like electricity in many different ways – we have all kinds of possibilities. When it really comes to making liquid fuel or making chemicals, we have very few options.

And one of the options we have is actually to use biomass. And I think this is a very important statement because it really is saying that if it has to be renewable, these areas have to include biomass.

We have two types of technologies right now. Of course, we'll see many more coming up over the coming years. We talk about the current technology, the first generation, which is starch-based and which we already have discussed yesterday, which we use, for instance, sugar cane or using corn as the major feedstock.

Future technology – as I'm sure you now probably have envisioned after hearing it from all kinds of speakers at this meeting – is a technology where we can use residues, agricultural residues that are not in conflict with food and where we can actually make dedicated crops that could have a high yield and really perform the job in a good manner.

We have already now many, in the United States, a lot of first-generation biorefineries. They are placed all around, and many more are actually under construction. Just this year we heard that a large number of new plants have been put into operation.

If we actually go and do an analysis – and this has been done very well by a professor from Berkeley – and look at actually the numbers that come from looking at technologies using corn, making corn-based ethanol, and looking at how much greenhouse gas we actually use per unit of fuel now produced and how much net energy we actually gain from it – the red star you see is actually gasoline, which is the base case, you would see to the right that the green round dot actually shows that you have very little net energy and you have actually not a lot of greenhouse gas reduction by using corn as a fuel for ethanol and as a liquid fuel.

But if we actually turn to the far right, you see a completely different picture. The picture now changes. You have real nice 80 percent CO_2 reduction compared to gasoline, and you also have high net energy. So now you actually have value for money. You actually get both high net energy and good greenhouse gas reduction. So that's why, in this perspective, maybe the first generation paved the road, but the time is up now and it is urgent to move on.

So as we know, and we heard it already and a lot of figures have been up, but in the year 2050 there will be maybe even more than 50 percent more people, and there will be 50 percent more cars in the world. And that's probably even a low number. And it puts the conflict on the table – Are we going to feed the cars, or are we going to feed the people?

And we already know that there have been these political tensions, the tortilla growers in Mexico and other people who actually have pointed to the fact that there is a competition.

The global vision for biofuel is very well outlined here. We see the U.S. perspective where President Bush quoted the use – actually, of all the production and use – of 35 billions of ethanol by year 2017.

And as you see on the low part of the graph, if this should be done with first generation, it could only give twenty – the maximum, using all possible means – would only give the 20 billion gallons so the rest has to come from second generation. And this is also why there is a major push right now, actually also a major funding going into the field. So this gives a very good perspective for the field.

So let's now go to technology. How is it, actually, when we come to second-generation biofuels? What are we dealing with? We are dealing with a raw material that's basically the major component is sugar, but the sugar is in a different form than what we actually have in a starch-based crop. The sugar will be like in cellulosic form or hemicellulosic form, and we will have a third molecule, the lignin molecule that would be there in up to 25 percent of the whole raw material.

And lignin is made with the purpose of giving the plant strength and also for prevention of microbial degradation. So basically lignin is one of the things we have to solve. If we want to do second-generation biofuels, we have to have a technology that detaches the lignin molecule away from our sugars. And this is the number one technology we need.

The second part of technology we need is a technology that can use all the sugars. It's not enough to have a technology that can use the glucose, the C6 sugars. We also have technology that can take care of the rest, the C5 sugars.

So with that in mind, I would like to go to the next slide, and that actually shows the way that we have approached this whole area. So what we said already when we designed – and this is 20 years of research and many, many people who were actually involved in this development – we said we need a technology that can do the job. It has to be able to depolymerize lignin, take it away from our nice sugars. But we also need technology that has all the sugars.

And finally, we need to make sure – and this is why we call it the "carbon slaughterhouse idea" – we have to make sure that everything that goes into such a unit has to be used. We cannot have a situation where we bring a huge amount of biomass into one spot and leave a lot of it unattended. If we do that, we will create waste, wastewater, and we create a lot of environmental problems. So what we said was, we need appropriate technology, we need a sustainable process, no input of water – lower the water need as much as possible within the process.

So what we did was we created a pre-treatment. It's a very nice pre-treatment; right now, it does a fantastic job. It's a steam explosion-based pre-treatment. I'm not going to go into details, but it does the job, and it makes a very nice slurry even out of hard, dry-matter biomass materials.

We also then created a two-step fermentation process, one taking C6, one taking C5, using first these and secondly a thermophilic microbe. And we create a solid fuel out of the lignin product, that is, the high-molecular lignin that's left that you then can market.

Finally, all the dissolved organic material that is in the water, the processed water, we turn into methane, and by doing that and then afterwards actually taking out the salts, the alkali salts that are in the raw materials, and using that as a product to actually go back to the field as a fertilizer in a concentrated form, we can close the water balance. This is an example of sustainable second-generation process that now has a lot of elements that actually right now are under testing on a larger scale.

We have a pilot facility that was built and put into operation in August 2006. Our spinoff company, Biogasol, has been a big part of this development and has tested a lot of different feedstocks in the pilot facility and is having actually a view now to how it actually looks. This is what we gain. Out of our raw materials that go in, you see we get a lot of products, and actually no wastewater, but energy products in a variety. And the lignin you can use for combustion or you can make it, by gasification, into more liquid fuel.

We also did an energy balance; it's a big work actually to do, but the fantastic beauty of this biorefinery, the MaxiFuel concept, is that actually it creates very high energy efficiency. Net energy is 69 percent for this base case where you have straw, 100 percent energy, and you actually have all the different elements that are produced in the biorefinery accounted for. And you can see that we fuel the whole process; the process takes around 12 percent of incoming energy part, and that is fueled internally by the energy product that we actually make in the biorefinery.

So what about the next step? The next step is a huge amount of different things that are actually going on at the moment. We're trying to focus on very much. We have some projects in the United States, we have projects now going on in Denmark, of bringing this into a bigger scale. And we are in the process of finalizing the first demonstration plant that we are going to build, starting and generating 2008 on an island called Bornholm in Denmark.

It is a concept where we use feedstock that is available, and it has no use already on that island. So we actually take grasses that are a cash crop and after crop after normal corn production. We take wet wheat straw, which cannot be used for combustion at all. We take manure fibers coming from a large-scale biogas plant, which cannot use actually the fibrous material without our pre-treatment method. And we take garden refuse and actually also some paper waste from the island, bring it all into the plant, and this is how it's going to look.

This is the model now after the final design phase. It will be a plant that will treat 40,000 ton of dry matter, and will give 10 million liters of ethanol, 2.7 million gallons of ethanol, and approximately 15,000 tons of lignin pellets and a large amount of methane where some of the heat that comes actually from the electricity production from methane would be used in the local city that is surrounding the plant.

A full-scale plant, how does that look? We have now here actually the figures that have come up from all the testing we have done. And as you can see, it will take a lot of biomass material. This is actually a small full-scale plant, and this is the – the other model was a 10 percent, this is the 100 percent. So now we are up to the 27.5 million gallons of ethanol, or 100 million liters of ethanol.

And what about economics? Yes, you can see that we have done a lot of work on that, the techno-economic model that actually has taken everything into account, which is based on actually a lot of the model that is coming out of ENRO, gives us price per liter of ethanol that is 30 U.S. cents for a feedstock price of $55 per ton. So it actually looks really – with a high perspective. So maybe we can get fuel now without subsidies, and that's exactly what we are working on.

So what else can we do? This technology has the beauty that it could also go in and help the first-generation biofuel plants. They have DDGs, which are shown here in the figure in the bottom, both the wet and the dry meal. And that actually, when you have the pre-treatment methodology and you have the C5 fermentation, you have the possibility actually of making up to 20 percent more ethanol and getting even better feed out of this because now it's more highly proteinated, more protein; the low-quality starch has now gone into more ethanol. And this is actually something we work with actually of putting online here in the States.

We know the sun (and this is finalizing), the sun gives. That's what we all live off, and that's what comes in and gives the biomass material that we now have to encounter and use. And what you harvest is what you actually will sow. And that is a very important lesson, and this is actually, I just took it in.

If you look to the left, actually the column is sugar cane, and you show that sugar cane actually can use around 7 percent of, can harvest around 7 percent of the incoming sun, while corn would only harvest around 2.2 percent. So you can see there is an enormous difference. And if it's wheat, it's even worse. So we have to really think about what we do for the future when we are going into this field.

And this is what I put into this slide. I took some quotes: "Corn is not the future fuel crop." That's for sure – you need seven gallons of gasoline to make ten gallons of ethanol, and it has very little greenhouse gas reduction, like we discussed.

And if we actually use the right crop – this is a quote from a professor from Stanford – we would need only 3.5 percent of the earth's surface to power the whole world, with the earth's energy demands of today. And we use actually 13 percent of our available land for agriculture, so you can see that this doesn't seem out of reach.

And, "A suitable crop could be a perennial prairie grass" – like switchgrass, which actually has high yields, very little water use. That last quote is actually from Vinod Khosla. He's a big venture guy for this, but of course he has also a lot of vested interest in this field.

Okay. My final slide is actually something that I think is very important for all of us to know and envision. That is, if we do not make the solutions now, if we do not succeed getting second generation now, and very fast, on the table, what is the alternative?

The alternative is not that the car will be in the garage. The alternative will be that people will start with tar sands – and you see now that you get much more CO_2 actually emitted compared to crude oil. Or you use coal to liquid – a really, really bad solution when it comes to our atmosphere.

So with that, I would like to leave this off. And thank you.