

BIOMASS CONVERSION ACTION PLAN

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IOWA ENERGY PLAN

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Photo courtesy of Sara Hirsh, Iowa State University



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IOWA ENERGY PLAN ORGANIZATIONAL STRUCTURE AND OBJECTIVES

VISION

Iowa is committed to the development of an affordable, reliable and sustainable energy system that maximizes economic benefits for our state.

We will continue to embrace energy efficiency, a mix of energy resources, infrastructure, and technologies to position all of Iowa – both rural and urban – for future growth.

As a clean energy leader, our efforts will drive innovation, foster research and development, create business and career opportunities and promote environmental stewardship.

GUIDING PRINCIPLES

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|--|---|
| Foster long-term energy affordability and price stability for Iowa's residents and business. | Stimulate research and development of new and emerging energy technologies and systems. |
| Increase the reliability, resiliency, safety and security of Iowa's energy systems and infrastructure. | Expand opportunities for access to resources, technologies, fuels and programs throughout Iowa in a manner that results in a fair and balanced outcome for all customers. |
| Provide predictability by encouraging long-term actions, policies and initiatives. | Seek diversity in the resources that supply energy to and within Iowa while preserving fair and reasonable costs for customers. |
| Support alternative energy resources, technology, and fuel commercialization in proven, cost-effective applications. | Encourage sector-based workforce development and educational activities that build clear pathways to rewarding energy careers. |
| Promote the protection of the environment and Iowa's natural resources. | |

PILLARS

| | | | |
|---|------------------------------------|-------------------------|-----------------------------------|
| Economic Development and Energy Careers | Energy Efficiency and Conservation | Iowa's Energy Resources | Transportation and Infrastructure |
|---|------------------------------------|-------------------------|-----------------------------------|

OBJECTIVES

| | | | |
|---|--|--|--|
| Facilitate the development of diverse financing options for widespread adoption of energy efficiency and renewable energy practices and technologies. | Increase the energy efficiency and decrease the operating costs of Iowa's existing and new buildings in all sectors. | Increase utility-scale renewable energy generation in Iowa. | Enhance the reliability and safety of Iowa's energy systems. |
| Foster innovation and increase the commercialization and expansion of energy-related businesses and technologies. | Encourage the expansion and diversification of energy resources, incentives, and programs. | Support distributed renewable energy generation including wind, solar, and other clean energy resources in Iowa. | Utilize smart grid and other technologies to modernize Iowa's electricity systems. |
| Strengthen energy education and awareness throughout Iowa. | Lead by example in Iowa's government practices. | Increase biofuel production and usage in Iowa. | Encourage the prudent maintenance and development of energy delivery infrastructure. |
| Increase the local talent pool for energy-related careers while promoting employment and training opportunities in the energy sector. | | | Expand the use of alternative fuel vehicles in Iowa. |
| | | | Optimize the movement of freight and people in Iowa to reduce energy use. |

EXECUTIVE SUMMARY

Consumption of renewable energy in the United States is at the highest level in history, contributing to energy security and other economic and environmental benefits. The largest single source of renewable energy is biomass, representing nearly half of renewable energy consumed in 2016. With Iowa's abundance of biomass potential, finding a way to better capitalize on this resource was one of the primary recommendations stemming from the 2016 Iowa Energy Plan. This work is the result of a year-long effort to create an action plan to provide direction for policy, programming and regulations related to the biomass industry.

Based on the input of committee members and other stakeholders, direction provided by the Iowa Energy Plan and research on strategies across the nation and the world, Iowa Economic Development Authority (IEDA) identified nine primary action items for the State of Iowa. The strategies have been divided into three objectives, related to national, state, and regional agendas. The table below summarizes the strategies.

Short-term and long-term approaches to optimize biomass conversion may look quite different and ongoing analysis is needed to ensure that state support and policies are evolving with the industry. The industry will grow as crop diversity and supply increase and the science around conversion matures. Early strategies may include modifying the operation of existing assets, such as power plants, while long-term strategies include the introduction of new technologies. To enable this maturation of the industry, strategies related to permitting, financing and other incentives must be technology and feedstock neutral and allow market signals to shape the industry.

Success stories will be among the biggest drivers of change in the sector. Replicable, highly visible projects are needed to engage agricultural, municipal and private sector stakeholders to create a robust and diverse biomass industry and hasten progress on the learning curve. The nine strategies outlined in this plan are intended to build on the success of the biofuels industry in the state and take Iowa's bioeconomy to the next level.

Iowa's Energy Resources

Biomass Conversion Objectives and Strategies

| Support and encourage federal policy | Optimize state policies and resources to better realize the benefits of a strong bioeconomy | Collaborate locally, while leading the regional conversation |
|--|--|---|
| <p>Strategy 1</p> <p>Work to maintain and expand federal policy to benefit biomass conversion</p> | <p>Strategy 2</p> <p>Streamline and consolidate permitting of bioenergy facilities and reconcile conflicting regulatory requirements</p> | <p>Strategy 9</p> <p>Align with regional organizations to promote biomass conversion</p> |
| | <p>Strategy 3</p> <p>Assess and monetize the economic, energy and environmental benefits of biomass in Iowa</p> | |
| | <p>Strategy 4</p> <p>Develop a strategy to facilitate access to transmission, pipelines and other distribution networks</p> | |
| | <p>Strategy 5</p> <p>Identify private, state and federal funding for feasibility studies, pilot projects and research to support biomass utilization projects</p> | |
| | <p>Strategy 6</p> <p>Create a bioenergy information platform (web based)</p> | |
| | <p>Strategy 7</p> <p>Implement measures to overcome supply chain barriers and optimize resource utilization</p> | |
| | <p>Strategy 8</p> <p>Establish dedicated state funding source to stimulate Iowa's emerging biomass industry</p> | |



Introduction

Photo courtesy of Erin Hazen, University of Iowa

Iowa is well positioned to lead the growth of the bioeconomy in the Midwest. However, a well-defined strategy is needed to take full advantage of the opportunities presented to the state. The primary need is an action plan to collectively and holistically address the broad range of environmental and economic topics associated with the biomass industry.

The IEDA, in partnership with the Iowa Department of Transportation (Iowa DOT) and under the leadership of then-Lieutenant Governor Kim Reynolds, released a new energy plan for the state of Iowa in late 2016 (2). The Iowa Energy Plan was created to provide a clear path to ensure Iowans have access to affordable, reliable, sustainable energy, while recognizing energy's strategic importance to Iowa's economy. A key focus area identified in the plan is Iowa's abundance of biomass with the potential to benefit economically and environmentally by further realizing the value-added attributes of biomass in the development of bioenergy, biofuels and biochemicals.

The word 'bioeconomy' is used broadly today in conversation to describe the integral role of abundant, sustainable, domestically produced biomass in the production of biofuels, the generation of bio-based heat and power and renewable chemicals and other bio-based products in growing the U. S. economy (1).

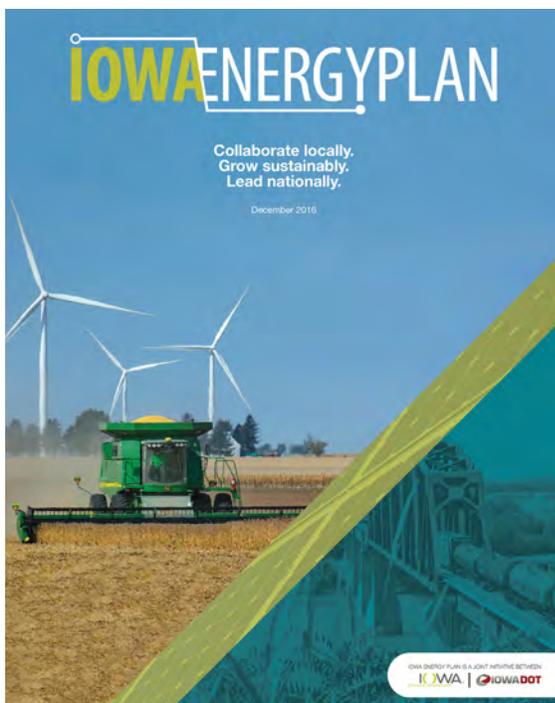
Biomass is renewable, organic materials, such as wood, agricultural crops or municipal waste, especially when used as a source of fuel or energy. The terms 'biofuel' and 'bioenergy' are used interchangeably throughout this plan. The term biogas refers specifically to bioenergy in the gaseous state.

Several energy-based economic development opportunities related to biofuels were identified. These include livestock waste-to-biogas projects, development of modular biopower systems for distributed generation and value-added chemicals from biofeedstocks.

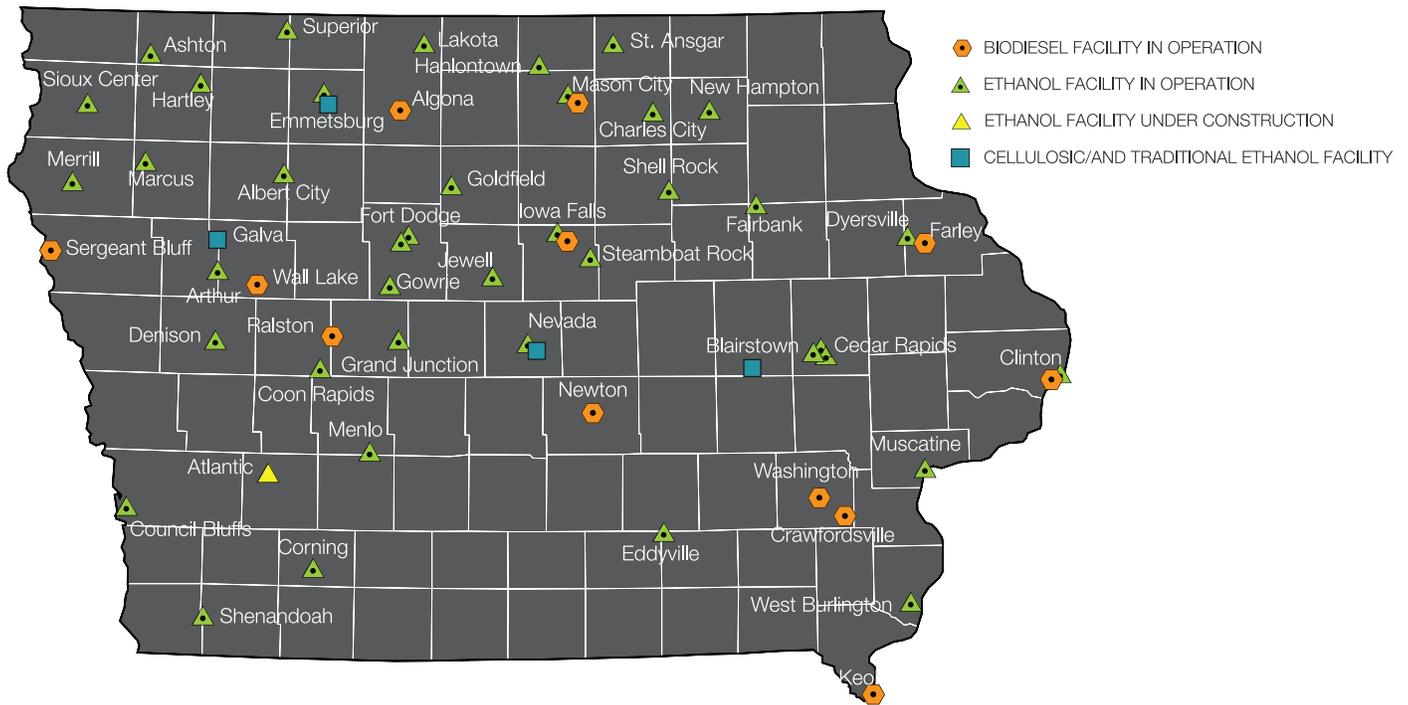
The Iowa Energy Plan recommended the creation of a group focused on exploring further opportunities for the conversion of biomass to energy. The Biomass Conversion Action Committee was formed in January 2017 and, per direction provided in the Iowa Energy Plan, the group's role is to identify the various markets, associated business cases and potential barriers for biomass-to-energy expansion in Iowa. The group is charged with accelerating the deployment of biomass conversion in Iowa by:

- coordinating existing biomass-to-energy efforts and initiatives
- aligning financial support mechanisms
- developing solutions to remove barriers
- expanding the overall use of biomass resources to produce energy

The committee met throughout the course of the year to share information and provide input. This action plan does not necessarily represent the views of all committee members.



ETHANOL AND BIODIESEL FACILITIES



The Role of Biomass in Iowa

Bioenergy has been recognized as an important aspect of Iowa's energy profile and an economic development opportunity for decades. Iowa is the nation's largest producer of ethanol, with 42 operating ethanol plants that account for 27 percent of U.S. output. (3,4) A few ethanol facilities produce cellulosic ethanol and several other sites are in the approval process, broadening the scope of feedstock supplies in the state. Similarly, Iowa is also the nation's largest producer of biodiesel, with 11 operating biodiesel plants that account for 16 percent of U.S. output (5). Ethanol production alone accounts for \$2.253 billion per year to Iowa's GDP, and the biofuels industry supports more than 15,000 jobs.

Limited success has been achieved in other biomass applications. The state has three on-farm digesters, with feedstocks including cattle manure, food processing waste and cover crops. These systems include generators and provide electricity to the grid. A handful of municipal wastewater treatment plants also have anaerobic digesters. These systems take effluent from primary treatment and add high-strength food processing waste delivered from sites without adequate treatment in the vicinity. Generally, these systems are combined heat and power (CHP) facilities, providing electricity to the grid and thermal energy to the site. There is also a limited number of landfills in the state with CHP powered by methane gases captured from the landfill. The University of Iowa has substituted local biomass sources for coal at the CHP power facility on campus. Biomass feedstocks include the energy crop

Miscanthus x giganteus (*Miscanthus*) grass, as well as oat hulls from a nearby food processor. Barriers facing these types of biomass projects can include failure to achieve design outputs, escalating costs between the feasibility and construction phases, shortened life span of equipment due to operating conditions, odor control and unstable financing structures. Lessons learned from these early adopters will enable the next generation of facilities.

Iowa's row crop farms are the best-known biomass source in the state, but other industries are also biomass stakeholders. Iowa is home to 36 of the largest 100 food manufacturers and processors (6) and is number one in the nation in corn, pork and egg production (7). Over 900 processors throughout the state produce more than \$35 billion in food products annually (8). Energy and wastewater treatment issues are critical for Iowa's food processing industries that generate significant volumes of wet waste with high organic contents.

Another key stakeholder is Iowa's animal agriculture industry, with a total output of \$38 billion in 2013. The animal industry contributed \$1.2 billion in state and local taxes and sustained over 160,000 jobs. Iowa's livestock inventory includes 21 million hogs and 3.9 million head of cattle (9). In the hog sector alone, Iowa has almost 2,000 swine farms with the potential to recover methane, generating up to 1,829,000 megawatt hours per year of electricity. (10)

An Abundance of Biomass Resources

Consumption of renewable energy in the U.S. is the highest in history, contributing to energy security and other economic and environmental benefits. The largest single source of renewable energy is biomass, representing 3.9 quadrillion of 9.6 quadrillion British thermal units (Btu) in 2015. Biomass includes agricultural and forestry resources, municipal solid waste (MSW) and algae. The *2016 Billion Ton Report: Advancing Domestic Resources for a Thriving Bioeconomy* (Billion Ton Report) evaluates the most recent estimates of potential biomass that could be available for new industrial uses in the future. (1)

The Billion Ton Report indicates that by 2040 the U.S.'s combined biomass resources will total 1.2 billion tons under the more conservative base-case projection and 1.5 billion tons under a high-yield scenario. The figure below (Billion Ton Report) depicts the combined potential supplies from forestry, wastes and agricultural resources with the base-case scenario. Most of Iowa falls within the highest potential supply (1,000-5,000 dry ton per square mile) or second-highest category (500-1,000 dry ton per square mile). Locally, significant amounts of waste resources are mixed throughout the state, including agricultural wastes, municipal solid waste and manure. Agricultural supplies, comprised of crop residues and biomass energy crops, represent the largest opportunity for the state as well as the entire Midwest region. As expected, forestry resources do not contribute significantly to biomass resource in the state.

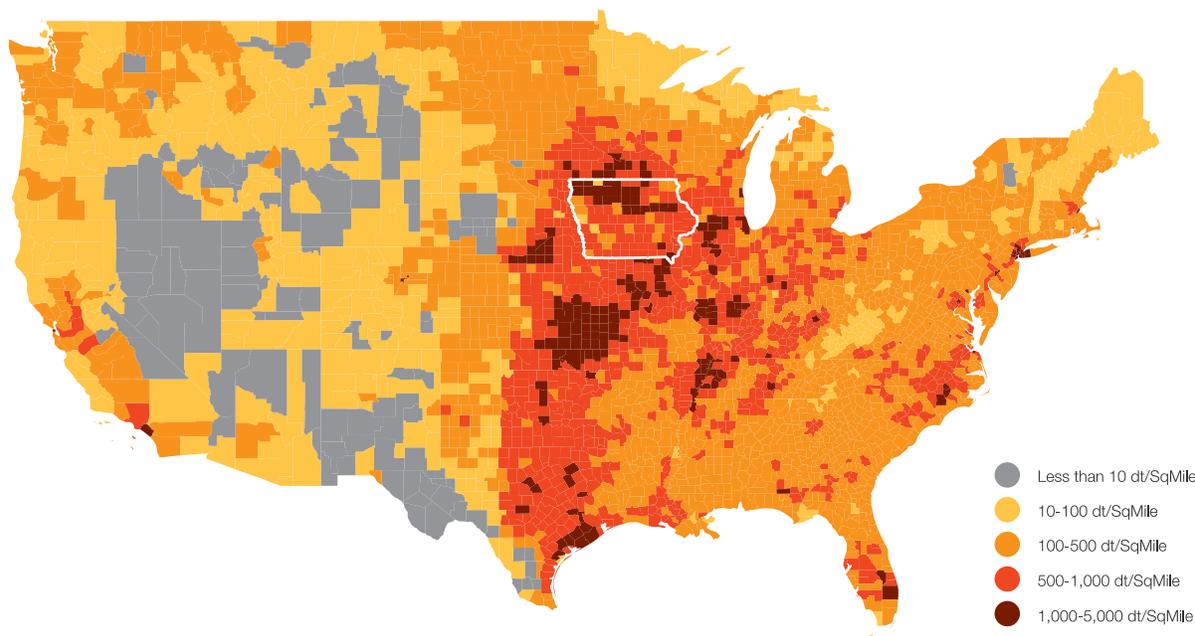
The agricultural potential of the state includes non-traditional commodities grown specifically for energy potential, such as switchgrass, Miscanthus grass and even native prairie plantings. Energy crops are especially attractive. These crops produce energy efficiently, requiring only modest amounts of fertilizer and pesticide and less fertile soil than is needed for other types of agriculture. Most are perennials, which can be harvested for years. Energy crops can be integrated into the agricultural system in various ways: buffer strips or wind breaks, on highly erodible soils or floodplains or on land cycled through longer planting rotations. Currently, 800 acres of Miscanthus grass and approximately 623,000 acres of cover crops are planted in the state, serving as demonstration sites for future market expansion. (11)

While energy crops are scarce in the near term, they offer the greatest source of potential biomass in the future, contributing 411 million tons and 736 million tons in 2040 under the base-case and high-yield scenarios, respectively. The chart (Biomass Dry Ton Potential) shows the growth of energy crops and crop residue resources over time, based upon the conservative yield estimate.

The Union of Concerned Scientists assessed bioenergy production, with a focus on identifying sustainably harvested resources. This group estimates that two-thirds of the total projected U.S. crop residues and manure in 2030 will come from ten states – Iowa, Illinois, Nebraska, Minnesota, Arkansas, Texas, California, Indiana, South Dakota and North Carolina. Iowa will lead the nation with 31 million metric tons of expected crop residue production. (12)

POTENTIAL BIOMASS SUPPLIES

FROM FORESTRY, WASTES, AND AGRICULTURAL RESOURCES, BASE CASE, 2040

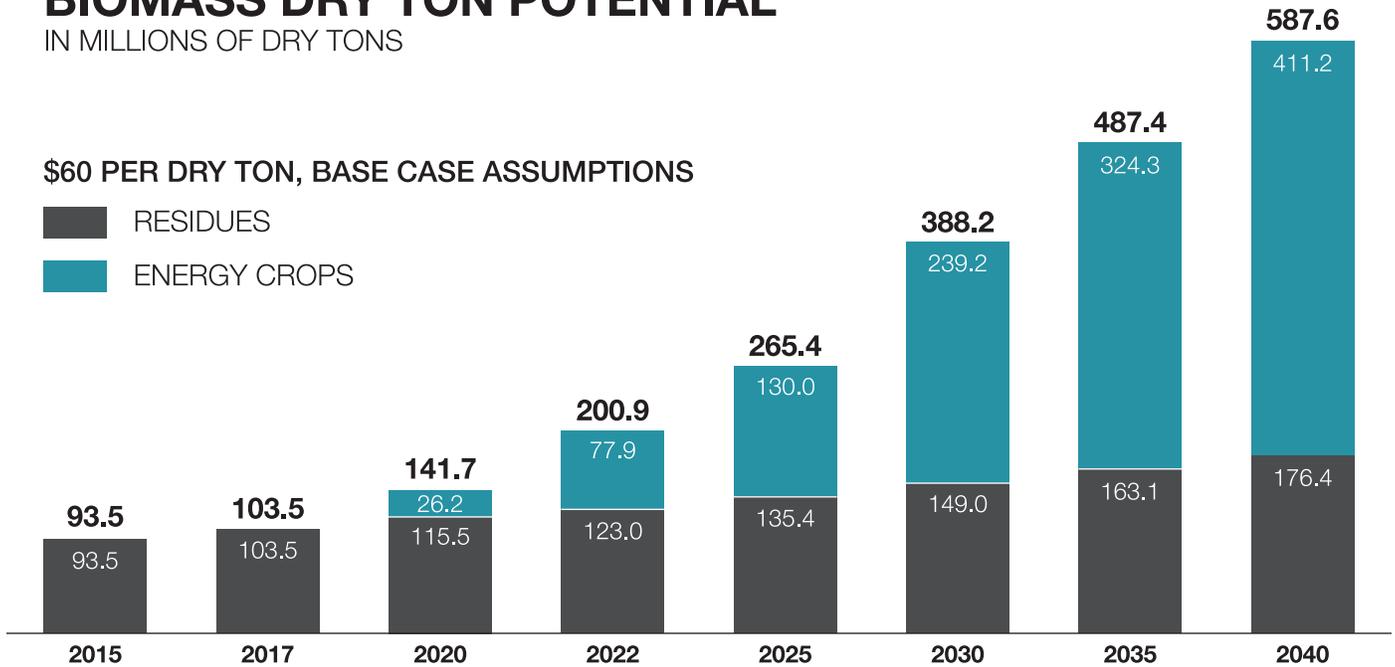


BIOMASS DRY TON POTENTIAL

IN MILLIONS OF DRY TONS

\$60 PER DRY TON, BASE CASE ASSUMPTIONS

RESIDUES
ENERGY CROPS



While the potential supply of biomass resources is substantial, further growth of the biomass industry is needed to capitalize on the potential. Approximately one third of the billion-ton potential in 2040 will exist in the field or the forest, but it will not be harvested without adequate market signals. Another one third of the potential lies in the form of energy crops and will not be realized without the development of this new market. (1)

Biogas Generation and Use

Biogas is one potential product of biomass conversion, and the current biogas market in Iowa substantially lags behind the liquid biofuels market. Biogas is produced through anaerobic digestion, a treatment process that is common in the wastewater treatment sector, yet is applicable to many other sectors and applications. Emerging technologies, such as gasification of biomass through a thermo-chemical process, also result in a biogas product. As a versatile energy resource, biogas can provide electricity and/or heat in addition to vehicle fuel. Biogas is used as a feedstock for biodegradable plastics and intermediates for other bio-based product manufacturing. In Iowa, this includes biomass from livestock production, food processing and crop residue. Other resources include wastewater treatment facilities, urban wood waste and yard waste and landfills.

Biogas is primarily a mixture of methane and carbon dioxide produced by the bacterial decomposition of organic materials in the absence of oxygen. Depending on the source of organic matter, biogas typically contains 50-70 percent methane, 30-40 percent carbon dioxide and trace amounts of other constituents such as hydrogen sulfide, hydrogen, nitrogen and siloxanes. Without capture and conversion, naturally occurring methane is a leading contributor to air quality concerns. (13)

Biogas can be used as a direct fuel source for heating, boilers, chillers or drying. In industrial applications, biogas can offset the use of natural gas, propane, fuel oil or other fossil fuels. Electricity can also be generated through an internal combustion engine, gas turbine, or microturbine technology for on-site use or for sale to the electric grid. Additionally, waste heat from the engine-generator set can be captured in cogeneration power systems and used for heating the digester, or for water and space heating.

Biogas may also be used in fuel cells, which can be configured to produce heat, as well as power. Upgraded and refined biogas, also called renewable natural gas (RNG) can be injected into existing natural gas networks. RNG can be used as various vehicle fuels including compressed natural gas (CNG), liquefied natural gas, hydrogen and liquid transportation fuels. RNG from biomass resources and natural gas are fully interchangeable from an end-user perspective. (13)

Raw biogas must be upgraded prior to injection in the natural gas network or directly used as a vehicle fuel. Upgrading biogas includes removing the carbon dioxide in the biogas to increase the energy density. Furthermore, water, hydrogen sulfide and other contaminants are removed. This step is commonly called gas cleaning or gas scrubbing. While storage of electrical energy is a current challenge, one advantage of the natural gas industry is its well-developed storage capacity. The U.S. is the global leader in below ground capacity, with a working gas volume of below ground storage at 121.4 billion m³ at over 400 storage sites (14).

Previous Biomass Initiatives and Studies

Several planning initiatives and studies have played a significant role in the development of Iowa's biomass industry. However, the most recent statewide biomass action plan dates to 2002. A diverse set of stakeholders formed the Iowa Industries of the Future/Agriculture project to develop a vision for converting agricultural crops and residues into biobased products and bioenergy and a roadmap to achieve the vision. The findings were published as the "Biobased Products and Bioenergy Vision and Roadmap for Iowa." (15)

Sponsors for the project were the U.S. Department of Energy, Iowa Department of Natural Resources (DNR) and the Iowa Energy Center. Coordination was provided through Iowa State University Center for Industrial Research and Service (CIRAS), Iowa State University Extension, Biorenewables Resources Consortium and Center for Sustainable Environmental Technologies.

Considerable progress has been made in the 16 years following the release of the 2002 plan. Accomplishments include the success of the ethanol and biodiesel industry, creation of the Bioeconomy Institute at Iowa State University (ISU), construction of model farm digesters and landfill/wastewater treatment capture projects, and the growth of supply chain logistics with the introduction of cellulosic ethanol technologies to the state. However, less progress was made in several key areas identified in the plan. Issues such as ensuring accessible financing, increasing the diversity of biomass feedstocks and end products and coordinating environmental, economic, agricultural and energy programs remain to be addressed for Iowa to fully capitalize on its biomass resources.

With the transfer of the Iowa Energy Office to the IEDA in 2011, IEDA's role in further developing the biomass industry broadened. In 2016, IEDA released the study "Anaerobic Digestion Systems and the Water-Energy Nexus" (16). The purposes of the study were to evaluate the potential economic impacts of installing anaerobic digester (AD) systems and producing pipeline quality RNG from biogas, quantify a variety of environmental impacts resulting from AD systems and identify the resources and reasons for Iowa to invest in AD systems and produce biogas.

Four sites located across the state were selected and detailed site analyses were conducted to evaluate the economics of installing anaerobic digestion and gas purification units. The boost to the regional economy from investments in new biogas infrastructure and the revenue from ongoing operations was analyzed using IMPLAN's I-RIMs model.



Three of the four sites were modeled to treat industrial wastewater. On average, sites would require \$17.6 million investment and revenues from the sale of RNG and associated environmental attributes would result in: an average 462 million BTUs per day of gas production; \$192 million per site in total economic output, from both the initial capital investment and 20-year operational revenues; 198 jobs created per site during the construction phase; 10 jobs created per site from the project operations and revenues; and \$2.7 million increase per site in tax receipts over project life.

One site was modeled with an on-farm AD utilizing a combination of manure and crop biomass. The resulting economic impacts from an investment of \$8.3 million to construct an anaerobic treatment facility and gas upgrading are production of 211 million BTUs per day per site; an average gross annual revenue of \$1.9 million from sale of gas and environmental attributes, \$528,000 of which will flow through to Miscanthus suppliers; \$69.5 million in total economic output from capital investment and 20 year operations; 97 jobs created during the construction phase; six jobs created from the project operations and revenues, of which two will be dedicated to Miscanthus cultivation; and \$1.3 million increase in tax receipts over project life.

Iowa's energy office isn't the only group with a focus on biomass. A current parallel effort with cross-ties to the energy effort is the Iowa Agriculture Water Alliance. This consortium of agricultural and state stakeholders is currently exploring the water quality and environmental benefits of certain agricultural practices such as processing manure through on-farm digesters and raising energy crops as feedstocks for bioenergy production. Several individuals represent both the Iowa Agriculture Water Alliance and the Biomass Conversion Action Committee to enable sharing ideas and aligning goals.



Biomass Innovation - Quad County Corn Processors

Quad County Corn Processors (QCCP) is a corn processing facility in Galva, Iowa, that produces protein, distiller's corn oil, ethanol and cellulosic ethanol. The company was formed in 2000 with investments made by local farmers and business owners and is currently owned by approximately 350 shareholders, which are mostly local farmers and local investors.

QCCP began production in 2002 and has doubled its production capacity over the past 15 years. In 2008, QCCP began the operation of its R&D facility in a quest to diversify its corn processing by adding niche products. The R&D facility has performed work for national enzyme marketing companies; analyzed potential performance improvements for the plant; and validated its patented process, which converts corn kernel fiber into cellulosic ethanol and additional distiller's corn oil while concentrating the protein product and making it more digestible. The patented process is trademarked Cellerate and is being licensed to ethanol plants in the U.S. and Canada by Syngenta, the exclusive licensee.

QCCP launched the commercial Cellerate process at its facility July 1, 2014. The Cellerate process at Quad County produces an additional two million gallons of ethanol annually (over 6.5 million gallons to date) from the same amount of corn.

Looking at broader applications of the technology, QCCP's CEO, Delayne Johnson, said "If the Cellerate process is added to all existing dry grind ethanol plants in the United States, the ethanol industry would produce an additional two billion gallons of ethanol without processing any more corn."

According to Air Improvement Resource Inc.'s analysis of Cellerate in 2011 using the GREET model, a gallon of cellulosic ethanol produced with the Cellerate process reduced greenhouse gas emissions by 126 percent compared to conventional gasoline.

Producing cellulosic ethanol by getting more products out of every kernel of corn is good for the environment, creates American jobs and improves our national security by reducing dependence on foreign oil.



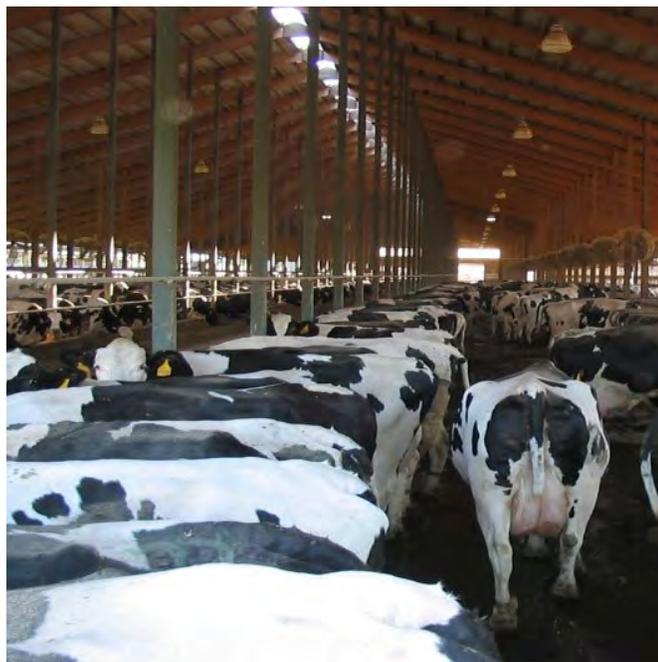
Key Considerations in Iowa's Bioeconomy

Photo courtesy of Matt Darr, Iowa State University

Multiple factors must be taken into consideration to effectively drive Iowa's bioeconomy forward. Discussion topics have been grouped into four categories:

- Securing sustainable biomass supply;
- Driving efficiency in biomass processing and conversion;
- Expanding the biomass/bioenergy market; and
- Creating an inclusive biomass business model capturing the ag/energy/water nexus.

IEDA, through Biomass Conversion Action Committee meetings, examined each of the topics in detail. Background information, data gaps and important findings are discussed in the following sections. In addition, primary stakeholders in each category have been identified.



Securing Sustainable Biomass Supply

Given the level of capital investment necessary for processing biomass feedstocks into usable end products, reliability of supply and price are critical concerns of project developers and feedstock producers. Building a strong supply chain and minimizing risk to producers are essential elements of a stable market. Lessons learned from the developing cellulosic ethanol industry highlight the importance of the role of intermediaries in the supply chain. Filling this role in biomass planting, harvesting and transportation can reduce the ramp up time for new projects to become competitive. Diversifying not only crop choices, but also market options will reduce risk to Iowa's agricultural community. Additionally, the potential for crop insurance policies to support less mainstream commodities is a factor impacting the supply of some feedstocks.

Iowa's research universities have been instrumental in assisting the development of the biofuels industry and are vital to growing the bioeconomy. Continued research is needed in many areas, including market development and energy crop yield improvement. Current trends in agriculture favor specialization, and strategies to broaden crop diversity must be proven and promoted through education and outreach. It is estimated that between two and three million acres of Iowa farmland is operating below the profitability threshold, resulting in over \$1 billion of misallocated working capital (17). Emphasizing the potential of these acres to support biomass commodities for energy and biochemical markets may be a means of strengthening the farm economy.

Maintaining accurate data on biomass resources will foster growth in the industry. Biomass potential estimates will need to be updated to keep pace with advances in agricultural innovations and changing markets. Future changes in demand from international sources will impact the biomass potential, and research is needed to determine the appropriate balance between export and local conversion.

Some feedstocks, such as manure and landfill gas, may be regulated and care must be taken to work within existing regulations. Local, state and federal permits may be required for air emissions, waste management, construction and other

activities. However, difficulties can arise when regulations are not well-defined or present barriers to project implementation. For example, long EPA timelines to provide determinations on Non-Hazardous Secondary Materials or to define feedstocks that qualify as cellulosic material have hindered new fuel development at several biomass conversion facilities in the state.

Key Stakeholders: Universities, wastewater treatment facilities, major livestock producers, solid waste agencies, food processors, agricultural commodity groups and other ag-based organizations, Iowa Waste Exchange, farm equipment manufacturers, seed companies and state agencies.

Driving Efficiency in Biomass Project Development and Operations

As with any developing industry, economies of scale can limit uptake of technologies that are new or not widely implemented. Efforts to minimize costs associated with designing, building and operating a biomass conversion facility aids in the cost justification of new projects. In addition, capitalizing on existing natural gas, electric grid, wastewater treatment and transportation infrastructures can help balance the economics of the biomass industry.

Further developments in equipment to plant and harvest biomass feedstocks is one area where improvement is needed. Equipment needs also occur in other areas, such as sorting and recovery of solid waste streams for conversion. Sizing and mixing challenges also occur and designing systems to accommodate multiple and changing feedstocks streamlines the conversion process and reduces operating costs.

Injecting locally generated biogas into a natural gas pipeline is a relatively new strategy. The interconnection process is complicated by the fact that, compared to conventional fuels, the level of standardization for gaseous fuels is less defined and consistent. The International Organization for Standardization issued a natural gas standard and a standard for compressed natural gas. However, these standards lack quantitative requirements. The wide range of compositions of raw gas present regulatory challenges, and more work is needed to develop uniform standards. (14)

Compared to other renewable energy resources, the biomass conversion industry is labor intensive. Workforce development strategies are needed to recruit and train system operators for conversion facilities. Biological conversion systems, such as ADs, require ongoing oversight to operate at optimal levels. Mechanical systems to prepare, transfer and mix feedstocks require routine maintenance. Workforce development strategies must ensure that system designers are qualified and that projects are constructed to system standards. Projects that aren't successful, due to poor planning or design, can tarnish the reputation of the biomass industry and slow growth in the state.

A unique feature of the biomass industry is the diversity of technologies employed in the conversion process. A variety of biological, chemical and thermal processes, such as fermentation, saccharification, AD, gasification or pyrolysis, can be utilized, and pilot projects are needed to better define which technologies are the best match with specific feedstocks or end products. ISU is participating in research projects to further develop modular processing technologies. Advantages of these systems include the ability to more easily adapt to changes in production levels and minimization of the risk of stranded assets. Care must be taken to keep regulatory requirements and incentives technology neutral and allow the market to adjust to technology changes.

Site selection is a primary consideration in project development, and providing resources to identify locations of stranded and underutilized assets will simplify the process. In addition, matching groups with co-location synergies (e.g. feedstock source with energy consumer) will facilitate industry growth. The cost of transporting feedstocks limits the range from which suitable materials can be drawn. Therefore, transportation considerations are critical to project development. Additionally, agricultural feedstocks are seasonal in nature and require strategies to store materials prior to processing. The developing cellulosic ethanol industry has addressed these issues and can serve as a model for other biomass conversion applications.

Financing and incentive options for biomass conversion projects are available, but are piecemeal and complex. Depending on the type of project, the owner and location, programs such as the Iowa DNR State Revolving Fund (SRF), Iowa Alternative Energy Revolving Loan Program, or USDA crop and energy programs may provide grants or loans. State and federal renewable energy tax credits, sales tax exemptions and the Renewable Fuels Standard may offer incentives. Power purchase agreements for electricity generated from the site may enter into the financial analysis for a project. A system that ties agricultural, environmental, energy and economic development incentives together will better account for the diverse range of benefits that can be realized through a stronger bioeconomy and lessen current barriers to project development. However, uncertainty over the long-term availability of some incentives remains a barrier to investors. A range of ownership models, such as public-private partnerships, third-party ownership, or cooperatives, could be needed to allow projects to take full advantage of incentives and financing opportunities.

Key Stakeholders: Universities, equipment manufacturers and vendors, design engineers, utilities, state agencies, existing biomass conversion facilities, community college workforce programs, USDA, EPA, third-party renewable energy investors and financial institutions.

Expanding the Biomass/Bioenergy Market

Economic development opportunities associated with Iowa's potential bioeconomy are far reaching. However, successfully growing the industry requires an intricate balance between inputs and outputs. Increasing the availability of biomass is needed to enhance the competitiveness of end products, while more competitive end products are needed to incentivize more efficient/larger scale biomass production. Additionally, both economic and regulatory uncertainties make it difficult for some advanced biofuel producers to sustain operations during periods with low oil and fuel prices. A diverse range of potential goods provides the flexibility to adjust end products to accommodate market fluctuations and will strengthen the biomass/bioenergy market.



Traditional end products take the form of liquid fuels for vehicles and electricity. In addition to energy resources, biomass projects can result in valuable co-products such as corn oil and the feed ingredient known as distiller's dried grains with solubles, both current outputs of ethanol production. Co-products of other biomass processors may include digestate, or output from a digester. The solid fraction of digestate is a stable organic material, comprised largely of lignin and chitin and can be used as animal bedding, compost or in low-grade building products such as fiberboard. The liquid fraction of digestate is nutrient rich and can be land applied as a fertilizer. Biochar is another potential co-product of biomass conversion, resulting from gasification and pyrolysis applications. Biochar is a fine-grained, highly porous charcoal that increases soil retention of nutrients and agrochemicals for plant and crop utilization, improving crop yields and reducing water quality impacts. (18)

The growing alternative fuel vehicle market provides opportunities to expand the biomass market, with potential to provide both renewable electricity for electric vehicles and biogas for vehicles powered by natural gas. RNG production for transportation fuel grew by a factor of five between 2013 and 2015. The average investment for each RNG infrastructure project is \$16 million and nationally the construction investment in 2018 is expected to reach \$352 million. (19) As of June 30, 2017, approximately 50 facilities were registered with EPA to produce RNG, which is increasingly used to meet government targets for renewable fuel production. In 2016, about 189 million gallons of RNG were used to meet 82 percent of federal targets set specifically for cellulosic biofuel (20).

According to the U.S. Department of Agriculture's BioPreferred® program, over 2,700 certified bio-based products are currently on the market (21). A total of 79 Iowa companies participate in the program, which features products ranging from a shoe manufactured from corn stalks to bio-based medical equipment, industrial sealants and electronics. Several biochemical end products can also be produced through biomass processing, including ammonia and carboxylic acids. Recognizing this potential, Iowa was the first in the nation to offer a Renewable Chemicals Production Tax Credit to incentivize high-value chemicals derived from biomass feedstocks. Understanding and promoting the market potential for these diverse products and co-products will support further growth in the biomass industry.

The development of biomass/bioenergy markets can potentially lead to growth in other industry sectors. For instance, developing biogas markets may be a critical factor in justifying the expansion of natural gas infrastructure and benefit areas currently underserved by the natural gas market. Natural gas provides almost 20 percent of the state's total energy needs. While production and processing occur outside the state, natural gas is transported into and through the state by five interstate pipelines. Iowa has four natural gas storage fields with a combined capacity of almost 300 billion cubic feet (22). While the infrastructure for transmission of natural gas is fairly well developed, some areas of the state lack adequate distribution networks. With increased availability and capacity of gas supplies, other industrial enterprises can be attracted to currently underdeveloped locations of the state.

Compared to other states, Iowa has a diverse mix of energy resources. Several high-profile companies have been drawn to Iowa to take advantage of its renewable energy resources, with wind providing nearly 37 percent of the electricity generated within the state. Bioenergy, which offers additional benefits to soil and water quality, can potentially attract other corporations looking to meet sustainability goals.

The bioenergy market's footprint is larger than most industries in the state, and growth in the industry is key to job creation in Iowa. Supply chains are diverse and include feedstock production, site design and construction, and continual operations and maintenance by skilled workers. The current bioeconomy employs close to half a million people in the U.S., and the potential exists to triple this figure in the next 15 years (23). Iowa has the potential to add 20,110 direct jobs and 37,430 total jobs through bio-based industries. This would add \$1.735 billion in direct value and \$3.022 billion in total value to the economy.

Key Stakeholders: State agencies, utility providers, local economic development agencies, universities, project developers/owners and fleet owners.



Photo courtesy of City of Dubuque

Creating an Inclusive Biomass Business Model Capturing the Ag/Energy/Water Nexus

Integrating the state’s agricultural, energy and environmental goals into the business model for the biomass industry is key to its expansion. Increasingly, organizations throughout the world are realizing the inextricable linkages between agriculture, energy and water production and use. The how and where these systems intersect is known as the nexus, and actions related to one system can impact one or both of the other systems. Building the bioeconomy has the potential to reduce soil erosion of prime farm land, improve water retention and lessen the impacts of flooding, control odors at livestock operations and wastewater treatment facilities, reduce nutrient and sediment loading of streams and rivers and minimize methane emissions to the air. Lessening dependence on fossil fuels reduces environmental impacts associated with non-renewable energy resources and promotes energy assurance. Monetizing the value-added benefits of these impacts is challenging and will require additional research and coordination between stakeholders. Capitalizing on the nexus between biomass production, energy generation and watershed improvements will lead to greater achievements in these critical issues.

Iowa may need to spend \$1.2 billion to \$4 billion to put in place nutrient control systems for non-point sources to meet the requirements of the Gulf Hypoxia Action Plan (24). Additionally, Iowa municipal wastewater treatment plants and major industries are projected to spend a combined \$2.5 billion or more to upgrade their facilities and/or bring them into compliance with the Iowa DNR Nutrient Reduction Plan.

Revenues from the sale of biogas and associated environmental attributes would expedite the implementation of these needed improvements and at the same time provide a boost to the regional economy (16). However, food processors, agricultural producers and others with biomass resources typically use all financial resources to meet regulatory requirements and infrastructure needs. The role of an energy exporter is seldom a primary concern and, therefore, often overlooked as a potential source of revenue.

Many existing programs focus on promoting one or more of the benefits resulting from an expanded biomass industry. These existing strategies must be layered to make the biomass industry more viable. Programs to couple include flood control, erosion control, habitat enhancement, water quality, air quality, energy resiliency, economic development, landfill diversion and more.

Developing a set of measures to account for the value of ecosystem services is necessary to fully evaluate the linkages of the ag/water/energy nexus. Benefits related to water, air and soil quality, as well as economic gains such as job creation, local and state tax revenues and other indirect monetary impacts are significant considerations in substantiating a business model for biomass conversion activities.

Key Stakeholders: State agencies, universities, environmental interest groups, agricultural commodity groups and other ag-based organizations, health organizations, watershed management authorities and flood control organizations

Biomass Innovation - City of Dubuque

Following a plant upgrade in 2013, Dubuque's Water & Resource Recovery Center (WRRC) began to capture biogas from anaerobic digestion tanks that were introduced to treat wastewater and serve as a renewable energy resource. The anaerobic digestion process produces methane gas that is captured, cleaned and burned to power turbines that generate electricity. The CHP system features three 200kW microturbines that generate 80 percent of the plant's electricity needs. Thermal energy produced through this process is used to heat the complex. An additional by-product is 15.5 tons of fertilizer output per day from the digesters, eliminating the previous need to incinerate residual biosolids.

The WRRC, which processes an average of seven million gallons of wastewater per day, has achieved a cost savings of over \$624,000 annually through the reduction of grid-purchased electricity, eliminating fuel oil costs related to the incineration process and increasing the efficiency of its operating staff. In addition, revenues over \$215,000 can be generated through the high-strength waste program.

The ability to process high-strength waste at WRRC provides an advantage to several local businesses, including a food processor that eliminated a daily 90-mile haul of waste and reduced its cost per gallon for wastewater disposal by 60 percent. Dubuque is the headquarters of Unison, the manufacturer of biogas conditioning units installed at the site and the project provided the opportunity for this supplier to showcase equipment locally.

In August 2016, Dubuque entered into a partnership with BioResources Development and Black Hills Energy to generate approximately 200 Mcf/day of pipeline quality RNG at the WRCC site, a portion of which will be injected into the natural gas pipeline distribution system. This product qualifies for gas revenues and RIN (Renewable Inventory Number) payments due to its use as an advanced biofuel. The city will receive lease payments and a portion of gross revenues from the sale of gas and RINs. With the city converting some fleet vehicles to natural gas fuel, there will also be the potential to power city vehicles with RNG produced at the facility. When the pipeline was tapped in late 2017, the project became one of the first biogas sites in the state with a direct feed to the gas pipeline.



Biomass Innovation - University of Iowa

The University of Iowa (UI) operates two CHP plants, located on the main campus in downtown Iowa City and at the University of Iowa Research Park in Coralville. The CHP facilities primarily provide steam to serve the heating, cooling and process needs of each campus and some of that steam is also used to generate electricity. The University's goals include achieving 40 percent renewable energy by 2020, and in early 2017, the University announced that the campus will be coal-free by 2025. University of Iowa President Bruce Harrelld stated "In 2025, we expect to have diminished our reliance on coal to the point it is no longer included in our fuel portfolio. The university will continue to pursue and develop its innovative renewable energy program to ensure an abundant supply of alternative sources of energy. It's the right choice for our students and our campus, and it's the surest path to an energy-secure future."

Because the University's campus depends on steam for heating, cooling and processes, its renewable fuel source must be capable of cost-effectively producing more than just electricity. Therefore, the University seeks to displace coal with renewable biomass fuels. One of the unique aspects of the University of Iowa Biomass Fuel Program is repurposing existing coal-fired boilers to use biomass to minimize the capital costs of the conversion. Knowledge and information, developed through years of trials and innovative operations, may pave the way for other boiler operators to convert to biomass fuels.

Since 2003, the University has burned oat hulls, a by-product of the nearby Quaker Oats production facility. In 2016, annual oat hull consumption reached 43,000 tons, comprising 20 percent of the overall fuel mix (by MMBTU). To further increase its use of biomass fuels, the University partnered with the Iowa State University Agronomy department to evaluate numerous plants that can be cultivated as an energy crop. The high-yielding perennial Miscanthus was selected due to its energy density per acre, compatibility with Iowa's soils and ancillary benefits to soil health and water quality. Perennial grasses offer the opportunity to sequester more carbon in soil compared to traditional row crops, grow on "marginal" agriculture lands, provide a new source of revenue, improve soil conservation and water quality and improve wildlife habitat. UI continues to partner with ISU and AgGrow Tech, a commercial grower of Miscanthus, to cultivate this new bioenergy crop in Iowa.

Miscanthus planting began in 2015 and by November 2017, the University had established 814 acres, with an overall target of 2,500 acres. Along the way, UI is working to optimize storage, harvest and densification options to drive cost from the supply chain. Ultimately, Miscanthus is expected to provide 22,500 tons of sustainable and renewable biopower feedstock annually, to replace a portion of the University's coal supply and supplement the use of oat hulls.



Iowa Biomass Conversion Action Items

Nine primary action items for Iowa have been identified based on the input of committee members and stakeholders, direction provided by the Iowa Energy Plan and research on strategies across the nation and the world. The action items have been divided into three objectives, related to national, state and regional agendas.

Objective: Support and encourage federal policy

Strategy 1: Work to maintain and expand federal policies to benefit biomass conversion

Iowa's leadership and record-breaking accomplishments in wind energy have been made possible, in part, by policy decisions at the state and federal levels that recognized the importance of clean, renewable energy. Likewise, the success of future biomass activities in Iowa will be achieved through strategic public-private partnerships and investments, along with innovative state and federal policies and supportive funding.

Recommendations and Next Steps

Iowa stakeholders should follow and encourage its congressional delegation to support the following federal policies and programs:

Farm Bill Programs

Congress is currently reviewing the Farm Bill. Farm Bill programs that are vital to the economy of Iowa and should be, at the least, maintained and potentially expanded to meet the changing landscape of the bioeconomy are:

1. The Biomass Crop Assistance Program (BCAP) helps farmers establish, produce and deliver biomass feedstocks. Without this program, farmers would have to take a multi-year risk in planting new energy crops before harvesting a return on their investment.
2. The BioBased Markets Program, also known as the BioPreferred® program, supports voluntary labeling that informs consumers about the biobased content of products.
3. The Biomass Research and Development Initiative sponsors research on new biomass sources and conversion technologies.
4. The Rural Energy for America Program (REAP) reduces operating costs for farmers and businesses in rural areas by funding energy efficiency and renewable energy projects. Since 2008, nearly 13,000 projects have been awarded in all 50 states, leveraging more than \$3 billion in private investment.
5. The Section 9003 Loan Program can support advanced biofuel and renewable chemical manufacturing facilities.

Agricultural Environmental Stewardship Act

The state should follow and support federal efforts such as the Agriculture Environmental Stewardship Act of 2017. This bill was introduced in the Senate on April 27, 2017 and in the House on June 8, 2017.

The bill amends the Internal Revenue Code to allow energy tax credits for investments in qualified biogas property or qualified manure resource recovery property. Creating a federal biogas incentive provides the opportunity for the state to continue the strategy of aligning state incentives with federal incentives.

EPA Renewable Fuel Standard (RFS/RFS2)

The RFS and the more recent expansion, known as RFS2, stipulates minimum amounts of specific fuels that must be produced each year and combined with conventional motor fuels. Renewable fuels under the RFS include liquid and gaseous fuels and electricity derived from renewable biomass energy sources. To qualify for the RFS program, the fuel must be intended for use as transportation fuel, heating oil or jet fuel.

A renewable fuel pathway includes three critical components: (1) feedstock, (2) production process and (3) fuel type. Each combination of the three components is a separate fuel pathway. Parties obligated to adhere to the standard – refiners, blenders or importers – may produce those fuels or purchase the legal right to them.

Renewable Identification Numbers (RINS) are the “currency” of the RFS2 program. Qualifying fuel pathways are assigned one or more D codes representing the type of RIN (i.e., renewable fuel, advanced biofuel, biomass-based diesel, cellulosic biofuel or cellulosic diesel) they are eligible to generate.

The state should continue to advocate for the RFS2 program and support extension beyond the 2022 sunset date. The state should also support RINs credits for a broader range of biomass feedstocks, production processes and fuel types to help advance the biomass industry. Additionally, measures to streamline the EPA review and certification process for RNG will enhance the effectiveness of the program.

Objective: Optimize state policies and resources to better realize the benefits of a strong bioeconomy

Strategy 2: Streamline and consolidate permitting of bioenergy facilities and reconcile conflicting regulatory requirements

The biomass potential for the country, and especially Iowa, is significant. These biomass resources in the state, many of which do not meet the traditional definition of “waste,” are currently stored, transported or processed through wastewater treatment, landfills or land application. Creating a regulatory framework to oversee the processing of the wide variety of biomass resources is a challenge. However, because the economic and environmental benefits of capitalizing on the biomass resources of the state are significant, state regulations must be carefully constructed. Regulators should obtain stakeholder input to avoid placing excessive restrictions on projects that could convert organic resources to energy and other valuable end products.

For example, the Iowa DNR recently proposed waste conversion rules which would impact the siting, permitting and operations of biomass conversion facilities. IEDA and others provided comments on the draft rules. Revised rules will be released by Iowa DNR and comments may again be submitted. The process for rule revision has been transparent, with opportunity for stakeholder input. Future rulemaking efforts should recognize the value of input from industry and those with environmental, economic and other associated project knowledge.

Recommendations and Next Steps

IEDA and interested stakeholders should continue to follow rulemaking processes in the state to ensure barriers to project development and economic growth are not presented.

Strategy 3: Assess and monetize the economic, energy and environmental benefits of biomass in Iowa

Defining and measuring ecosystem services associated with the bioeconomy is a significant challenge to the industry. The U.S. Department of Energy’s (DOE) Bioenergy Technologies Office lists air quality, water quantity and quality, soil quality, biological diversity, land use and productivity as key environmental sustainability considerations for biomass technologies. Energy security and external trade, resource conservation and rural development and workforce training are among the impacts and factors noted. Integrating these values into the biomass business model is a critical step in building the industry.

One current opportunity is integrating a bioenergy component into the cover crop discussion by assessing the economic potential of winter cover crops as a biomass feedstock. This practice involves planting crops, such as wheat or rye, after the harvest of the traditional corn or soybean crops. Many in the agricultural circle, including the Conservation Infrastructure Initiative led by the Iowa Agriculture Water Alliance, are evaluating the economic and environmental attributes of cover crop plantings to retain soil and improve water quality. Integrating a bioenergy component into the cover crop discussion may provide the economic impetus to advance this strategy.

Recommendations and Next Steps

IEDA, in collaboration with key stakeholders like the Conservation Infrastructure Initiative, the state’s agricultural commodity groups and research / academic partners like Iowa State University should produce quantitative assessments on the economic potential of cover crop utilization in Iowa. Two examples follow:

Iowa should work with Oak Ridge National Laboratory (ORNL) and others to model the economic potential of cover crops in more detail. Through the Billion Ton Report, ORNL developed models to project the supply of various energy crops and residues at a variety of market prices. Current models did not include a detailed review of various cover crops planted, or could potentially be planted, in Iowa. Using the existing model, data can be gathered to better assess the market point needed to encourage more wide-spread use of cover crops.

Iowa should support the development of a lifecycle cost analysis on the benefits associated with the use of cover crops. Using data gathered from an on-farm digester system currently using cover crops as feedstock, a lifecycle cost analysis can be completed to quantify the range of economic benefits provided. Results are transferable to other farmers adopting a similar model and encourages more wide-spread use of cover crops.

Strategy 4: Develop a strategy to facilitate access to transmission, pipelines and other distribution networks

There are several economic development possibilities for Iowa related to the conversion of biomass to bioenergy. One is the conversion of organic resources-to-biogas projects. According to the American Biogas Council (ABC), Iowa is ranked eighth in the country for methane production potential for biogas sources. ABC also reports potential for more than 1,140 new projects that could be developed based on the estimated amount of available organic material (25).

As a versatile energy resource, biogas can provide electricity and/or heat, as well as vehicle fuel. It's important to note that raw biogas must be upgraded prior to injection into the natural gas network or directly used as a vehicle fuel.

While the economic potential for biogas production sparks optimism, Iowa should carefully and collaboratively work with utilities, transportation companies, and respective regulatory entities to ensure locally-produced energy resources are maximized, while aligning with pertinent regulations and standards.

Recommendations and Next Steps

IEDA should establish a collaborative effort with key stakeholders like utilities, the IUB, transportation companies and the alternative fuel industry to exploit the most efficient means of using biogas. As an example of an action item, steps should be taken to ensure that upgraded biogas has uniform and cost-effective standards for injection into the natural gas grid. It will be important to take into consideration and to work to promote uniform standards at a regional and national level. Additionally, efforts to minimize the liability of pipelines regarding interconnection will facilitate the process.

Strategy 5: Identify private, state and federal funding for feasibility studies, pilot projects and research to support biomass utilization projects

Establishing a range of financing possibilities will attract a diverse set of potential biomass project developers and increase the rate for deploying and demonstrating commercial and emerging bioenergy technologies. Biomass supporters should engage investors and funding sources in a dialogue to identify strategies to help enable project investment.

It is also important to gain an understanding of which business models fit best with different financing strategies. Public-private partnerships, third-party developers and business cooperatives are different ownership structures that have unique benefits. Initially, the ethanol industry was largely driven by the farmer cooperative model and some cite

increased local economic and job creation impacts as a result (26, 27). To incentivize local ownership, some states created ethanol incentives geared to small producers. A well-known example of this strategy is termed the Minnesota Model.

Action can also be taken to maximize existing state grant and loan program funding to impact biomass projects. The inventory of Iowa programs that should be deployed and marketed includes the following:

1. The IEDA-led Iowa Energy Center (Energy Center): The gas and electric utilities' rate-payer-funded entity transferred to IEDA effective October 2017. The Energy Center has two funding mechanisms to help support the development of biomass/bioenergy projects throughout Iowa.
 - Alternate Energy Revolving Loan Program (AERLP): The AERLP is a low-interest loan fund to support the development of a wide variety of renewable energy production projects (e.g., wind, solar, hydro, biomass or a combination of technologies)
 - Grant funds can be issued for eligible projects and programs that align with the new mission of the IEDA-led Energy Center. The Center's new mission aligns with the seven focus areas of the Iowa Energy Plan, one of which is supporting the development of biomass conversion projects.
2. The State Revolving Fund (SRF): Jointly administered by IFA and the Iowa DNR, the SRF is the premier choice for Iowans to finance the design and construction of water and wastewater infrastructure and may present an opportunity for biomass/waste conversion projects.
3. U.S. Department of Energy (DOE) Competitive Funding: Typically, on an annual basis the DOE makes available competitive funds to advance innovative approaches to localized energy development (including bioenergy projects).

Recommendations and Next Steps

IEDA will promote the availability of dedicated Iowa Energy Center resources to support the development of biomass projects in the state.

In conjunction with stakeholders including Iowa DNR, IEDA should examine ways that the SRF and the impacts of other supportive financial offerings can be maximized.

Additionally, IEDA's Energy Office, Iowa's research universities and industry partners should collaborate when DOE bioenergy grant awards are available to ensure Iowa project submittals reflect a professional and diverse mix of expertise and cost-share strength.

Advantages of various business models can be shared through case studies and other means of outreach and education.





Strategy 6: Create a web-based bioenergy information platform

As Iowa works to cultivate the immense economic potential of biomass projects, it will be imperative to make information available on supportive financial and technical resources. Interested biomass stakeholders will need reliable and centralized web-based tools to provide accurate information.

The Biomass Conversion Action Committee and its synergy with the Conservation Infrastructure Initiative have an opportunity to establish informational platforms with input and support from a diverse mix of public and private sector partners.

Recommendations and Next Steps

As an action item of the Iowa Energy Plan, IEDA is currently adding information to its website to serve as an energy information clearinghouse, including biomass-related financial and technical resources.

In collaboration with stakeholders, including those engaged with the Conservation Infrastructure Initiative, IEDA should examine the establishment of additional cloud-based services and/or resources which enable Iowa stakeholders to easily identify available financial and technical resources for the adoption of conservation practices including biomass activities. It may be useful to tie biomass-related information to watershed areas across the state, thereby facilitating the connection of energy and water initiatives. Other outreach opportunities, such as social media, can be used to further the public's awareness of the benefits of bioenergy.

Strategy 7: Implement measures to overcome supply chain barriers and optimize resource utilization

With significant agricultural resources, established biofuel refining facilities, significant research capabilities and numerous businesses operating in this space, Iowa is well positioned to lead the next generation of biomass-to-energy technologies.

To lead the way, Iowa stakeholders must view current challenges as opportunities to address barriers and gaps related to optimizing resource utilization and strengthening supply chains. There is presently a need to develop and make information accessible regarding the availability of organic wastes/resources in Iowa for bioenergy development - a key factor to enabling the market.

Similarly, there are many potential links in the biomass supply chain. Examples of biomass supply chain barriers/opportunities follow:

- Increased demand for raw biomass inputs for new generation facilities provide business growth opportunities in agricultural and other by-product businesses that supply such material. IEDA should capitalize on this impactful business development opportunity when working to expand and recruit entrepreneurial projects in this space.
- Capacity is lacking for laboratory analysis of biomass feedstock to assess the suitability of a variety of biomass sources as feedstock for various technologies. As a result, biomass samples are often sent out of the state, or even internationally, for testing which is cost prohibitive.
- There is a lack of facilities in the state that can pelletize biomass into a suitable feedstock for some energy applications.
- More access for end users, such as RNG vehicle fueling infrastructure to facilitate biogas as a transportation fuel.

Recommendations and Next Steps

IEDA and relevant stakeholders should develop a web-based tool which provides information about the availability and physical locations of organic resources (biomass feedstocks) in Iowa for bioenergy development.

Efforts should also be made to recruit additional supply chain services to the state. IEDA should establish public-private partnerships with an emphasis on encouraging private investment in biomass energy projects. This will enable more effective translational deployment of innovative biomass technologies to occur by accelerating funding access for early-stage companies, as well as enabling more established companies to deploy new ventures or expand current projects in biomass-related markets.

Strategy 8: Establish dedicated state funding source to stimulate Iowa's emerging biomass industry

Supportive policies and tax incentives are often used to jumpstart an emerging industry and to enhance the financial viability of renewable energy projects by lowering cost barriers for project development.

One supportive state program that Iowa offered, the Renewable Energy Tax Credit program (Iowa Code Chapter 476C), recently expired. The program provided a state production tax credit for energy sold by eligible renewable energy facilities (wind, solar and biomass/biogas facilities) or for production of energy consumed on-site by these facilities. Eligible facilities could receive credits for a ten-year period. The law required that, to receive tax credits, an eligible facility must have been initially placed into service before January 1, 2018, and no additional tax credits will be issued after December 31, 2027.

As a productive agricultural state, Iowa has immense potential to benefit economically and environmentally by further realizing the value-added attributes of biomass in the development of bioenergy, biofuels and biochemicals. Revitalizing and modernizing the 476C state tax credit program with a focus on bioenergy-related facilities or investigating the establishment of a new and dedicated biomass funding mechanism would be an impactful state-led action, which encourages Iowans to capitalize on economic opportunities of a more robust bioenergy industry.

Recommendations and Next Steps

Key stakeholders such as the Iowa Utilities Board (IUB), Iowa Department of Revenue (IDOR), utilities, environmental organizations, IEDA and members of the state legislature should evaluate the revitalization and modernization of the Renewable Energy Tax Credit (476C) and/or consider the establishment of a new and dedicated tax incentive to support the deployment of bioenergy production in Iowa and ultimately, for the state to realize its associated economic benefits.

Objective: Collaborate locally, while leading the regional conversation

Strategy 9: Align with regional organizations to promote biomass conversion

Biomass-to-energy opportunities are not unique to Iowa. Many neighboring states in the Midwest have similar biomass resources and established, supportive programs to enhance the associated economic development benefits.

Iowa not only recognizes the economic and environmental attributes of a robust biomass conversion platform, but the state has taken the initiative to lead regional dialogue on best practices. IEDA collaborated with the Midwest Governors Association (MGA) in offering the "Smartland Series - Maximizing Bioenergy Resources in the Midwest." The series included webinar discussions and culminated with an onsite meeting in Iowa City in October (28).

A similar MGA organized discussion in 2010, exploring the development of a Midwest Low Carbon Fuel Standard Program (LCFP), has synergy with Iowa's current efforts to maximize the economic potential of biomass conversion (29).

Recommendations and Next Steps

In collaboration with other key state stakeholders, IEDA should continue efforts to participate in further regional discussions and share best practice information with neighboring states. Likewise, IEDA and stakeholders should gauge the interest amongst state and regional stakeholders to establish a Midwest Low Carbon Fuel Standard Program.



Biomass Innovation - Sievers Family Farms

Sievers Family Farms, established in 1873, is a family owned cattle farm located in Stockton, Iowa. The farm is also the site of a 1 MW CHP system fueled by methane produced from an anaerobic digester utilizing cow manure and other substrates. A diverse set of feedstocks including corn cobs, cover crops and high strength industrial waste from area food processors is mixed with the manure from 2,400 head of cattle.

The project was completed in September 2013 and an average of 390,00 scf/day of biogas is generated to produce electricity. The system consists of two digesters with a volume of 970,000 gallons each and a Caterpillar 3516A Engine Generator. Other components include separate storage structures for effluent, separated solids and biomass, as well as two cattle barns.

The mixture of manure and other feedstocks has a retention time of roughly 40 days in the digestion process. The electricity powers the farm and the excess is purchased by Alliant Energy. Thermal energy from the conversion process heats the facility and maintains the temperature of the digesters. Digestate from the system is used as fertilizer and residual solids for animal bedding and compost.

In addition to providing environmental improvements to manure management practices, the project also allowed the farm to expand from 400 to over 2,400 head of cattle. Sievers Family Farms was awarded Biogas Project of the Year by the American Biogas Council in 2014.

COMPRESSED

Biomass Innovation - Ruan Transportation Management Systems

Ruan, an Iowa-based transportation provider, has extensively invested in fuel-efficient vehicle deployment, operating CNG and RNG-powered vehicles within its fleet. Ruan's fleet has traveled more than 70 million miles on CNG fuel, 50 million miles of which were renewable. Recently, one of Ruan's units—a 2014 Kenworth T660 CNG-fueled Class 8 tractor—reached the milestone of one million miles in service.

“Continually improving our sustainability performance is important to Ruan, as well as to our customers. These efforts not only benefit the environment through a minimized use of diesel fuel, but also cut our fuel costs, benefitting customers,” said Ruan Director of Procurement and Fuel Steve Larsen.

Several customers, including large food, retail and manufacturing customers, are serviced through a CNG-fueled fleet. Ruan's Fair Oaks operation utilizes 40 CNG-fueled tractors. This is one of the largest renewable CNG Class 8 tractor dairy fleets in the nation and displaces 1.8 million gallons of diesel annually.

Routinely recognized as an industry leader in sustainability by trade publications such as Inbound Logistics and Food Logistics, Ruan is an official partner in EPA's SmartWay Transport Partnership. In 2016, Ruan was the recipient of the Advanced Clean Transportation Expo Fleet Award in the Private Fleet category.

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