Megatrends Reshaping American Agriculture

Q&A

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Irwin Goldman (University of Wisconsin): For Peter Ashcroft: I'm unschooled in the policy scenarios, but I read that the cap-and-trade system, the carbon-cap system, has the potential to create a vast capital market. How will the creation of a capital market figure into the equation and the support for that? Is that true for the other types of policy approaches? And if it isn't, does that give it any more push?

Peter Ashcroft: Maybe one of the things I should have been clear about is that those various policy tools aren't necessarily incompatible with each other. It's not necessarily an either/or situation. So, for instance, the renewable-fuel standard included some performance requirements and it's entirely possible and desirable that a cap-and-trade system would have some complementary policies. For instance, maybe a low-carbon fuel standard that would apply some additional influences to transportation and to fuels. So, they're not meant to be mutually exclusive.

Tom Richard (The Pennsylvania State University): Peter asked if we can make that much corn ethanol in a short period of time and I think that there are people here who might be able to respond to that in terms of the yield increases to expect over the next 7 years from that particular crop. John Pierce actually can comment on that as well, but a few percent a year is not going to get us to doubling. I did notice on that slide that you had 17% exports for corn last year—not too far away from 25%. When you think about the fact that feed is the largest part of the use of corn in this country and the potential to recycle some of the byproducts, as you mentioned, I think there are some issues there. Fundamentally though, the point we all need to look at is that, over the last couple of years, we've gone from many decades where we could overproduce from our agricultural system. We were exporting because we could produce more than we needed and markets didn't always exist for all that material. When we put energy into the equation, the markets

are huge. They are insatiable. At least in this country they seem to be that way. And that changes the game. This means that land is now a fundamentally precious resource and we have to increase its productivity for all of the things we need, whether it's food or fiber or flowers or whatever. And fuel is just part of that equation.

John Pierce (DuPont): I'm not sure there's a question left to answer, but I think there were two challenges. One is how do you double production in the near-term? How do you get to 21, or so, billion gallons of so-called advanced biofuels (which many people think means cellulose when there's a broader definition than that)? I agree with Tom. Agricultural productivity is going up at a faster rate now than it has in the past number of years without corresponding increases in alternative demands, which could go straight to fuels. There's a bigger challenge in obtaining the technology for advanced biofuels. For 21 billion gallons, somewhere between $40 billion and $100 billion of investment will be needed. However, in the fuels industry that's chump change. So people ought to be able to find that. The technologies are emerging. We're going to see some this year and next year. I think it's going to be a challenge to get production facilities sighted appropriately and to deal with feedstock supplies, but I do think that the fundamental processing technologies will be there. The capital will be there, but whether you can build it fast enough and whether you can find enough stainless steel all at once, I'm not entirely sure.

Uko Zylstra (Calvin College): A question for Steve Pueppke primarily: I appreciated your analysis as far as a shift in understanding with regard to farmers, is concerned, and how they relate to the food system. Although farmers in the twentieth century did not concern themselves much with the consumer or the food system, there were some major players in that food system that did determine policy and still determine policy. And even though consumers are now more concerned about where food is coming from, to what extent do you see food policymaking being put into the hands of different people? In other words, whether ADM or whether it be the meat packing CEOs that you referred to—they often are the ones who shape food policy because they control the system. Will the food system become more decentralized so that more people will have input?

Steven Pueppke: The players in the food system are responsive to the consumers, and my little quote from the CEO at a meat packing company was an example of that. We can be pretty sure that they will respond to what consumers request. We shouldn't view consumers as being monolithic and all wanting the same thing. We'll see more and more consumers segmenting or differentiating and wanting different things. You and I both live in a state where fresh and local is a big issue right now. That will create opportunities for some that will be irrelevant for others. So, we are in for an interesting time where a lot of different things are going to happen, but I would not discount the power of the consumer because, at the end of the day, the players have to meet the consumers' needs.

Charlie Carr (The Andersons): Peter, you mentioned a dollar per gallon cellulosic fuel credit. Is that something in the Farm Bill? Or what is that? And who gets the credit?

Ashcroft: It's in the Farm Bill. It was recently passed, so it hasn't historically been true. It's new, but if it operates the same as other tax credits, it doesn't go to the person who produces the cellulosic ethanol, it goes to the blender. The implication is that the blender will pass it along to the producer. People can argue about whether or not that's what happens, but that's the way it works.

Allan Eaglesham (NABC): Dr. Lee, how much does your 1-kilowatt fuel cell cost to the buyer, what are its maintenance needs and what is its longevity?

Benson Lee: Installed fuel cells are largely demonstration and test systems. So, nobody can give you an answer as to actual cost and maintenance. Those that are out there were engineered by people who put them into space, and while they have pioneered a wonderful market opportunity, the rest of us are not going to have the luxury of getting paid what they got paid for theirs. Now I can try to give you an answer, but it's theoretical. The life of a high-temperature fuel cell should be in the 4-to-5-year timeframe, 40 to 50 thousand hours continuous service. In terms of the maintenance, there are no moving parts in a fuel cell; it's a chemical process. Maintenance of pumps and compressors will be required, and engineering of more durable units will be required for the fuel-cell industry. In terms of target price, all of us recognize that at low volumes we are going to have to pick off the early adopters and go into markets that are less price sensitive. Most of us are looking at what solar is getting today, which is on the order of $10 a watt and I would think that you are going to see entry points up the kilowatt scale at that point. The first fuel cells that you are going to see will be battery replacements and those are coming to the market now. But those are different types of fuel cells. They are not intended to run for years and they are nowhere near the kilowatt scale.

David Koetje (Calvin College): Microalgae have been getting some press lately. There was a study several years ago funded by the Department of Energy, I think, that suggested that microalgae have potential as a biofuel source from algae farms in places like the Sonoran Desert. Nobody has said anything about that yet today. Is anything in the works regarding that?

Pueppke: There's immense interest in algae for oil production that could be converted to diesel. The theoretical yields per acre are absolutely unbelievable, but a number of issues need to be solved. For example, if they are grown in open ponds, think of the issues of trying to keep the culture clean—essentially a 640-acre petri plate. If one would use closed containers, plastic bags or things of that sort, which have been suggested in the desert, then the cost issue must be deal with. But, in theory, the combination of the high yields plus the relatively simple extraction of the biomass to yield the oil makes it very, very attractive. In Michigan, we have certainly seen people coming out of the woodwork with great interest in moving the technology a little faster than perhaps we are really prepared to do, given what we know today.

Pierce: There's got to be a dozen or more companies in the United States alone working on various aspects of that—trying to balance the capital costs of enclosures vs. open ponds—all that kind of stuff. Most often they are finding a need to make early competitive bids to have co-culturing of the algae with some other, let's call it higher value, product like fish, and then you get biofuels and seafood out of the same pond. Or, if you supplement the atmosphere with carbon dioxide the algae grow faster. So there are schemes to site algae ponds close to ethanol facilities, for example, that make lots of carbon dioxide, or next to coal-firing plants. Some outfits in New Zealand are doing that too. We still have got a long way to go. The National Renewable Energy Lab ran a program for some 10 or 15 years, quit, and is now starting up again. I happen to agree that oil prices are not going to go down as far as they've been, and $100 to $130 oil makes a lot of things possible.

Lee: We would love to get our hands on some algae oil to see if that can be added to our portfolio. And if it can, we can take our fuel cell to the algae pond, run it directly off the oil and hand back, to those that are covered, heat and carbon dioxide and electricity, which might kick up the efficiency and the economics of the overall algae production. That's a wonderful combined opportunity for distributed power and heat generation.

Michael Long (Resource 100): In one of your slides, you had a small-scale biomass-to-energy system. One thing that was missing there is the fact that, since you are running that system on waste material, you have an additional revenue stream that may make this project work where it wouldn't in other cases. You get more income than just the production of power and heat. Please comment on how the economics works with the avoided costs and the additional income.

Lee: That was a soft ball. Mike Long is the well known director of the Solid Waste Authority of Central Ohio here in Columbus, and he's absolutely correct. As we look at waste as a feedstock for many of the conversion devices, one of the compelling arguments is accompanying cost offsets. Mike, why don't you speak to it, because you have taught me everything I know.

Long: If you recall Benson's slide—he didn't describe it in detail—along the left side were listed waste materials from restaurants, grocery stores, hospitals and other institutions. If you think about the chain of custody, starting at the farm and moving to the food processor, to the grocery, the restaurant and the home, at every step along the line waste is created. So the question is, how can we gather that waste in a cost effective way and direct it to some sort of a facility where we do not have any negative environmental impacts? I'm not looking for direct combustion, but I'm looking for conversion of waste biomass into fuels that can then go into small-scale systems such as Benson's, avoiding transportation costs. In the waste business, moving stuff around is 75% of the cost. When you pay your garbage bill, you can bet that 75% of it is for moving it from the curb to the landfill. So, if you can take transportation out of the equation by putting in a small-scale system, you make projects like this cost-effective and produce a lot of energy at the local level.

Lee: In my talk I mentioned that a number of megatrends would be emerging and what you just heard from Mike is one of them. The notion of converting waste to energy is well known. The thing that Mike has taught me is the best way to deal with solid waste is to not let it occur in the first place. This is an exciting area that is starting to emerge and its got to take off.

Larry Curtis (Oregon State University): John, is DuPont or any other large chemical company investing in liquid-fuel molecules other than butanol or ethanol—any other ideas out there for energy-rich small molecules?

Pierce: I don't know what other companies are doing. I don't want to oversimplify it, but a fuel molecule is something that burns in the presence of oxygen. It's not real fancy. If you put gasoline or diesel through a gas chromatograph, you get lots of peaks and they all work just fine. One of the issues in using renewable resources is that you start off in a highly oxygenated state, whereas most of our existing fuel molecules are entirely reduced. So you need to find a way to get rid of those oxygens if you want to make it just like diesel or just like gasoline, and, in fact, some small companies are doing that. Half a dozen small companies are looking at making more gasoline-like and more diesel-like molecules. DuPont has a hydrogenation technology that makes triglycerides more like diesel, but conversion volumes remain small. I think that the world is open to that, but there are some fundamental thermodynamics that you need to deal with when you go from highly oxygenated to highly reduced molecules, which is why we landed in the middle, as a kind of optimum. There's no reason you couldn't land in another place in the future, but I can tell you that DuPont isn't doing it. DuPont is doing butanol.

Bruce McPheron (The Pennsylvania State University): I want to take off from Steve's presentation where he implied that our paradigm has shifted. Whether it was a complete transformation or something more gradual, we need to think about different things and I want to turn to the other three panelists, who spoke about various aspects of bioenergy and moving into a biobased economy. The other product beyond the research that we do at our universities is obviously our educational portfolio. In your disciplines, what attributes should our students have to be successful in this new world? Steve set the question, so he gets off the hook here.

Lee: They should challenge the very effective silos that have made America's great research universities and challenge whether that is the way to go forward. The point that Steve made is that where universities have done a great job is they understand that their mission is to teach critical thinking. The problem is that most of the time it is restricted to a narrow field and thinking laterally. Crossing into what we will call the "softer" sciences is what I heard. You start not by looking around the university, but by going out and listening and observing more than teaching. So that would be it from my side. It's very difficult in our business to teach top engineering minds to look at the softer areas because they are so adept at dealing with hard numbers and metrics. And it's even more difficult to take

them into a field like fuel cells. That's called disruptive technology. There's no paradigm or blue print on how you move it into a market. This is where the entrepreneurs' comfort level in leaping into ambiguity puts them well ahead of scientists who absolutely wouldn't think about leaping into ambiguity. We'll just plunge in and we will figure out a solution when we get there, but don't ask me beforehand what the solution is going to be. I think a blend of the two is what we can put together in this country.

Pierce: I'll add to what Benson was talking about—the softer side. I was thinking of folks that really can do integrated science and technology and that requires a little bit of the "softness" that Benson was talking about. The group I run is called "biochemical sciences and engineers" and we have all of those types of people in there. Initially, their inability to talk was profound for some of the reasons that Benson cited. Scientists are fine with ambiguity. Engineers can't stand it. And you have to work on that together because, when you have an engineering mindset it's reality based and its not going to be head-in-the-clouds forever. When you let them roll around in that multidisciplinary ambiguity for a while, major things can happen. Maybe we're saying the same thing in different words, but integrated science and technology is what's going to have to work, especially when you look at something that goes all the way from a farmer planting a seed to some polymer or some fuel cell working away or some diesel molecule. An enormous number of hands have to touch it. It's a fascinating time.

Ashcroft: At the risk of just echoing the insights that the other speakers have offered, I would also say that intellectual agility or diversity or breaking out of the silos is the most desirable aspect in education. If you can't be excellent in all fields, at least be conversant enough that you can talk to those people. So, you're not an economist but you understand the language enough to talk to people who are. That's a recipe for personal satisfaction and personal success in your career; but, also, its necessary because, frankly, the challenges that we see are almost overwhelming if you think about them deeply enough. The only hope we have to rise to the occasion of addressing these huge social challenges is by revolutionary approaches and breaking out of the silos.

Steve Howell (Iowa State University): Regarding the goal of 21 billion gallons of cellulosic ethanol by 2022, I'd like to get an industry perspective on this in terms of where we are with respect to being able to technically produce that volume of ethanol using cellulosic feedstocks. As I see it, there are innumerable hurdles in the biochemical approach and the fermentation involved in getting there. What's the industry perspective on either the biochemical route or the thermochemical route of being able to reach these kinds of goals by 2022?

Pierce: We should see legitimate working facilities of both thermochemical and biochemical persuasions in the next 18 months or so. Now, which of those will turn out to have an advantage with respect to feedstock that allows them to work, and which of them can be generic enough that you can place them in a random location in Iowa and allow

them to work, I don't know. At DuPont we have a long history with, for instance, syngas production and synthesis with molecules from syngas and all that catalytic thermochemical stuff. We've done an analysis and our conclusion was that the biochemical route is the near-term way to go despite the specificity of some of the steps of that route that cause headaches. Although we like the lack of specificity of the thermochemical route, we've picked, right or wrong, the biochemical route. I think the good news for society is that every route you can think of, and some you have not thought of, are being studied even as we speak. I hear rumors of big plants firing up later this summer that no one has heard about, with some wonderful new technology. Okay, that's good. As I said, we just recently doubled up a bet by doing a joint venture with a company called Genencor which provides some of the enzymes needed to do the saccharification. We're absolutely convinced we now have the pieces to do that. And every other kind of technological do-dad you can imagine that can be applied to this is being applied by someone. Who's going to win? I don't know. Twenty-one billion is a lot of gallons and a lot of capital dollars. Over the next 2 or 3 years some legitimate-sized facilities will be out there and we'll be able to see. The first one is not the trick. It's the second, one right? Because when you build the second one that's like the clue. Right now, everyone is building their first one. The second one is a few years away.

Ashcroft: It's been suggested that part of the reason that corn ethanol grew so fast recently was the 2005 renewable-fuel standard; because, even though the number wasn't huge by our new definition of huge, it guaranteed that there would be a market for the product. It's possible that the advanced biofuel mandate will prove to be very useful in the sense that they guarantee a market for the product in the year 2022 independently of whether the number is 21 billion gallons or 15 billion gallons.

Pierce: 2022 is a little bit away in terms of the rate at which technology is improving. If you had asked at the start of this ethanol boom whether we'd be able to make as many gallons as we are today there would have been all kinds of reasons to say absolutely not, there's no way to do it. I wouldn't discount the ingenuity of the American farmer or the American entrepreneur or the American engineer, with these types of mandates in front of them.

John Glaser (US Environmental Protection Agency): I have two questions. First of all, linking to the question previously asked, and also some of the predictions, or at least perspectives, offered in Peter's talk, it strikes me that we are talking around an invisible elephant in our midst and that is dependable agricultural production. We are positing, at least in part, that we can rely on corn or some other carbonaceous material as feedstocks for these biofuels. I suspect and suggest to you that, in that perspective, we are really technologically focused, that is production-technologically focused for the biofuel and not agriculturally focused. There are many ways we can lose crop yields on the agricultural side. We have not worked into the agricultural yields the expectations of meeting these fuel goals as influenced by weather, insect pressure, *etc*. We are going now, in many cases,

to corn on corn exclusively throughout the corn belt, which is going to have deleterious effects on the soil. We'll have to apply more fertilizer and other treatments to maintain yields. Right now we are getting some spectacular yields in the central part of the cornbelt but, the fact is, we are projecting an enormous amount of expectation that that will be a static basis that we can build on. And I suggest to you that it's a fool's paradise to expect that situation to stay in place. So that's question one. Question two, which is to John: in your biobutanol technology, do you have a US production facility? I have read that your work with BP is centered in the United Kingdom.

Pierce: I think your assertion was that agricultural productivity goes up and down over the years.

Glaser: It doesn't just go up and down. It is highly reliant on uncontrolled components.

Pierce: One of the main parameters driving our Pioneer seed business is yield stability. We couldn't agree more that this is a profound difficulty, not only for biofuel producers but also for farmers. I would say that the way you could deal with the swing, mathematically, would be based on how much variation you expect. So, if you need fifty units of something you should arrange to have access to seventy-five and then you could depend on never having less than fifty. And then the question would be can you afford to do that? And that applies whenever you have an innovation in agriculture. If you come out with a new corn plant or high-oleic soybean, you want to be sure you have enough oleic oil. You better ask for more because you never know if that's going to be a year when production is low. Therefore, innovation has to pay for that early overhead until it fills up enough of the infrastructure that you start dampening out those effects. I understand your general point. I don't know specifically where people are assuming something at odds with expected reality. There may be some, but I don't see that 21 billion gallons in and of itself is at odds with an expected ability of US agriculture to produce the raw materials. Were you asserting that you thought it did?

Glaser: No, I was reflecting on our current dependence on corn. Corn certainly is a good starting point, but to suggest that we can double the production in the timeframe that has been identified—I just don't see it. But I can be proven wrong too.

Pierce: I understand. Well, I will tell you that, at DuPont, we have big expectations built on trying to make those targets come true. In fact, we do have a lot of interesting things in the pipeline—as do other seed companies—that have rather dramatic yield-enhancing capabilities like drought-tolerance and improved nitrogen-use efficiency that have been the bugga-bears of traditional agriculture.

We are working with BP, but butanol is not some kind of European fuel although it is important for Europe. The United States and Brazil have all these nice ethanol-blending facilities all over the place. Europe doesn't have those, and so the ability to interact with the pipeline infrastructure in Europe is particularly advantageous. But, we also have a

blending wall today in the United States. When I go to the gas pump in Wilmington, Delaware, it says, "May contain up to 10% ethanol" or may not. But the point is that ethanol can't get from Iowa to Wilmington with any surety. And part of the reason is because of lack of infrastructure even in this country. So, it will help out here also. We're piloting abroad but we are planning on producing in the United States, absolutely.

Michael Kahn (Washington State University): The way I interpreted the question just asked is a little bit different, and I'd like a comment on it. Because we are having a problem with global warming, which is caused by a very large scale emission of carbon dioxide from fossil-fuel burning and other things, what would have been a minor perturbation on a small scale becomes a major thing when we scale it to the consumption that we have in the United States. I think the estimate is that if the entire world burned gasoline at the rate that we are burning it, it would be something like two and half earth's capacity. Where is conservation? Peter basically said commuting is not something we can deal with in the short term. Solid waste—clearly if you don't generate problems they are not there to solve. Where might be the next problem? Because if we move to large-scale cultivation of switchgrass or, if we move a large fraction of our corn into ethanol, where do you see other problems coming and how do we deal with them? Peter pointed out that the new Farm Bill has a fuel standard that is much higher than the current fuel standard. In fact that's sort of a trick. It turns out that the way gasoline mileage is calculated is on the basis of miles per gallon of gasoline that's burned and if you have a flex fuel vehicle then the mileage is assumed to be 50% on 85% ethanol, which effectively doubles your gas mileage for the cost of putting in about $200 worth of piping. It looks good, but it's a trick. How are we going to come to grips with these sorts of things?

Ashcroft: Working backwards, you are absolutely right in that when fuel performance is calculated for a manufacturer's vehicles, an assumption is made about flex-fuel vehicles that's a very arguable assumption. That's a detail that we'll work out one way or another, and I hope it works out in a way that leads to the most efficient vehicles. But no matter how that's worked out, it's pretty clear to me that simply improving the efficiency of our vehicles isn't going to be enough to single handedly reduce greenhouse gas emissions by 60% to 80% if we are ignoring those other terms in the equation, the vehicle miles traveled and the fuel characteristics. So, I don't want to minimize the importance of the accounting that's used when EPA decides whether or not vehicle manufacturers have met their legal requirement, but I'm saying that, regardless of how that works out, we've still got a big problem. You mentioned conservation and I guess that corresponds to the vehicle-miles-traveled factor in the equation. I think that is something that can change over time, but it doesn't change quickly. And, as I mentioned, it's difficult to reduce the total number of vehicle miles traveled when the population is growing. The vehicle miles traveled are affected by things like the layout of our cities. Those are things that can change over time and, as public-transit systems go in, they can change over time, but they don't change quickly.