



How will ‘Disruptive Challenges’ in the Electric Market Impact Michigan Energy Decisions?



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NextEnergy is a 501(c)(3) nonprofit organization established in 2002 to drive advanced energy investment and job creation in Michigan. Located in Midtown Detroit's innovation corridor, NextEnergy serves as a catalyst for advanced energy technology demonstration and commercialization in the state. Since its inception, NextEnergy has helped to attract more than \$1 billion of new investment, including over \$150 million generated by programs in which we have directly participated. <http://bit.ly/17FSTPG>

How will ‘Disruptive Challenges’ in the Electric Market Impact Michigan Energy Decisions?

The United States stands at a crossroads with regards to its energy future. New technologies, new policy mechanisms, new sources of energy, and outmoded delivery systems, as well as the increasing awareness of the need for reliable, affordable and cleaner energy, are posing additional challenges for state energy infrastructures. To help chart this future, six organizations (the Erb Institute, 5 Lakes Energy, Growth Capital Network, the Institute for Energy Innovation, the Michigan Energy Innovation Business Council and Next Energy) co-hosted the Energy Futures Conference at the University of Michigan, Ann Arbor on June 26, 2013. The conference brought together experts from a variety of fields across sectors to consider the question of how disruptive challenges in the electric market will impact Michigan’s future energy decisions.

Keynote: Ronald Binz, Principal at Public Policy Consulting (*shortly after the conference, Mr. Binz became President Obama’s nominee for Chairman of the Federal Energy Regulatory Commission*)

U.S. electricity demand has grown significantly in the past decades, leading to unprecedented carbon emissions; in 2012, the globe reached 400 ppm of carbon in the atmosphere. Cellphones, computers, tablets and other associated peripherals are all contributing to disruptions to the utility model; as these products emerge, the highest energy users among them also changes. For example, in most U.S. households, the refrigerator is no longer the largest energy consumer. Despite past growth, one point is clear; utilities cannot count on continued growth in electricity demand.

Couple this point with the changing economics of the utility sector. Every 10 years (beginning in 1970 to just recently in 2010) the composite bond ratings for utilities have been measured. Up until 2010, this modal bond rating has been AA, but by 2010 the rating was BBB — with 27 percent of utilities rated at BBB. What does this mean? The industry’s borrowing costs are going up and its collective financial strength is much weaker than 40 years ago. Yet we are now asking them to commit to trillions of dollars in upgrades to generation, distribution, and transmission assets, as well as adding smart-grid technologies. This creates a great deal of tension. At the same time that load growth is decreasing, utilities are weaker; something has got to give.

By 2032, the Western Electricity Coordinating Council (WECC) projects that 20 percent of the peak demand in Colorado may be met by distributed generation. Germany has the most solar deployed, but has only 3.5 kWh/m²/day (similar to Alaska!). Michigan has a better solar regime than New Jersey and Germany. The National Renewable Energy Laboratory’s Renewable Electricity Futures (REF) Study 2012 explores the possibility of going to 80 percent renewables by 2050.

As energy providers, utilities need policies that will allow them to develop new business models. Today’s regulation neither rewards nor encourages utilities to change their behaviors. The evolution from traditional



Ronald Binz, Principal at Public Policy Consulting

Ron Binz most recently served as the Chairman of the Colorado Public Utilities Commission. He was appointed by Colorado Governor Bill Ritter in January 2007 and served until April 2011. As Chairman, Ron led the Colorado PUC in implementing the many policy changes championed by the Governor and the Legislature to bring forward Colorado’s “New Energy Economy.”

utility to energy-services utility depends upon a new regulatory regime that rewards performance. The most important reform that we could make now would be to move the residential retail rate structure to reflect variations in costs of electricity over time. Time-oriented pricing is essential to unlocking the smart-grid revolution. Though it's politically sensitive to put residential customers on time-of-use pricing, commissions should move toward that goal by mandating time-of-use rates for the largest residential customers, such as the 20 percent of customers with the highest usage.

Panel: Grid-Based Technology and Business Model Innovation: *Jean Redfield, Next Energy; Stu Bresler, PJM; Lisa Wood, Edison Foundation*

State regulatory policies drive energy efficiency (EE) via rate-payer-funded EE programs. However, mandates such as codes and standards have also been very effective. Energy codes and standards developed and advanced by DOE under the Obama administration will fundamentally change the energy picture in the U.S. By 2035, we will see 400 TWh of energy savings because of codes and standards. This will have a huge impact on the U.S. energy picture.

Smart-grid technologies will drive energy management innovations. In Michigan, DTE has already deployed more than 1 million smart meters to households. Networked customers open doors to possibilities in energy management and demand response, smart technologies, smart EV charging and more. And time-varying rates will change how people use energy every day. Tech companies, innovation, and new ideas will help this market explode.

On the demand side, the picture for the electric power sector is changing dramatically. Energy-efficiency efforts are flattening energy consumption growth in the U.S., and it is estimated that there will be 25 million EVs in the U.S. by 2035. Distributed generation (DG) will further alter the generation picture and could be a fundamental game-changer. EIA projects that renewables — large-scale renewable and some DG — will provide 16 percent of generation by 2040, but some suggest that figure is too low and too conservative. Growth in renewables is changing the power sector. Demand response and energy storage can influence how we accommodate intermittent renewable energy on the power grid. However, we're not yet seeing energy storage at commercial scale.

Both policies and subsidies are jump-starting distributed generation (e.g., rooftop solar). However, as this market grows, the real challenge is fair and equitable pricing. In many states with net-metering, DG customers are paid the retail rate for selling "wholesale" power into the grid. These customers are, in fact, highly subsidized by those customers without DG. Looking to the future, distributed solar generation coupled with energy storage could drive fundamental changes in the electric power system in



Jean Redfield, Next Energy

Jean M. Redfield joined NextEnergy in 2010 as vice president of Public Policy Programs. NextEnergy Center is a 501 (c)(3) incubator and accelerator of advanced energy technologies, businesses, and industries. In her role as vice president, she leads public sector initiatives that convene key technology, economic development, and public policy stakeholders to drive the deployment of advanced energy technologies. She joined NextEnergy after working with the firm as an independent strategy consultant.

the U.S. However, pricing DG right is critical to success.

Going further, resilience has become a huge national security issue. Groups like the National Security Agency and Department of Defense want to make sure that they understand the impacts that they need to manage going forward. This is leading to greater understanding of load forecasting — where will the load be located in the future? It's changing the way power is distributed. We are also planning for intermittent resources — how do you manage that, given a duck-shaped load curve? We are also working on system upgrades — we want to maintain reliability while not overbuilding, but not underbuilding either.

Looking forward, another challenge is the business models used by regulated electric utilities, and the policies by which they operate. Finding a way for innovation and regulation to work together is key.

On the wholesale level, the deregulated wholesale markets (independent system operators or regional transmission organizations such as PJM and MISO) are working well and integrating both demand response and energy efficiency into the market. As part of an ISO, Michigan can take advantage of that.

However, on the retail level, what's the new policy? The power industry isn't rewarded for innovation. Decoupling levels the playing field for utilities to invest in energy efficiency. Now, if our goal is to create an environment that rewards utilities for innovation, we need to think more about incentive- and performance-based regulation.

The future likely is a power system with a mix of large supply resources, small distributed supply resources, and flexible demand resources.

What the President said in his Climate Change speech was a call for reliable, low-cost, and increasingly clean electricity. For decades, the power sector has focused on reliable, low-cost and safe electricity. And more recently, the fourth pillar — increasingly clean energy — has been added. In the absence of a national carbon price or cap-and-trade policy, the states are leading the way toward cleaner energy primarily through renewable portfolio standards and energy efficiency goals and standards. So far, it's a grassroots movement on the state level.



Stu Bresler, PJM

Stu Bresler, vice president of Market Operations and Demand Resources at PJM Interconnection, is responsible for Forward and Real-Time Market Operations, the Financial Transmission Rights Markets, Market Settlements, the development and support of the technical systems utilized in markets and operations, and the coordination of Demand Response implementation across Planning, Operations and Markets.



Lisa Wood, Edison Foundation

Lisa Wood is Executive Director of the Institute for Electric Efficiency (IEE), a program established by the Edison Foundation to accelerate the industry's energy efficiency efforts and increase the industry's energy efficiency investments. IEE serves electric utilities, electricity customers, and energy policymakers across the country as a clearinghouse and resource for information, best practices, and innovation.

Keynote: Orjiakor Isiogu, Michigan Public Service Commission



Orjiakor Isiogu, Michigan Public Service Commission

Isiogu's public service experience is extensive. Beginning in 1989, he served as an assistant attorney general for Michigan in their special litigation division. Following that, he was the director of telecommunications for the Michigan Public Service Commission. During this, he was responsible for carrying out Michigan's Children's Protection Registry Act and the Uniform Video Services Local Franchise Act.

Investment in the smart grid can provide new economic and revitalization opportunities and support Michigan's automobile industry by facilitating vehicle electrification. Smart-grid deployment will require important decisions regarding technology selection, compatibility, and user protocols, and will also challenge regulators and policymakers who must ultimately determine that smart-grid investments are reasonable and prudent.

Prior to enabling and authorizing smart-grid deployments, important questions must be asked and answered, including:

- What is the business case beyond grid reliability and resiliency? Can the benefits be quantified? How do we avoid overpaying or "gold-plating" these investments?
- How can we anticipate obsolescence in selecting technologies and avoid improvident investments?
- Will ratepayers understand the advantages and issues relating to the smart grid and be able to provide meaningful input through a transparent process?
- How are we to protect ratepayer privacy and security concerns? Will the accessibility to ratepayer data be consensual?
- What are the lessons to be learned from early adopters?

Keynote: Phyllis Cuttino, Pew Charitable Trusts



Phyllis Cuttino, Pew Charitable Funds

Phyllis Cuttino is director of Pew's Clean Energy Program, which works to accelerate the clean energy economy in order to seize its economic, national security and environmental benefits for the nation. Pew advocates for national energy policies that enhance industrial energy efficiency, expand energy research and development and deploy advanced transportation and renewable technologies.

The deployment of clean energy reached record levels in 2012. Even with private investment decreasing by 11 percent, the clean energy sector expanded because the cost of renewables is declining. Based on more than nine years of investment tracking, the sector is growing by approximately \$90 billion every three years. Countries are racing to capture market share in this sector. In 2012, China retook the global lead from the U.S., and the Asian region is becoming the center of gravity for clean-energy investment. Emerging nations are becoming larger forces as well. For example, South Africa had a 20,000-percent increase in investment in clean energy, moving it from No. 20 in the world to No. 9. This is a direct result of new policies set by the South African government.

The U.S. is still a leader and has inherent advantages, including its ability to produce and export high-value materials and components. America's strength is innovation and advanced manufacturing, and U.S. firms have a larger global footprint. These strengths can work to provide the country a positive trade balance in clean-energy goods and services.

But policy matters. Countries that adopt national policies are positioning

themselves to capture the significant economic and security benefits in clean energy. Pew's Clean Energy Business Network has identified key policies that can strengthen a culture of energy innovation in the U.S., including a clean-energy standard, long-term incentives such as the Production and Investment Tax Credits, access to tools like Master Limited Partnerships and Real Estate Investment Trusts, and increased federal investment in clean-energy research and development.

Panel: Innovative Utility System Resources: *Dan Scripps, Energy Innovation Business Council; Tom Catania, Erb Institute; Greg White, Michigan Public Service Commission; Frank Lacey, Comverge*

Tom Catania: A renewable energy future, married with ubiquitous demand response at the residential level, is close and could significantly enable renewable energy resources. The current uneven demand curve results in 25 percent of distribution and 10 percent of generation assets, costing hundreds of billions of dollars, being required to meet only 400 annual hours of peak demand. Demand response resources can supplement generation capacity to flatten demand curves and fill existing demand valleys with renewable energy. An industry analysis suggests there is a potential of 300 GW of daily peak demand reduction available through the aggregated demand response resources available only through home appliances. Demand response is a more cost-effective way of substituting for wasteful “spinning reserves” — unneeded power generation that is maintained solely to ensure grid stability and reliability, and finally, can jump-start the smart grid and reduce peak demand by 20 percent.

Traditional regulatory requirements must adapt to the evolving needs of the modern, greener grid. As the low-hanging fruit in traditional individual product energy efficiency has been harvested, manufacturers began examining the potential of offering system benefits through aggregated-demand-response-capable products. New regulatory costs at the bleeding edge of individual product efficiency challenged manufacturers who needed to identify these new benefits and capabilities. Utilities are excited about being able to control their demand curves; this is an economic opportunity for utilities to get more value from distributed and renewable energy resources.

Greg White: We are witnessing the proliferation of clean-energy technology and a clean-energy economy — it's happening very quickly. Renewable energy resources are inevitable. Challenges include the tremendous cost of an aging infrastructure and integrating new technology into a system that wasn't designed for it.



Dan Scripps is Vice President of Capital Innovation at AEE where he is responsible for developing and implementing strategies to accelerate the flow of capital into the advanced energy sector. Dan also serves as president of the Michigan Energy Innovation Business Council, AEE's Michigan state partner.



Greg White, Michigan Public Service Commission

Greg White has extensive experience in energy and telecommunication policy. He has served as a legislative liaison to the Michigan Public Service Commission. He also served as a liaison to the Department of Energy, Labor, & Economic Growth from the Public Service Commission.

Customers are going to adopt renewable energy resources because they can — even if it isn't economically efficient. Telecom users switched because they could, not because they had to. New services and technologies became available, providing more consumer choice. These innovations are opportunities. Utilities, as essential participants, need to move the system forward, and leading utilities will move to distributed energy; if not, other innovators will.

These changes should not be forced by regulators, but should come from the ground up. Regulators need to encourage the evolution of system design. Michigan's policies are working well; we are achieving our energy optimization goals and our Renewable Portfolio Standard is being implemented at a fraction of the projected cost (\$130 to \$150 per MWh then; now less than \$50 per MWh). This is a tremendous success story leading to further success.

The financial community can help reshape energy landscape. Wall Street needs to take a look at how it finances the utility industry. Today it is still focused on vertically integrated, single-station base-load power. It needs to look at distributed generation and finance smaller plants built closer to load centers. Everything should be on the table — demand response, renewable energy, and microgrids. We need to look at new regulatory models and financial models as well, and we need to educate policymakers. The economy will value efficiency — this movement is inevitable.

Frank Lacey: Demand response is not disruptive — it enables and supports utilities and system operators to meet ratepayer needs. Demand response helps consumers use energy more efficiently and needs to be built into the regulatory construct. Utilities are good at what they do, but not the best at everything they do; they need to collaborate with others offering innovative services.

The utilities can't stop the forces of change in the industry. They and other market participants will have better market information and be able to make better decisions if DR and other technologies are incorporated into the market.

MISO-area states are not as liberal with retail choice, and MISO does not yet have a capacity market. Customers in MISO states are still largely captive; they cannot leave their providers, and some states restrict demand response opportunities.

“Negawatt” is old school; “Intelliwatt” is a superior term because it recognizes that we can move demand and resources in both directions.



Frank Lacey, Comverge

Frank Lacey joined Comverge, Inc in June of 2011. He is charged with managing Comverge's government and regulatory initiatives across North America. He is also a member of the company's Executive Council and has Strategic Planning responsibilities for Comverge's C&I business unit.

Keynote: Janet Peace, Center for Climate and Energy Solutions

Climate change is a present-day reality, with excessive heat, drought, wildfires and hurricanes in recent years. The International Energy Agency (IEA) recently announced that it is not anticipating that we will meet the goal of keeping temperatures under a 2-degree C rise. Globally, CO2 emissions continue to rise and were up 1.4 percent last year.

That said, U.S. emissions have dropped, and are today at levels equal to that seen in the mid-1990s. This is due to three factors. The first is the recession and the sluggish economy. The second is fuel economy standards and anticipation of additional standards kicking in. And the third, and likely most significant, is that natural gas has grown as a percentage of our fuel mix in the electricity sector. While the impact of natural gas has been most pronounced in the electricity sector, there are opportunities across the economy to substitute natural gas for higher-carbon fuel sources (a topic we will talk more about shortly).

Turning to why reducing greenhouse gas emissions is important, it is important to realize that globally we had almost 900 weather- and climate-related disasters last year that led to \$116 billion in damages. We can't say that all of these events were caused by climate change, but we can say that the risk profile for these types of events has changed. Climate scientists tell us to expect more frequent and intense heat waves, droughts, downpours, flooding and storms. Extreme weather events can significantly impact cities and businesses. For example, a Connecticut nuclear power plant had to shut down last year because water from Long Island Sound was too warm. Droughts have impacted movement of cargo on the Mississippi River and there is concern about the level of the

Great Lakes. Cities and communities across the country need to be more resilient. In New York City, Mayor Bloomberg has set aside \$20 million to make the city more resilient to extreme weather and climate change. In our review of what companies in the Global S&P 100 have said publicly about climate change, we have found that 90 percent talk about climate and 38 percent report having experienced a climate-related extreme weather event. I think it is clear that we are already paying the price for climate change as we cope with more extreme weather events.

On the plus side, this new supply boom of natural gas can help in the short-to-medium term to reduce our carbon footprint. As noted earlier, it is already helping in the electricity sector, as many utilities have substituted natural gas for coal. However, many other opportunities exist. For example, if you consider the “full fuel cycle efficiency” — meaning the efficiency of the electricity generation, transmission and appliance — an electric water heater is typically 30 percent efficient, whereas a natural-gas water heater is about 92 percent efficient in its use of the energy. Unfortunately, only 54 percent of new homes have access to natural gas. While we have pursued a national policy of full electrification of all homes in the U.S., we have not pursued a similar



Janet Peace, Center for Climate and Energy Solutions

Janet Peace is the Vice President of Markets and Business Strategy at the Center for Climate and Energy Solutions. In this role, she manages the Center's Business Environmental Leadership Council (BELC), the largest US-based association of companies devoted to climate-related policy and corporate strategies.

Keynote: Janet Peace, Center for Climate and Energy Solutions

policy of natural gas access. Natural gas can be good for U.S. greenhouse gas emissions in the short-to-medium time frame: it produces one-half the emissions of coal and about one-third the emissions of petroleum when combusted. But it can't be our long-term solution.

To get to the level of GHG emission reductions that we need in the longer term, we need zero carbon energy, like renewable and nuclear; we need carbon capture and storage for coal and natural gas; and we need conservation and efficiency. There is a danger that left to themselves, market forces could crowd out renewable and nuclear energy in the longer term. We need policies to make sure that doesn't happen.

In addition, to get the maximum climate benefit from substituting natural gas for other fossil fuels, we need policies to minimize the leakage of methane, a very potent greenhouse gas that is nearly 21 times more powerful than CO₂ if you look at it in a 100-year time frame (it is 72 times more powerful if you look at it in a 20-year time frame). We've made significant progress on reducing the leaks on the production side, but there is still room for improvement, and we also need to look at the entire natural gas value chain, including distribution and use. We know pipelines leak. Fortunately, we have the technology to measure, manage and minimize — we just need to ensure that this technology is deployed.

Now turning to where we are with policy, there is very little chance for climate and energy policy in Congress. As Obama said in his speech on climate change at Georgetown University, if Congress is not going to act, the Administration will. While C2ES has long favored a price on carbon, we think that if Congress is not going to move forward, the Administration is right to do this. In terms of the electricity sector, the most likely path for the Administration and EPA is a section called 111d and b in the Clean Air Act. This provision gives EPA the ability to use a "market" type of approach to set standards for new and existing power plants. We believe a market-based approach would let us integrate a federal approach with the trading systems already in place in the Northeast (Regional Greenhouse Gas Initiative) and clean air programs.

It was interesting to see the responses to the speech. Many companies came out supportive, but some conservative groups came out saying that they opposed EPA action and preferred more business-friendly approaches like a carbon tax. We believe there is a small window of opportunity for a carbon tax, but how you spend the revenue is a question. One option that might make a carbon tax more feasible would be if it was revenue-neutral. We have a new report in the works that suggests it could be revenue-neutral if the revenue was used to compensate for a reduction in the corporate tax rate — which is the second highest in the world. It seems like it could be possible to get from a tax rate of 35 percent down to 28 percent (or maybe even 24 percent) with revenue from a carbon tax. While there are folks who believe that we can "pay for" such a reduction by closing tax loopholes, other people call those loopholes tax preferences, and there are constituencies that will fight to protect them.

But as long as Congress lacks the power to move forward on this, we support anything that reduces greenhouse gases and provides certainty, such as new-source and existing-source performance standards. We hope that the EPA will use the most flexible approach, such as CAA 111d. Obama also called for improved efficiency and conservation, expanded access for renewable energy on federal lands, and continued improvement in fuel economy standards. Efficiency is important; the product standards, which the government has put into place since the 1970s, have enabled us to avoid emissions equal to the output of around 50 average coal power plants over one year. Energy efficiency is the watchword of the day. There is a lot we can do.

I am a technology optimist. We've seen the significant improvements in the cost of photovoltaics. Other areas of great hope are small modular nuclear reactors (SMRs). The Department of Energy is funding prototype development and by 2020, we may see SMRs actually providing electricity. However, technology, especially environmental technology, does not appear on its own. We cannot rely on market forces alone to get new technologies into the marketplace. A price on carbon is ideal, but until we can get there, policies like those in Michigan — its revolving loan fund, its alternative energy portfolio standard, net metering, plug-in electric vehicle incentives, etc., are needed. We need states to take on clean tech leadership, and we need policies that push and pull low-carbon technologies into the market.

Summary and Conclusion

The electric utility sector is undergoing great change. New technologies for energy generation and management coming online are poised to reshape our energy infrastructure. Solar, wind, smart grid, energy storage, building energy management systems, and most of all, distributed energy are the most-discussed disruptive technologies entering the market on the supply side. But equally important, the focus on the demand side is on energy efficiency, conservation and demand response, driven in part by a desire to make the grid and its participants more resilient. The overall focus continues to be on reliable, affordable and cleaner energy.

But an economically efficient pathway requires a supportive policy structure. More efforts in energy codes and standards, net-metering, real-time pricing, renewable portfolio standards, and stable production and investment tax credits will help to lead the market to a future that enables the objectives of creating reliable, affordable and cleaner energy.

That leads to innovations in the business models used by utilities. In addition to energy providers, utilities need to become energy-service providers. Unfortunately, policies that presently exist do not create incentives or reward utilities to make this shift and innovate towards new solutions. We need to move beyond a focus on vertically integrated, single-station base-load power to look at distributed generation with smaller plants built closer to load centers.

Many were optimistic as a result of the discussion that took place, seeing rapid change in the content of the dialogue over the past 10 years. For example, five years ago we didn't think it was possible to bring solar and wind to Michigan, but now it is. We need to start recognizing that we will be able to do these things in ways that we can't even imagine.

Others were less optimistic, feeling that things had not changed much in the past 10 years. One solar developer mentioned that he heard similar comments about the need for policy and regulatory change 10 years ago, and that he saw Michigan as an unattractive state for development for this reason. Some suggested that we need new conversations. One attendee asked, "Why are we still selling solar door-to-door like Avon ladies if coal-fired plants can be easily funded?"

That led to a focus on public engagement and education as critical to bringing about the next energy future. One participant felt that what was needed was to teach people about their energy use. We need to teach energy literacy in K-12 and college training, and then have the capital to move it forward.

But overall, a common theme was policy development. Policy needs to create the financial interest for utilities and individuals to innovate. We need to democratize the right to produce and sell electricity.

The Erb Institute for Global Sustainable Enterprise



Andy Hoffman, Erb Institute

Andy Hoffman is Erb Institute Director. His research addresses institutional change, organizational culture and corporate strategies as they relate to environmental and social issues. He has published over one hundred articles and twelve books on these topics.



Tom Catania, Erb Institute

Former Vice President of Government Relations at Whirlpool Corporation, Catania works to enhance the Institute's visibility in the business community and among policymakers through written communications and by organizing meetings for executives on corporate strategies on energy and environmental issues. He also works with Erb Institute directors and faculty to create and strengthen the Institute's ties with corporate executives, donors and industry organizations.

The Erb Institute is committed to creating a socially and environmentally sustainable society through the power of business. Building on nearly two decades of research, teaching, and direct engagement, the Institute has become one of the world's leading sources of innovative knowledge on the culture, technologies, operations and governance of business in a changing world.

Created in 1996 through the generosity of Frederick A. Erb (BBA '47) and his wife, Barbara, the Institute is a partnership between the School of Natural Resources and Environment and the Stephen M. Ross School of Business at the University of Michigan.

The scope of the Erb Institute's research mission can be illuminated by reference to the larger scientific research agenda involving issues of sustainability. In recent years, researchers from the natural and social sciences have begun to recognize the emergence of a field coming to be referred to as "sustainability science," and have identified a set of seven core questions. Four of these questions are related to the institutional environment within which business operates, and the Erb Institute seeks to address these questions. They include:

- How can the dynamic interactions between nature and society – including lags and inertia – be better incorporated into emerging models and conceptualizations that integrate the Earth system, human development, and sustainability?
- How are long-term trends in environment and development, including consumption and population, reshaping nature-society interactions in ways relevant to sustainability?
- What systems of incentive structures – including markets, rules, norms, and scientific information – can most effectively improve social capacity to guide interactions between nature and society toward more sustainable trajectories?
- How can today's operational systems for monitoring and reporting on environmental and social conditions be integrated or extended to provide more useful guidance for efforts to navigate a transition toward sustainability?

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