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INTERVIEW WITH CHRIS ZYGARLICKE | Energy & Environmental Research Center

Current State of Biofuels

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Zygarlicke has over 20 years of project management experience working in power and fuels. He currently oversees research related to renewable energy and fuels, advanced coal and biomass gasification systems, alternative liquid fuels development from fossil and renewable feedstocks, hydrogen and fuels for the military, integrated gasification solid oxide fuel cell development, hydrogen production, and energy storage. He has authored and coauthored over 200 publications, including over 60 peer-reviewed journal or book articles. He has a bachelor's degree from the University of Wisconsin-Platteville and a master's degree in geology from the University of North Dakota.

What is the current state of biofuels in the United States? What can we expect as the country moves forward on identifying and producing new energy resources? To help us answer these questions, NCRLC staff interviewed Chris Zygarlicke, deputy associate director for research at the Energy & Environmental Research Center (EERC) at the University of North Dakota. Zygarlicke provides clear, comprehensive and straightforward information that explains what we can expect from biofuels and bioenergy.

NCRLC: What are the current types of biofuels available in the United States?

CZ: There are only two that are really of any economic significance. The first is ethanol, and that is 100 percent corn-based ethanol. There is no other way we make ethanol to any significant degree except by fermentation of corn. The other biofuel is biodiesel, and that is what's called a methyl ester fuel. That's important because there are different types of biodiesel being developed that use a different process than the methyl ester. The ethanol that we have in the United States is all made from corn, and the biodiesel is all made from vegetable oil. The primary oils that make biodiesel in the U.S. are soybean oil and canola oil.

NCRLC: Where is biofuel produced in the United States?

CZ: Ethanol is produced primarily in the middle agricultural states of the Midwest and the Plains region – anywhere that's not on the coasts or in mountain ranges or that is heavily forested. Most of our agricultural states are where you'll find ethanol plants. They are springing up in a few other places a little farther to the west, such as Washington, or a little farther to the east in places like Georgia, but most ethanol plants are in the middle agricultural states.

Biodiesel is also produced primarily in the middle states, but you'll find a few more plants in the coastal regions, although they're still a little more rare. I think there are currently – and this number changes – about 217 ethanol plants that produce about 13.5 billion gallons of ethanol a year. There are somewhere around 175 biodiesel plants that have the capacity to produce close to 3 billion gallons a year of biodiesel. I have a feeling that they're not all in operation either. That was as of a couple of years ago. The recession knocked out a lot of ethanol and biodiesel plants.

NCRLC: What is meant by "advanced" biofuels?

CZ: Advanced biofuels is a term given to anything that's not corn ethanol or vegetable oil biodiesel. There's a lot of different rhetoric out there about first-generation, second-

generation, and third-generation biofuels, but I think your term is probably best. There are the traditional biofuels: ethanol and biodiesel, and then there are advanced biofuels that are still being proven, tested, and developed. So, there are no advanced biofuel commercial plants in the U.S. right now. None. There are lots of plans and there is a lot of research, which we do at our center.

The U.S. consumes about 140 billion gallons of gasoline a year, so if all gasoline were blended at 10 percent with ethanol, we would be at an ethanol consumption of 14 billion gallons; we're currently producing nearly 14 billion gallons a year. As a matter of fact, under current corn production and use, once we reach 15 billion gallons, tillable land becomes an issue for growing the necessary corn to make ethanol. After that, we may run into problems. The United States, for a variety of reasons, has only so much acreage for corn: around 90 million acres a year. In order to use more of that corn for ethanol, we're either going to have to gain more acreage or gain higher yields of corn per acre. At about 15 billion gallons of ethanol, corn will probably need to be supplemented with some other feedstocks and that's what we call biomass. This same scenario exists for biodiesel. We may only have so much capacity to grow crop oils that can be converted into biodiesel using traditional methyl esterification methods. To go beyond 3 to 4 billion gallons of biodiesel production a year, we may need to use biomass and other advanced processes.

Biomass consists of organic materials such as agricultural residue like wheat straw, corn stover, or maybe forest wood or trimmings or, basically, most organic or cellulosic materials. Cellulosic matter can be converted to ethanol or other fuels like diesel, and those fuels would be advanced biofuels. There are no commercial plants right now that take straw, wood, or biomass and convert it to ethanol. Those efforts are currently the focus of substantial research and development, and it is hoped that successful demonstrations will soon occur. There are several near-commercial plants being built. That's the biomass feedstock part of advanced biofuels: using cellulosic materials instead of corn or crop oils. The processing part of making advanced biofuels from celluloseic ethanol from straw or wood is not the same as a corn ethanol biorefinery. There are a couple of dozen different processes being worked on, experimented with, and tested in the advanced biofuels processing arena. Some processes use biology to break down and ferment biomass to fuels, and other processes use heat, catalysis, and chemistry to convert biomass to ethanol or hydrocarbon fuels like diesel or even components of gasoline. There are different varieties of vegetable oils and different techniques for converting specific biomass types; basically, everyone is trying to get a low-cost, viable technology that can be used to make advanced biofuels.

Badger State Ethanol Plant in Monroe, Wisconsin

NCRLC: Advanced biofuels hold the promise of reducing U.S. oil dependence and global warming emissions. Where does the advanced biofuels industry stand in respect to meeting the demand as set out in the federal Renewable Fuel Standard?

CZ: It's probably lagging behind. The federal standard is 36 billion gallons of biofuels by 2025. As I said, we're currently producing about 14 billion gallons of ethanol; it probably will go to 15 or 16 billion gallons, and maybe there's 2 to 3 billion gallons of biodiesel that's included. That still leaves 15 to 20 billion gallons of advanced biofuel that have to be produced commercially in 10 to 15 years. It's quite the challenge. I really don't know if we're on pace to meet that goal. There's a lot of work going on to try to create these fuels, and they certainly do have their place. Biofuels, believe me, have a place in augmenting our petroleum supplies, but realistically, at least in the near future, they are only going to offset a small portion of our fossil-based fuels.

Technician conducting ozonolysis experiment

NCRLC: How do we build the support and enact the policies needed to bring the fledgling advanced biofuels industry to maturity?

CZ: I think, number one, is to continue to support the research behind the processes and the feedstock development. The U.S. Department of Energy, the U.S. Department of Agriculture, the U.S. Department of Defense, and the National Science Foundation have been funding a variety of efforts to stimulate the production of advanced biofuels, especially over the last 5 to 10 years. Before that, the funding was always fairly paltry. In the last five years, more funding has gone into large demonstration projects and loan guarantees, essentially to test the technical and economic viability of production of advanced biofuels in small commercial plants. So there are several ongoing efforts.

There are probably three or four similar efforts that are building 20-million-gallons-a-year plants that use cellulose to make advanced biofuels, usually ethanol, but they're all about two years away from being fully operational. So in about two to three years, we'll know if some of these advanced biofuels are economical, at least for ethanol.

NCRLC: How do we ensure that advanced biofuels help to maximize taxpayer investment and strengthen U.S. energy security?

CZ: I think, number one, that the American population needs to be educated in the benefits of having a biobased fuel: that although biofuels will not replace petroleum-based fuels, they certainly can contribute to reducing greenhouse gases and to helping economies by creating processing plants right here in the United States, which means the creation of jobs. On average, an ethanol biorefinery employs about 50 people, and that's just a corn ethanol plant. These are developments that can happen in rural areas for cellulosic plants as well, so it definitely brings jobs to the area. Right now, a lot of these technologies are still being proven, so it's kind of hard to say how we can ensure that they're going to work. Well, we didn't know that about building the space shuttle until it was built and we launched it into the cosmos. So these developments are possible and, if successful, would most likely add strength to U.S. energy and economic security. Every billion gallons of biofuel that we produce takes a little strain off of how much oil we need to import.

NCRLC: Research studies have concluded that avoiding dangerous climate change will require the United States and other industrialized countries to reduce their global warming emissions by 80 percent below 2000 levels by 2050. Is this goal attainable in your estimation?

CZ: I think it may be a worthy goal to shoot for. I think it's attainable technologically, but I don't think it's easily attainable economically. We still have an active and essential fossil fuel industry in the United States and around the world, with significant resources that, economically, are going to beat out any bio-based fuel or energy source for several decades. There are significant quantities of oil and gas. Natural gas has especially boomed as new reserves have been discovered and unleashed in the last few years through fracturing technologies and new drilling techniques. Although many of our electrical power plants have added solar, hydro, or wind generation capacity, they still need to incorporate a baseload capacity to cover the inherent intermittency in renewable generation. And the lowest-cost baseload for several years to come will be environmentally sound natural gas and coal plants. Everything is driven by the bottom line.

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Perhaps we need to instill in people's minds the need for smart renewable technologies, incorporating what

makes the most sense until some of these technologies can truly compete in the marketplace. The fossil fuels are still in a position where it's substantially cheaper to produce fuels, heat, and electricity with the available fossil resources we have. So trying to get to that 80 percent below the 2000 level would probably require smartly crafted carbon incentives. Otherwise, world industries will continue to go after what is the most cost-effective.

NCRLC: Would you say there is no doubt that we need to we act immediately? Do we also need to act on multiple fronts?

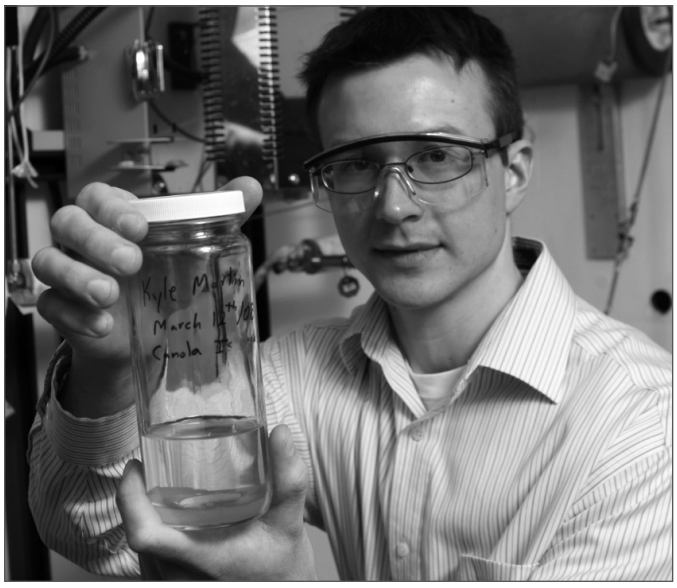
CZ: Yes, absolutely. If we want to reduce carbon emissions, then some of the things that the industry is doing right now definitely need to continue, especially in the area of research. I think the industry has taken a step forward. For example, electric utilities have listened to their constituents, and perhaps the constituents need to get even more involved. Utilities listened by putting in wind generators and more solar. Many oil production companies are reducing their carbon footprint by increasing the efficiency of how they drill and process petroleum fuel. There's a lot going on. The U.S. government has instilled incentives for the production and use of ethanol and biodiesel, and they've invested in research, so maybe we'll have green hydrocarbon fuels that will be economical in the near future. The military has invested heavily in trying to produce biofuels for aircraft and other parts of the war machine. I think we are definitely taking the steps. It's not like we need to get going. We are already going in the direction of lowering greenhouse gas emissions. It's going to need continued effort to ramp up those types of technologies between now and the middle of the century.

Other fronts that I think we need to continue to act on are the ways to implement more hydro in the United States. There are some really environmentally safe concepts for improving hydro, and I think the U.S. Department of Energy, just in the last couple of years, has started programs to look into that more. We have about 80,000 dams in the U.S.; I think only 3 to 4 percent of those have hydro capabilities. Basically we just need to go after all renewable technologies. They're all going to add up to become a powerful effect toward reducing dependence on fossil fuel and to improve energy security and the domestic economy in the U.S.

NCRLC: By all accounts, use of bioenergy has the potential to increase energy security, promote economic development, and decrease global warming pollution. But efforts to expand bioenergy production could have unintended economic and environmental consequences. What might these be?

CZ: I think there's always a potential for unintended consequences with biofuels and bioenergy, but I think the industry has been pretty careful to go in the right direction, number one, with feedstocks. A lot of the research I've seen in the last two to three years has been related to nonfood types of feedstocks. For example, vegetable oils that have no use in the food industry have been a goal of several research projects in advanced

Biomass feedstocks from corn husks and stalks



Experiment with Canola

Energy & Environment Research Center, University of North Dakota

biofuels here at the Energy & Environmental Research Center. We produced the first 100 percent renewable jet fuel from crop oil feedstocks like crambe oil. Crambe has no food production pathway, and its oil has had some limited use as an engine lubricant.

I think we are headed in a positive direction for biofuels. There is a groundswell of innovators and industry trying to make nonfossil carbon fuels economical and competitive. Other countries have implemented carbon taxes and incentives to stimulate similar growth. The United States has not instituted any such carbon incentives, but we do have national biofuels production goal and state-driven renewable portfolio standards providing incentive. Incentives need to be done with a lot of discretion and the involvement of the entire industry so that it's not just imposed on an industry. There could be unintended consequences of immediate restrictions on the use of carbon and fossil fuels. I guess what I'm saying is that incentives need to be such that industry can adapt. Otherwise, there could be severe economic consequences if energy and fuel spike up dramatically.

NCRLC: A definition of "sustainability" is that we must meet our present needs without compromising future needs. When it comes to the development of bioenergy resources, in what ways can we meet this definition?

CZ: I think there has got to be a lot of thought put into what the impact on the land will be if we start growing energy crops in large fashion. An energy crop is a type of biomass, such as switchgrass, that's grown specifically for the purpose of going into a liquid transportation fuel or some type of energy generation system. There is available cropland that is not used specifically for food crops where switchgrass could

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be grown. There just needs to be a careful understanding of how we utilize the land, so we're not exempting certain lands that produce food for energy uses. There are issues, such as the toll on the nutrient level in the soil. I believe great progress is being made here in that there are crops that can be used for energy that replenish the soil with nutrients, that are amenable to conversion to energy, that are efficient in water uptake, and that don't require as much for nutrient replacement. We need continued good stewardship and discipline so that future generations will have plenty of water and plenty of land that's still fertile while producing biobased fuels and electricity.

NCRLC: Even the smartest bioenergy policy can only be successful if pursued as part of a larger solution set, including increases in energy efficiency and reductions through conservation. How do we – locally, state-wide or nationally – achieve this holistic solution?

CZ: As a researcher, I am a person who more typically would provide solid information to the people who do prescribe energy policy, but just from good common sense principles, I personally think that education is important. Our high school and college students need to have balanced information on energy and the environment. I derived a mindset very early on to conserve, so that is just a matter of practice for me. It's good to have a mindset for sustainability in order to preserve resources for future generations.

Achieving a holistic solution is going to take energy synergy. In order to truly achieve a holistic solution, I think we need to have an energy synergy mindset as well. Synergy is a word that gets used often to describe the situation where a group of factors or inputs contribute to a better result than just individual ones. We need the whole "ball of wax" to contribute to local, state, and national energy scenarios. Oil, gas, coal, biomass, nuclear, hydro, solar, and wind resources, coupled with energy-efficient buildings and conservation, will all need to work together to produce a harmonious energy solution. ■