
Blue Ribbon Panel

Envisioning the Future of Biorenewables

July 12, 2012

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Summary

Iowa has the potential to be the Biorenewables capitol of the world. Realizing this vision will result in a diversified entrepreneurial and growing economy for the state. Biorenewables consist not only of corn-based ethanol, but also second-generation biofuels, industrial chemicals, and high-value bio-based products. To realize this vision, it will require translating fundamental research discoveries through proof-of-concept demonstrations and lifecycle analyses. Investing in translational research is often considered too risky by established commercial organizations, but is nonetheless essential for commercial adoption of fundamental advances and economic growth and development. Iowa's universities and colleges, especially Iowa State University, have the infrastructure, desire, and talent to help mitigate this risk and bring new products to the marketplace. In particular, the Iowa Energy Center's (IEC) Biomass Energy Conversion (BECON) facility can be retooled for evaluating potential of concepts to move from the laboratory to production facilities.

Background and Panel Charge

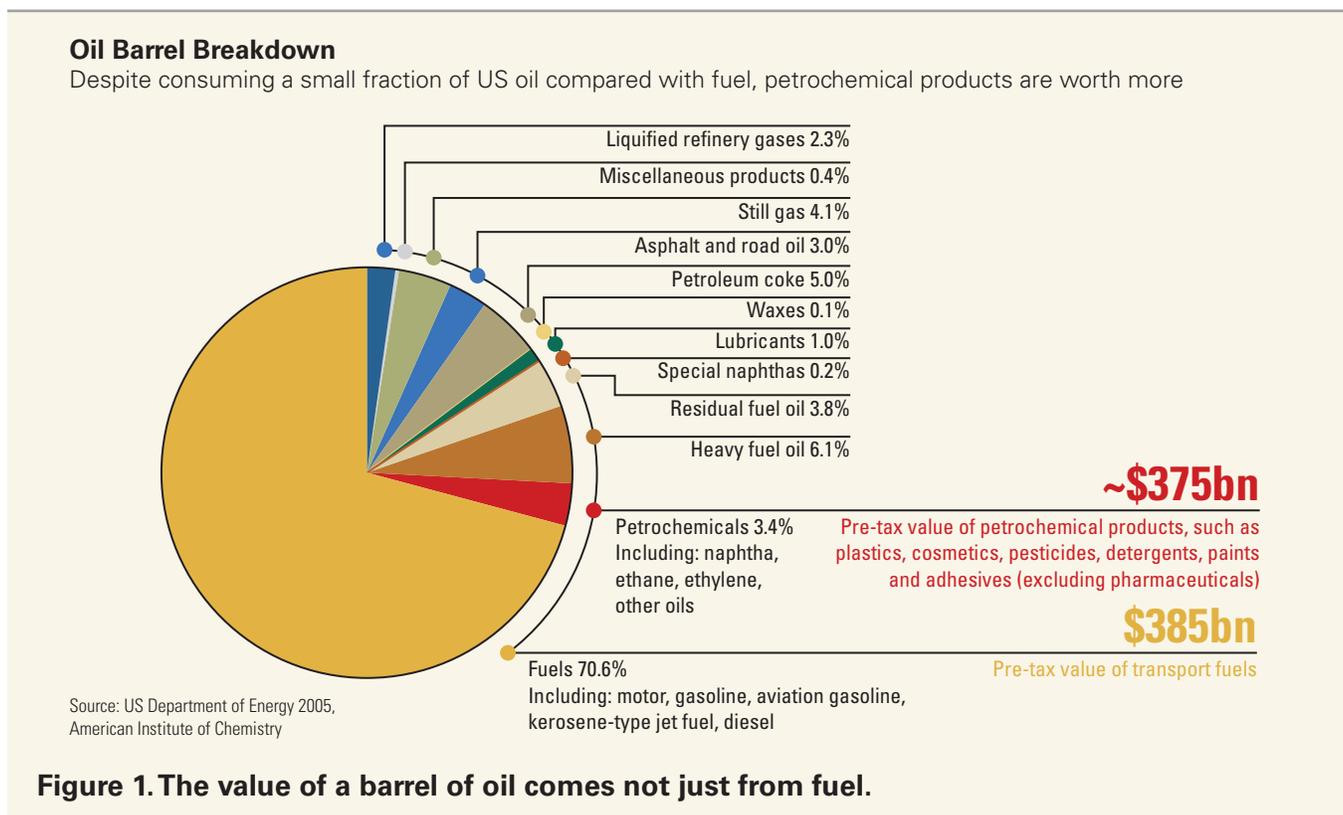
This report explains how Iowa can become the leader in development of biorenewables. The report was compiled from written responses and a consensus-building meeting held on May 29, 2012 involving experts in biorenewables at Iowa's universities and colleges, and state agencies. The panel considered involvement and recommendations for all Iowa universities and colleges and they are not limited to any one institution; however, many focus on making BECON a more effective resource. The report covers the following topics as charged by Chitra Rajan, Interim Director, Iowa Energy Center:

1. Why will biorenewables become increasingly important to the world economy, and why should Iowa pay attention?
2. How can the Biomass Energy Conversion (BECON) facility help to make Iowa a leader in the emerging biorenewables market?
3. What will a reimagined BECON look like?
4. What are Iowa's advantages, and what are our challenges? How can we address these challenges?
5. What strategic actions are needed to make Iowa the best location in the world for biorenewables research, development and commercialization?

This report is intended to clarify Iowa's advantages and challenges, and describe how the IEC can foster the development of the next generation of biorenewables industries in Iowa through carefully targeted support of biorenewables research. All individual panel recommendations were documented, considered, and provided to the IEC Interim Director.

Why will biorenewables become increasingly important to the world economy, and why should Iowa pay attention?

Over the next 10 to 20 years, **it is likely that crude oil prices will remain at levels sufficient to encourage the development of technologies to convert biorenewable resources as replacements for petroleum-derived gasoline and diesel fuel.** It is also likely that these higher oil prices will provide incentive to the development of biorenewable resources for producing commodity chemicals. **The future of biorenewables includes value-added products as well as fuels.** Examples include industrial and specialty chemicals, materials (including plastics, fibers, etc.), pharmaceuticals, and food and feed ingredients. Currently, the petroleum industry annually creates more than \$400 billion worth of petrochemical products (\$480 billion in 2011) - as much value as motor fuels (Fig. 1). The biorenewables industry needs to think much like petroleum companies and seek ways to produce value-added products as well as biofuels.



Some have advocated that natural gas, which is currently very cheap in the United States, will replace oil for some uses. While this might be the case, natural gas does not provide a direct alternative to most of the transportation fuels and biobased products. Inexpensive natural gas is a result of it having limited distribution ability. Prices are expected to increase as natural gas is diverted to new markets including power production and export. Where it does overlap, it is important that we continue exploring the feasibility of using biorenewables (biofuels, bioenergy, biobased products) as *replacements* for natural gas, as natural gas could easily become subject to the same pressures that are raising oil prices.

Iowa is well positioned to become *the place* where practical problems of converting biomass to transportation fuels and chemicals are solved. The resulting bioeconomy, where biorenewables help meet our need for biofuels and biobased products, will create high-paying employment opportunities, generate economic activity, spur rural development, and increase land values. We have this opportunity for four reasons: 1) Iowa is a leading agricultural state capable of delivering large amounts of biomass feedstocks; 2) Iowa has a critical mass of leaders in developing biorenewables technologies; 3) Iowa has a track record of leading in producing first-generation biofuels; and 4) Iowa is well positioned to unite the various types of stakeholders who need to collaborate to bring new technologies into being. If future growth in crop productivity exceeds growth in demand for crops, as is expected, then the Midwest can supply crops and crop residues in sustainable ways for biofuels and biobased products (industrial and specialty chemicals, polymers, etc.), as well as, meet our needs for food and feed.

Advanced technologies make possible carbon-negative fuels and biobased products. Iowa will lead in these emerging industries only if it invests in research and development to make these technologies environmentally, economically and socially sustainable. We accomplish nothing if we replace the unsustainable petroleum industry with an unsustainable agriculture-based biofuels industry. Our competitive advantage, after all, exists because Iowa is a place where the practice of growing plants is important and fertile soil and excellent climate are unmatched resources.

How can BECON help to make Iowa a leader in the emerging biorenewables market?

We want central Iowa to become *the “knowledge and innovation” center for biorenewables.* Although Iowa is well established in first-generation biofuels, we are not the only state to aspire for prominence in advanced biofuels and biobased products. **We want Iowa to own the biorenewables brand.** This means companies and public agencies should think first of Iowa and its universities when investing in biorenewables. Too often companies and federal agencies think that places like Massachusetts Institute of Technology (MIT) and University of California-Berkeley can solve any problem if given enough funding. Even those places know better, as illustrated by MIT’s recent overtures to collaborate with Iowa State on industry-funded research in biorenewables.

Our biggest challenge is that Iowa does not presently have a well-articulated vision. Our first priority is to more clearly define Iowa’s role in the development of biorenewables industries. While we need to make more efficient the first-generation biorenewable fuels industry that we have, it is more important that we work to encourage the development of advanced biofuels (and biobased products defined by the Department of Energy to not be starch or vegetable oil derived). We need to anticipate the future of biorenewables. We need to educate decision-makers, policymakers, the private and public sectors, and the general public on the potential for creating new industries focused on biorenewables. Unless people are educated on the needs and opportunities, it will be hard to create a vision that is widely accepted and supported.

A key issue is the lack of statewide investment in biorenewables research and development. Figure 2 demonstrates the path that a scientific idea must follow if it is to become a commercially successful technology. No one segment can do everything in that system. We cannot, by ourselves, make Iowa the innovation center that we want it to be. For Iowa to become a “*knowledge and innovation*” center (or corridor as some have advocated) for biorenewables, we need to identify strategic parts of the process and then strategically identify partners that will fill the gap.

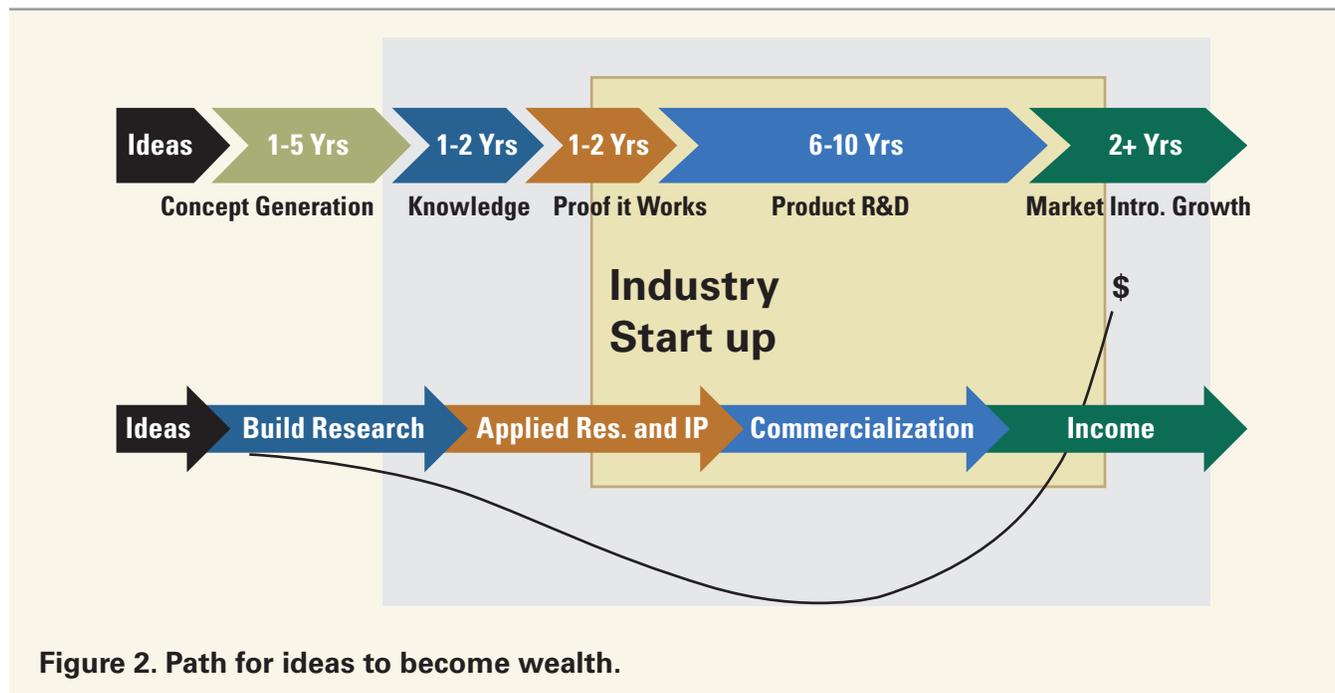


Figure 2. Path for ideas to become wealth.

BECON, in collaboration with Iowa’s universities and colleges, should focus on “proving the feasibility” of emerging concepts in biorenewables. This **focus on “translational” and “proof-of-concept” research addresses strategic steps in the pathway to developing and commercializing new technologies.** BECON should serve Iowa’s university and college faculty, and others who want to move lab experiments into a larger scaled, engineering-oriented site to test the viability of new innovations prior to commercialization. Our infrastructural advantages, as well as our pragmatic Midwestern ethos, ideally position us to play this role.

New technologies that do not yet have applications or markets are risky ventures for industry. **Our role can be and should be to help “de-risk” biorenewables technologies.** Moving from “concept generation” product R&D is difficult because it demands that companies invest in unproven technologies. We can ease this step by conducting proof-of-concept and translational research. By specializing in this type of research, we can also help other partners in Iowa and the nation, including industry and government, to anticipate which new technologies are most promising.

However, even as Iowa focuses resources into translational research, its universities should not neglect basic research. Basic research provides credibility as well as a base of knowledge essential for translational research. **Our strategy for owning the biorenewables brand is to build an international reputation in**

advanced biofuels and biobased products through excellence in translational research, supported by basic research that inspires technology development. In fact, our goal is to foster a broader commitment to every stage in the process of creating new biorenewables technologies by mitigating some of the risks inherent in the process and by making it easier for people with ideas to move their work to a larger test site.

What will a reimagined BECON look like?

BECON needs to return to its roots as a test bed for ideas emerging from Iowa innovators, especially creative faculty from Iowa's universities and colleges. Over the past several years it has strayed from this original intent and has become more like an industrial research park, essentially providing subsidized real estate for technology companies. The connection between faculty and BECON has diminished to insignificance. BECON should be a place where concepts in biorenewables technologies can be tested on larger scale than is available in a typical bench-top research lab. BECON's ability to facilitate research on larger scale is what will distinguish its contribution to the future bioeconomy.

BECON should become the hub for research sponsored by the IEC and performed by non-profit organizations, in keeping with the original intent of the legislation that established the IEC. The research should not be limited to biofuels and bioenergy but include any research that falls within the mission of the IEC and can benefit from the kind of facilities found at BECON. The research need not be exclusively funded by the IEC. In fact, leveraging IEC funds to secure research contracts from federal agencies, private foundations, and industry should be encouraged and supported. Towards these ends, BECON should be remodeled into a series of individual research bays to accommodate translational research by researchers from non-profit organizations to replace the industrial pilot plants that now dominate BECON. Although this remodeling is expensive, it is essential to accommodate the kind of translational research that is likely to secure for Iowa the biorenewables brand. Funds that IEC has earmarked for a second warehouse-like structure at BECON should be diverted to remodeling the existing high-bay building at BECON to make it more useful to translational research.

In order to transform BECON, it also needs adequate staffing. Ideally this would include a facilities manager, a project/design engineer, a mechanic, a technician, and an analytical chemist to support projects. This staff need should be added in a way that is commensurate with user needs in order to avoid excessive fixed costs. **The facility needs to be retooled according to a “plug and play” model** along the lines of the BioCentury Research Farm (BCRF). A well-equipped shop is also a critical support need. BECON should offer not just facilities, but expertise in the design, construction, and maintenance of experimental equipment needed by researchers at BECON. **The facilities manager needs to aggressively market BECON to the public, companies, federal and state agencies, and most importantly researchers at Iowa's universities and colleges, as well as attract and recruit projects, funding, and opportunities for collaboration.** The staff should help manage safety issues that currently monopolize a lot of clients' efforts. The laborious task of ensuring safety compliance at BECON, and the liability issues that go along with that task, should be streamlined.

BECON needs to develop a business model that addresses the overhead costs of BECON as it focuses on its re-defined mission, the IEC and BECON do not receive any indirect cost return nor any intellectual property return from research projects conducted by facility users. The fee structure for facilities that collaborate with both academic and business partners need to be reconsidered, and we need to further explore government funding available for projects like the ones we want to attract. User fees should vary depending on the applicant. Academicians should pay a reduced rate, and industry should pay full fees. BECON should have no trouble attracting users or funding once it has established itself as an important facility for translational research, but BECON needs to quickly respond to the need to refocus.

What are Iowa's advantages, and what are our challenges? How can we address these challenges?

Other states that are actually accomplishing very little in biorenewables are outperforming Iowa in promotion and marketing. **We need to brand Iowa as *the place for biofuels and biobased products*. Developing a reputation as "*knowledge and innovation*" center or corridor is important.** The most pressing tactic, at present, is to promote a vision of Iowa as more than a place where plants grow and biofuels are produced. At the same time, Iowa has to become the place where the *next* generation of biorenewables and biorefineries will be created. We want companies to come to Iowa not only to take advantage of low feedstock costs, but also because Iowa has developed into a "*knowledge and innovation*" center for biorenewables.

New technologies are created not just through academic research, but also through collaborations between academia and industry, and through practices that support startup companies. Participating in the developing biorenewables industry must be a holistic, statewide effort. We believe that refocusing BECON will help to push Iowa in the right direction, but we need to also work to encourage others to adopt more forward-looking attitudes toward biorenewables.

In order to fully consider how Iowa might establish itself as the leader in the creation of biorenewables, we need to consider three topics: the infrastructural issues related to biorenewables, our relationship with the private sector, and our relationship to government.

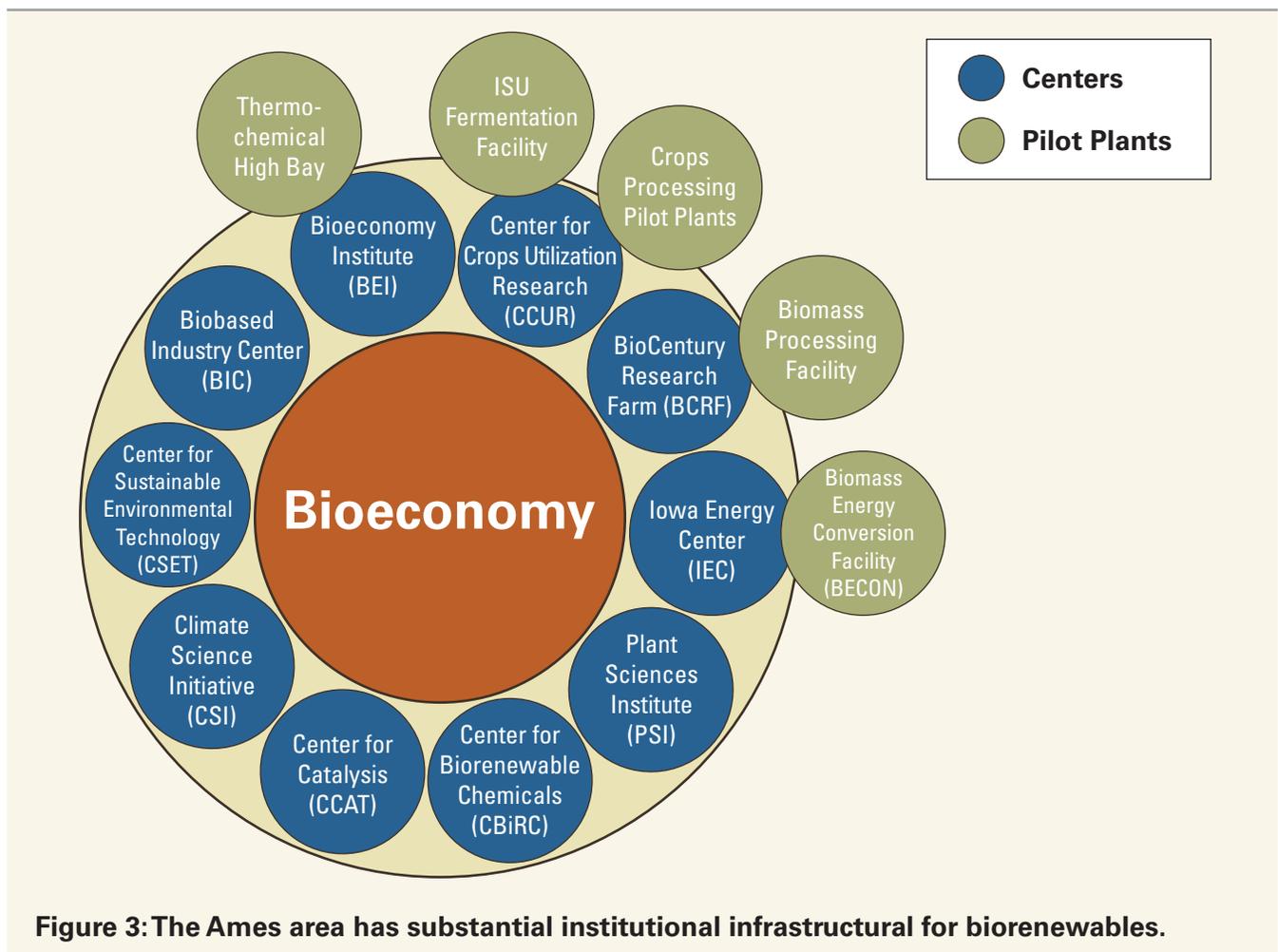
Infrastructural issues related to biorenewables

Iowa has the best facilities in the world for developing biorenewables technologies. Nowhere else in the world has the capabilities that can be found within a 10-mile radius as does Ames, and no university has as much facility resources or expertise in biomass supply chain and thermochemical conversion as does Iowa State. Pilot plants are key tools for conducting translational and proof-of-concept research, and they are expensive capabilities to acquire and maintain. For that reason, few exist at other institutions. Iowa has extremely unique capabilities as shown in Figure 3, however, we cannot become complacent, and we need to adopt a forward-looking attitude.

Our collective strength is what really counts, and we need to further develop ways to share resources.

More coordination and partnering between units and institutions are needed. If we are to make Iowa into a *“knowledge and innovation” center* for the coming bioeconomy, we need to encourage Iowa’s biorenewables industries to adopt a more holistic vision, and we need to work to build connections across academic disciplines at Iowa universities and colleges.

Our focus should be to develop broader programs that facilitate interaction among university centers and to support activities that are beyond the reach of any one center. Each of the facilities in the Ames area (Fig. 3) was an investment made by multiple units; it is not practical to bring them under one administrative structure. However, **a coordination committee or some other type of management structure is needed to help them to partner with each other and work in concert and seamlessly to build a world-class *“knowledge and innovation” center.*** For example, we are still lacking a vision for genetic modifications that will enable plants to become engineered production systems designed to produce whatever molecules are needed for the bioeconomy. Agriculture has focused on food, feed, and fiber, now it is called upon to provide feedstocks for biofuels, industrial chemicals, and biobased products. New technologies can only be economically viable if the entire value chain is optimized. Conversion technology must be connected to agricultural systems to distribution systems.



We need to better coordinate the work that happens at these various facilities. We need to optimize our capabilities across the entire set of units and facilities rather than maximize for a specific unit or facility. The challenge is how to do this when the missions of the different units and facilities, and the methods by which they are funded are not congruent. **A formal coordinating structure needs to be created to help coordinate the different facilities involved with biorenewables.**

We also need to work to promote more forward-looking commercial activity in biorenewables in Iowa. Iowa is a strong leader in thermochemical conversion of biomass, but it is not a leader in biochemical conversion (fermentation and enzyme treatment), and our current biorenewables vision needs to include expertise in both biochemical and thermochemical conversion processes. Today's dry-grind ethanol industry contributes over \$8 billion to Iowa's economy and consumes more than one-half of Iowa's corn crop. We must protect and improve this industry; but no one is investing in the next generation of corn ethanol technology despite many opportunities to improve energy efficiency, water efficiency, and co-product values. The corn seed industry projects doubling corn yields by 2030, and this new source of biomass could provide the raw material for an expanded bioeconomy in Iowa.

Investment capital is in short supply in Iowa. Nonetheless there is huge untapped potential for private investment in Iowa, and there is significant capital infrastructure in Iowa that could be put to better use. For example, Iowa could concentrate on much more valuable chemical opportunities like higher-end liquid fuels (jet) and other higher-end chemicals instead of ethanol. **We need to focus on being able to process multiple feedstocks into multiple energy and chemical products** (described as "flex fuel polygeneration"). The value of Iowa farmland has more than doubled during the last 20 years. Not all of that wealth is available as fungible capital, but it indicates that there is substantial local wealth that could be invested in Iowa ventures. The investment that corn ethanol industry received is an example. Iowa successfully participated in the first generation of biorenewables. We need to work to make sure that we are leaders of the next generation of biorenewables.

Our relationship with the academic community

To own the biorenewables brand, the academic departments at Iowa's universities must make targeted faculty hires in biorenewables and central administration must continue to share the vision of biorenewables with our stakeholders and benefactors. Iowa State provides a base of intellectual capital for biorenewable projects in Ames, but we need to better engage Iowa's other universities and colleges if we are to succeed at becoming a "*knowledge and innovation*" center for biorenewables.

While there is a small base of outstanding faculty involved in translational research, this personnel base must be expanded. Iowa cannot expand its engagement with biorenewables without more investment in and from the academic community. One of our challenges is that academic departments are driven by competition with peer institutions and fellow scholars rather than by concern about Iowa needs and opportunities. More administrative guidance and incentives for departments to hire new faculty in key areas of biorenewables are

needed, and we need to encourage translational and proof-of-concept research. **We need to broadly support both academic and industry-related research that will create new ideas.**

BECON can help encourage faculty to participate in translational research by making it easier for them to conduct research that goes beyond the bench top. We can also encourage post-doctoral research associates and graduate students to do translational and proof-of-concept research. BECON should provide opportunities and housing for graduate students from other Iowa universities and colleges, in addition to Iowa State, who conduct research at BECON.

Iowa also needs to expand investment in academic programs and research so that Iowa will have a well-trained pool of workers both for startup companies and others who are looking to locate facilities. There should be a range of associate, bachelor's, and master's degree options to enable students to receive the specific training that working in a future \$15 billion industry requires.

Our relationship to government

Efforts designed to grow Iowa's bioeconomy should be led by a consortium of government and industry leaders. The biggest obstacle that stands in the way of such collaboration is a lack of a clear direction toward the future. **We need a vision that is easily understood by citizens of Iowa and that the Governor and Iowa State President can promote.** Too often, the State and the public understand biorenewables to mean "ethanol supplements to gasoline." We need to work to educate people about the next generation of biorenewable products.

We need to enroll the Governor, the Board of Regents, and the Presidents of Iowa's universities and colleges in our biorenewables effort. Governor Branstad recently became the head of the Midwestern Governor's Association, making him well positioned to encourage a shift toward biorenewables in the Midwest. It would be politically advantageous to him for Iowa to "own the brand" of biorenewable technologies. Iowa State also recently announced that it seeks to hire 200 new faculty members, many of whom will work in biorenewables. We are, therefore, in a time of political opportunity.

We need to persuade these participants not just through direct advocacy, but also through the enrollment of business leaders, who might be particularly supportive of research designed to reduce risks of investment.

What strategic actions are needed to make Iowa the best location in the world for Biorenewables research, development and commercialization?

Foremost, a shared vision needs to be developed between the state, industries, and Iowa's universities and colleges as to the strategy for connecting research, development and commercialization. Iowa can only become the best location in the world if we tie together the various elements (state, industries, and Iowa's universities and colleges) in a way that no other location has, which will require shared commitment.

All units need to leverage limited state funds to attract additional funds from both federal and industry sources in advanced biofuels and biobased products that go beyond the state's current focus on converting corn and soybeans into first-generation biofuels. At the same time, we must not forget today's corn- and soybean-based biofuels and biobased products that are the current foundation of the bioeconomy – we must make more efficient the corn ethanol technologies that provide more than \$8 billion to the Iowa economy and provide a basic infrastructure that can be expanded upon.

We need to pay attention to the needs of both established companies and startups. Existing companies need skilled labor and ready access to infrastructure. Startup companies need access to capital and access to facilities where they can work collaboratively with academics and their scientists and engineers to develop or fine-tune their processes and technologies.

The panel recommends the following actions for moving forward and helping Iowa capture the biorenewables brand:

State

- Assist Governor Branstad and Iowa State President Leath in developing a vision for forward thinking biorenewables policies (catalyze a statewide vision)
- Expand the biorenewables brand and Iowa's vision to include biorefining and producing high-value biobased products
- Encourage Iowa to invest in translational research as well as economic development of mature ideas; Iowa must also be the source of new ideas
- Promote the idea of moving towards second-generation biofuels and biorefining for biorenewables research
- Enroll business leaders in forward-looking biorenewables industries by stressing research that will reduce the risk associated with investment
- Create a Biorenewables Coordination Committee to facilitate communication and foster partnering between units at Iowa's universities and colleges
- Acquire a capital improvement fund for continual facilities and equipment improvement
- Engage biorenewables units and facilities more in teaching and outreach
- Engage ISU Extension and Outreach in outreach to producers to reliably supply high-quality feedstocks
- Review the budget models for all units and identify and correct those that are not sustainable
- This report needs to be forwarded to appropriate administrators of Iowa's universities and colleges so that these statewide recommendations are implemented

BECON

- Refocus BECON to be a facility for translational and proof-of-concept research conducted by Iowa's universities and colleges, in partnership with companies as appropriate, and eliminate "in-house" research
- The facilities manager needs to aggressively market BECON to the public, companies, federal and state agencies, and most importantly researchers at Iowa's universities and colleges, as well as attract and recruit projects, funding, and opportunities for collaboration
- Establish a BECON oversight committee
- Recruit BECON staff, in a way that is commensurate with user needs in order to avoid excessive fixed costs, that includes a facilities manager, a project/design engineer, a mechanic, a technician, and an analytical chemist to support projects at BECON
- Retool BECON to be a "plug and play" facility consisting of individual research bays
- Develop a business plan and fee structure for different categories of BECON users
- Refocus IEC's competitive grants program on translational research; the IEC director needs to identify and address barriers to proposal submissions
- Make BECON more of a partner with the faculties of Iowa's universities and colleges; the BECON facility manager should work to attract translational and proof-of-concept research with faculties from Iowa's universities and colleges
- Establish a plan for moving commercial ventures out of BECON and a policy for future engagement of companies
- The director of the IEC needs to make certain the recommendations of this report are implemented within a short time frame and are a high priority for these recommendations to be successful