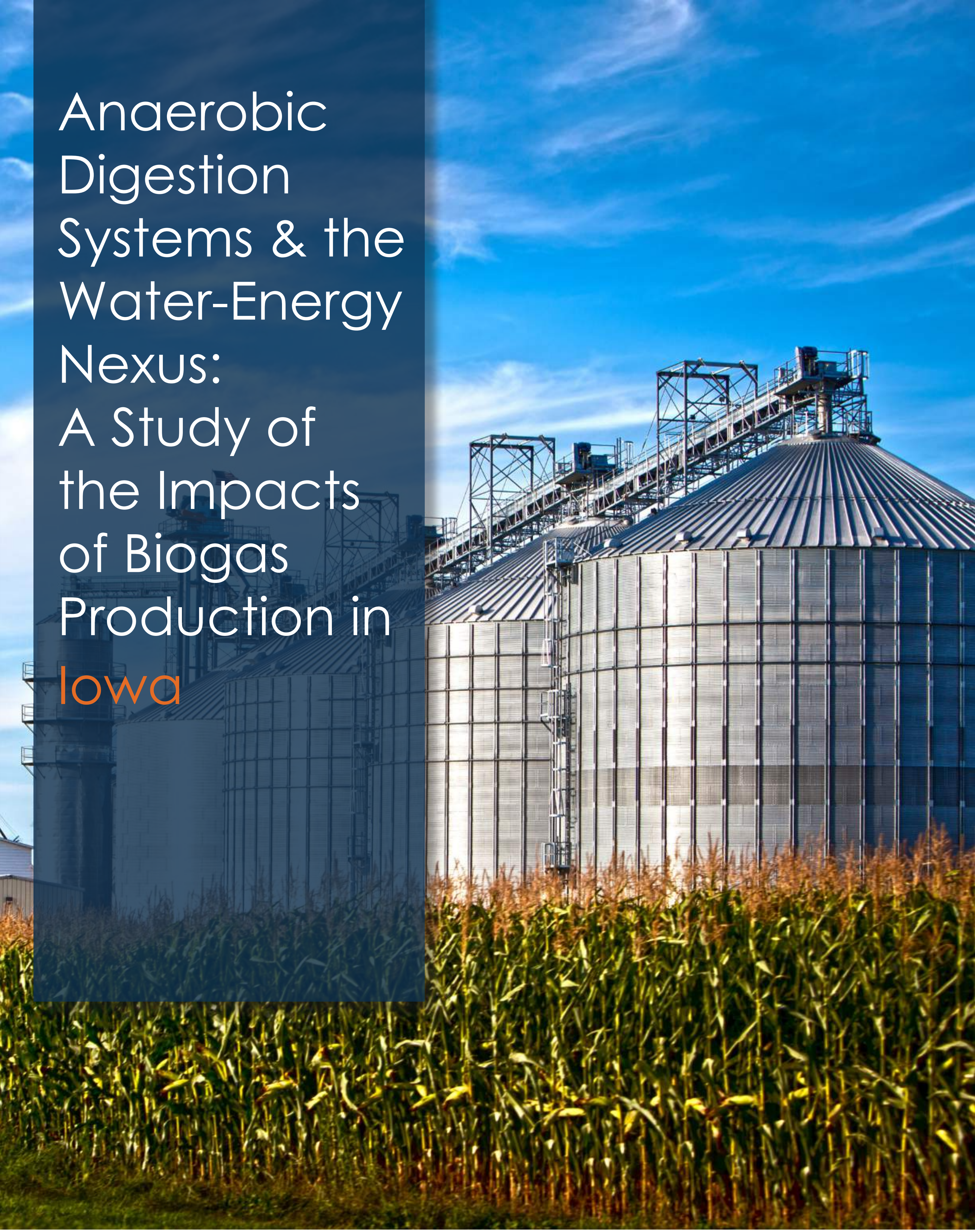
Anaerobic Digestion Systems & the Water-Energy Nexus: A Study of the Impacts of Biogas Production in Iowa



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I. Executive Summary

There is a significant opportunity to create a new industry in Iowa around biogas production from municipal, agricultural and industrial food wastes. Biogas system feedstocks include the following, all of which are in abundant supply in Iowa:

1. Industrial wastewater – organic-rich by-products of water recovery treatment at commercial food processing industries
2. Livestock manure – cattle, dairy, hog, poultry
3. Municipal wastewater, solid waste (separated organics) & food waste
4. Agricultural biomass

There is a growing trend towards integrated, regional biogas systems (Anaerobic Digestion systems or AD Systems) that are built to produce energy and high-value products such as renewable fertilizers. AD systems can offer a wide range of potential revenue streams, create jobs and boost economic development. They can also improve rural infrastructure for organic waste management and distributed energy delivery. Biogas systems can be an integral part of manure management plans and produce high-quality, concentrated liquid organic fertilizer. Separated fibers from the effluent stream can be used as animal bedding. Finally, biogas systems can create a market for energy crops.

Regional municipal AD systems that can serve the industrial food production and commercial livestock production could address multiple objectives. As municipalities across Iowa plan to upgrade their wastewater facilities, they could do it in conjunction with a regional economic development plans that take into account the expansion of the livestock facilities and food processing in their region. Many regions within Iowa have concentrations of food processors, an affinity for the dairy or beef industries and high concentrations of hog lots. These are all prime areas to strategically explore the installation of systems that can process manure and industrial wet waste from food processing.

The purpose of the study, Anaerobic Digestion Systems and the Water-Energy Nexus, is to:

- Evaluate the potential economic impacts of installing anaerobic digester (AD) systems and producing pipeline quality renewable natural gas from biogas
- Quantify a variety of environmental impacts resulting from AD systems
- Identify the resources and reasons for Iowa to invest in AD systems and produce biogas

Four sites were selected in Iowa and detailed site analyses were conducted to evaluate the economics of installing anaerobic digestion and gas purification units. Two sites were at municipal wastewater treatment plants with large industrial client bases. One site was dedicated to process industrial waste from two private companies. The last site was a conceptual agricultural digester designed to process animal manure and energy crops (Miscanthus).

At each site, the study conducted a detailed waste shed analysis to determine the amount of organics that is readily available to be processed into biogas. The organics were sampled and tested for their bio-methane potential, both individually and in a co-mingled recipe, to arrive at an accurate estimate of bio-methane that could be produced at each site. Subsequently, detailed cost analyses were conducted to determine capital and operating costs at each site. Finally, revenue estimates were calculated from the sale of purified bio-methane (renewablenatural gas or RNG) into the utility pipeline. For study purposes, it was assumed that revenues would be maximized by taking advantage of energy credits available for the use of RNG as vehicle fuel. Finally, detailed site plans were drawn for each site, potential vendors were contacted and capital and operational costs were estimated. Cost and revenue details for each site are provided in Section II A.

The majority of project revenues are from carbon credits created as a result of regulations governing transportation fuels in the US. The federal Renewable Fuel Standard1 promotes energy independence and domestic renewable fuel production, including bio-methane from biogas. California's Low Carbon Fuel Standard (LCFS)[2] is the first low-carbon fuel mandate in the world, and it calls for a 10% reduction of carbon in California transportation fuels by 2020. Table 2 provides an example of how the value one million British Thermal Units (MMBTUs) of natural gas is almost eight times more valuable after the environmental aspects are monetized.

Revenues are in direct proportion to the volume of gas produced, which, in turn, is in direct proportion to the mass of volatile solids in the organics available for conversion into methane. The costs do not always show a direct correlation with volume of gas produced due to variable factors, such as, ease of co-locating with existing infrastructure, added costs for biomass processing, access to a pipeline, etc.

The boost to regional economy from investments in new biogas infrastructure and the revenue from ongoing operations was analyzed using IMPLAN's I-RIMs model by Goss & Associates. A detailed description of the methodology is provided in Section III. Average per site benefits for the three sites processing industrial wastes (2 municipal facilities serving both municipal and industrial clients and the 3rd a conceptual private facility serving specific industrial wastewater steams), are below with site specific summary details in Table 2.

- Average cost of $17.6 million to construct or upgrade an anaerobic treatment facility and gas upgrading.
- Average 462 million BTUs produced per day per site. Average gross annual revenue of $4.3 million.
- Average $158 million per site in total economic output from capita investment and 20-year operations.
- Average 188 jobs created per site during the construction phase.
- Average 9 jobs created per site from the project operations and revenues.
- Average $2.7 million increase per site in tax receipts over project life.

1 https://www.epa.gov/renewable-fuel-standard-program
2 https://www.arb.ca.gov/fuels/lcfs/lcfs.htm

Key Insights

As municipalities across Iowa plan to upgrade their wastewater facilities, they could do it in conjunction with a regional economic development plans that take into account the expansion of the livestock facilities and food processing in their region.

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 Iowa Department of Natural Resource's (DNR) Nutrient Reduction Plan.[3&4] Anaerobic Digestion (AD) is a robust and technically reliable wastewater treatment system and could be the desired outcome for many of these projects. Each of those projects should conduct a detailed examination of its surrounding waste shed and the potential to be a producer of biogas and renewable natural gas (RNG). Revenues from the sale of biogas and associated environmental attributes could allow some treatment plants to operate like a profit center as opposed to a cost center. This will expedite the upgrading of the State wastewater infrastructure; and the investments in the projects will provide a boost to the regional economy.

Due to Iowa's abundant availability of crop biomass, its potential to grow energy crops and the concentration of livestock industry in Iowa, this study included an agricultural digester as a potential project type and evaluated its impact on a rural economy. The agricultural digester also addresses the creation of new markets for agricultural outputs and suggests a potential solution for non-point source nutrient runoff into Iowa's watersheds. The economic benefits from a typical agricultural digester producing 211 million BTUS of bio-methane per day from manure and energy crops (Miscanthus) are as follows:

- Investment of $8.3 million to construct an anaerobic treatment facility and gas upgrading.
- Production of 211 million BTUs per day per site and an average gross annual revenue of $1.9 million from gas sales and sale of carbon credits from use of biogas as vehicle fuel
- $528,000 will annually flow through to Miscanthus suppliers
- $69.5 million in total economic output from capital investment and 20-year operations.
- $20 million of the total economic output will flow through to the farm economy for Miscanthus cultivation.
- 97 jobs created during the construction phase.
- 7 jobs created from the project operations and revenues, of which 2 jobs will be dedicated to Miscanthus cultivation.
- $1.6 million increase in tax receipts over project life.

Since an agricultural digester processing energy crops could result in a reduction in nutrient runoff, the study looked at the economic impact of creating a market for Nitrogen reduction. Nutrient trading, although unavailable in Iowa at this point, is being explored as a viable option for lowering the costs of meeting Iowa's water quality goals. Policy options that address water quality enhancement could include nutrient caps coupled with a market-based instrument such as nutrient trading. Nutrient trading could allow regulated sources achieve their allocated discharge limit in a manner that is most cost effective. Other private entities could also voluntarily purchase nutrient

3 http://www.nutrientstrategy.iastate.edu/sites/default/files/documents/INRS-3-161001.pdf
4 https://www.epa.gov/sites/production/files/2015-12/documents/cwns_2012_report_to_congress-508-opt.pdf

Key Insights

Revenues from the sale of biogas and associated environmental attributes could allow some treatment plants to operate like a profit center as opposed to a cost center.

This will expedite the upgrading of the State wastewater infrastructure; and the investments in the projects will provide a boost to the regional economy.

reduction credits to meet their water quality and environmental conservation goals. Finally, downstream water treatment bodies could also sponsor projects by applying the cost of Nitrogen removal to Nitrogen mitigation. Detailing the full range of policy recommendations that can support this concept is beyond the scope of this study, but is recommended for further discussion.

Revenues from potential sale of Nitrogen reduction credits would flow to the farmer-suppliers of the biomass who implement a nutrient reduction practice, which, in this example, is switching 1,200 acres from corn and beans to Miscanthus. Assuming a range of values from $7.5/lb. to $22.5/lb., the study calculated the range of impacts on the rural economy from Nitrogen trading.

- Over the 20-year life of the project, for the assumed range of values, revenues from Nitrogen removal credits could increase sales activity in the local economy by $7.9 million to $23.7 million.
- Earnings could range between $1.3 million and $3.9 million over the life of the project.
- Revenues from Nitrogen removal could increase state and local tax collections by up to $400,000.

A free market is not efficient till it captures all the costs of production and consumption; hence, the need to account for the costs of nutrients flowing into streams and greenhouse gases leaking into the air. **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 Plan[5]. We recommend that the State conduct a thorough review of the agricultural digester model and the potential to produce biogas from a mixture of energy crops and manure.** Revenues from the sale of biogas and associated environmental attributes, including Nutrient reduction credits, could incentivize investments into these projects and increase regional economic output. Proactively managing land use and the organic waste shed in Iowa's watersheds could create a new market for biomass.

Key conclusions of this study are as follows:

- Given the estimated investment of $2.5 billion required to overhaul Iowa's municipal wastewater treatment infrastructure, these projects should conduct a detailed examination of the regional waste shed and the potential to be a producer of biogas. Revenues from the sale of biogas and associated environmental attributes could allow these treatment plants to operate like a profit center. This will expedite the construction of these projects and the upgrading of the State wastewater infrastructure.
- Given the estimated 1.2 billion to $4 billion that may be needed to put in place nutrient control systems for non-point sources in Iowa, the State should conduct a thorough review of the potential to produce biogas from a mixture

5 http://www.nutrientstrategy.iastate.edu/sites/default/files/documents/INRS-2-161001.pdf

Key Insights

Since an agricultural digester processing energy crops could result in a reduction in nutrient runoff, the study looked at the economic impact of creating a market for Nitrogen reduction.

The total increase in economic activity resulting from Nitrogen trading if all these acres were planted with perennials could be over $100 billion over the life of these projects.

of energy crops and manure. Revenues from the sale of biogas and associated environmental attributes could incentivize investments into these projects and increase economic output in the region. Proactively managing land use and the organic waste shed in Iowa's watersheds could create a new market for agricultural biomass such as cover crops and energy crops.

- Since agricultural biogas systems that process biomass crops will have an ancillary beneficial impact on regional watersheds by reducing Nitrogen loss, assigning a price for the displaced Nitrogen will quantify and monetize this important environmental benefit. Revenues from trading in Nitrogen credits will have a direct impact on the farm economy.
- Over the 20-year life of the project, the revenues from Nitrogen removal (assuming a range of $7.5/lb. to $22.5/lb. of displaced Nitrogen) could increase local economic output by $7.9 million to $23.7 million from the 1,200 acres of farmland considered in this study. According to estimates from the Iowa Nutrient Reduction Strategy, the State will have to plant perennials on 6.5 million acres to meet the goals of the Gulf Hypoxia Plan[6]. The total increase in economic activity resulting from Nitrogen trading if all these acres were planted with perennials could be over $100 billion over the life of these projects.
- Maintaining and growing a livestock industry is an economic development goal for Iowa. Manure digesters functioning as manure management systems can ease the environmental and social burden of animal agriculture by reducing odor, eliminating methane releases from lagoons and reducing the pathogen in waterways from manure application. The nutrient value of manure can still be retained by the farmer for land application.
- Given the likelihood of public dollars being spent on infrastructure projects to improve wastewater treatment and reduce nutrients in watersheds, there are several policies considerations for evaluation. Nutrient trading programs, revolving loan funds and loan guarantees are a few examples of how the State could pro-actively support investments and invite public-private partnerships into this sector. Private parties can voluntarily commit to purchasing the displaced Nitrogen motivated by their sustainability goals or in exchange for higher discharge limits resulting from purchased offsets. Downstream water treatment bodies could also sponsor projects by applying the cost of Nitrogen removal to Nitrogen mitigation. The full range of policy recommendations that can support this concept is beyond the scope of this study, and is recommended for further study.
- A key next step would be to support the installation of a pilot project to closely study the full environmental, social and economic impact of Anaerobic Digestion systems.

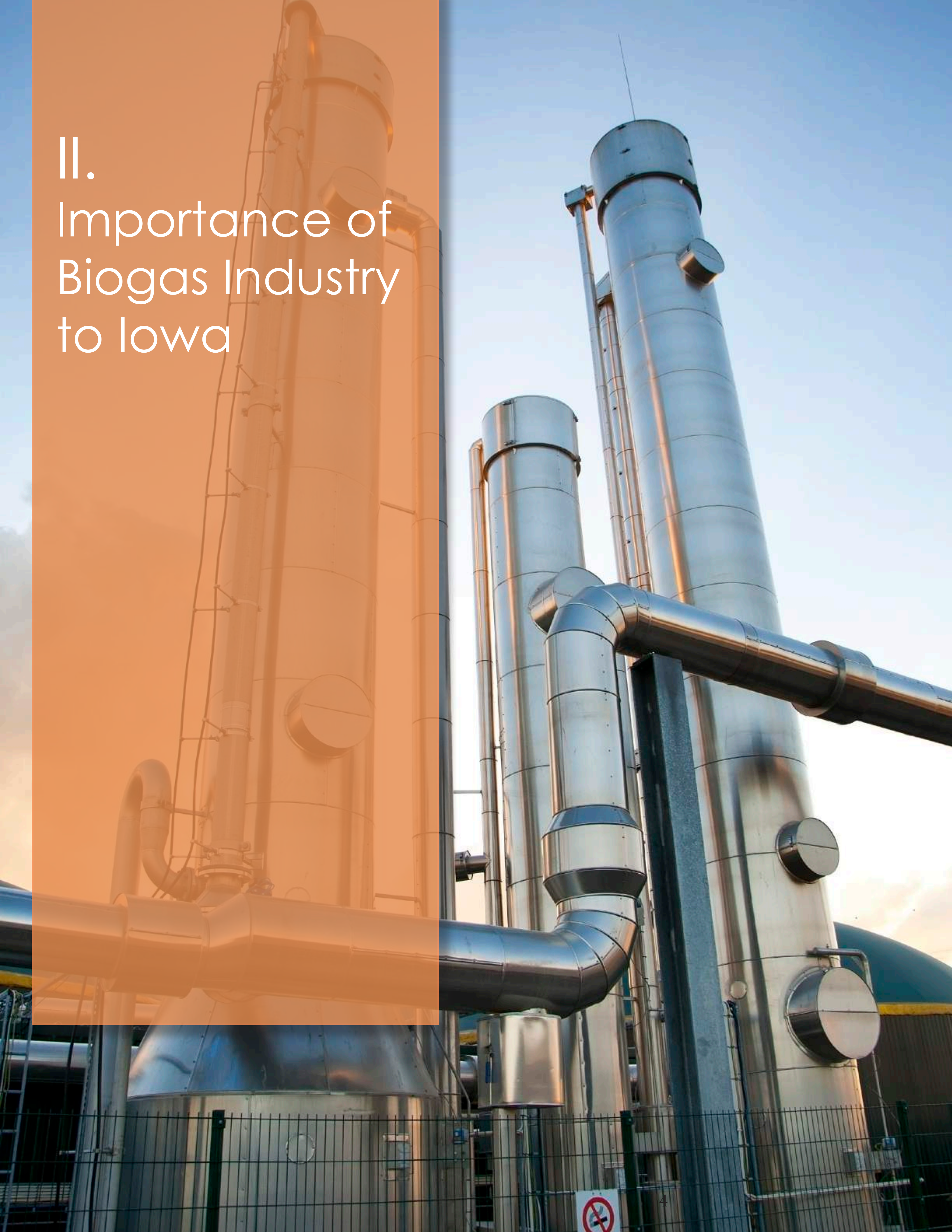
Key Insights

Given the estimated 1.2 billion to $4 billion that may be needed to put in place nutrient control systems for non-point sources in Iowa, the State should conduct a thorough review of the potential to produce biogas from a mixture of energy crops and manure.

Proactively managing land use and the organic waste shed in Iowa's watersheds could create a new market for agricultural biomass such as cover crops and energy crops.

6 http://www.nutrientstrategy.iastate.edu/sites/default/files/documents/INRS-2-161001.pdf

II.
Importance of Biogas Industry to Iowa



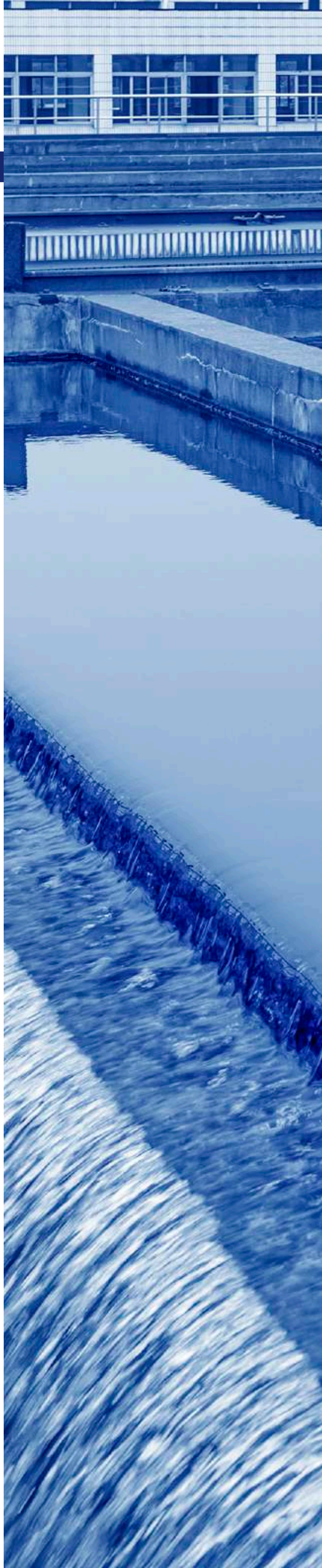
A. Background

In 2014, EcoEngineers collaborated with Iowa State University (ISU) and Iowa Economic Development Authority (IEDA) to develop IBAM (Iowa Biomass Asset Mapping) tool. IBAM is a Geographic Information System (GIS) that displays a database of Iowa's biomass on an interactive map. IBAM suggested that Iowa had sufficient quantities of biomass to justify exploring commercial applications such as biogas production. It was apparent that there is a significant opportunity to create a new industry in the Midwest around biogas production from municipal, agricultural and industrial food wastes.

Subsequently, several communities in Iowa began exploring the potential to produce biogas by analyzing the regional waste shed and conducting design-build estimates for anaerobic digestion systems and pipeline injection. This study is a result of those efforts at four sites across Iowa. The site details have been kept confidential, and only the total investment, gross revenues, the operating costs and operating profits were used as inputs to conduct this economic analysis. The sites included two municipal wastewater treatment facilities, one private industrial site and one agricultural biogas system.

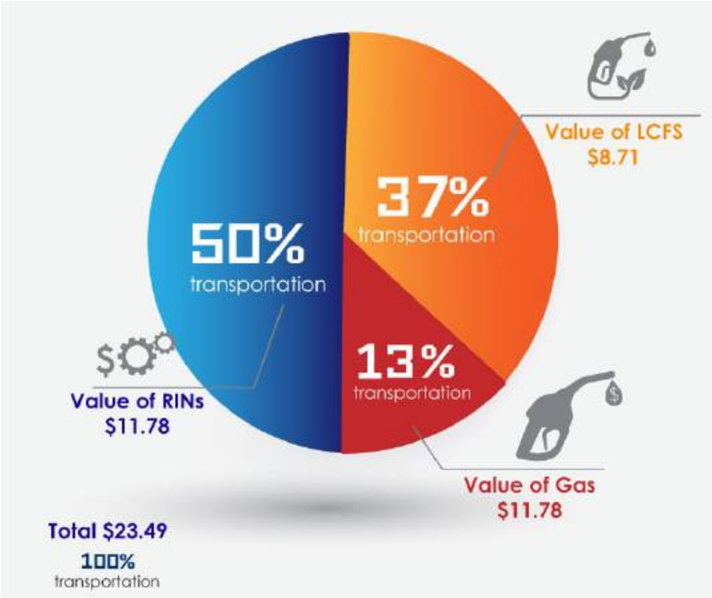
Table 1: Summary inputs for economic impact analysis

ITEM	Site 1 (industrial)	Site 2 (Municipal NE)	Site 3 (Municipal SE)	Site 4 (Agricultural)
Cost of the land developed.	$ 0	$ 0	$ 0	$ 0
Area of land required	2.87 acres	4.11 Acres	0.6 SF	16 acres
Cost of the land development (sewage, rail, highways, etc.).	$2,842,953	$5,936,791	$846,000	$308,700
Cost of building construction.	$835,000	$796,361	$922,000	$657,738
Cost of the capital equipment.	$11,984,815	$17,112,235	$11,611,000	$6,459,815
Costs of biomass processing				$886,738
TOTAL CAPITAL COST	**$15,662,768**	**$23,845,388**	**$13,379,000**	**$8,312,991**
Operating budget (annual).	$1,600,000	$1,319,472	$858,000	$1,551,272
Direct permanent jobs created	3 FTE	5 FTE	5 FTE	3 FTE
Time period of construction.	18 months	18 months	18 months	18 months
Time period of operations.	20 years	20 years	20 years	20 years
Potential Gas Production (MMBTUs/day)	**471**	**495**	**420**	**211**
Potential gross annual revenues from RNG and environmental aspects	$4,962,144	$4,500,000	$3,500,000	$2,456,615



All the project sponsors were motivated to take advantage of pipeline injection and revenues from carbon credits. These carbon credits originate from regulations such as the Renewable Fuel Standard (RFS) and California's Low Carbon Fuel Standard (LCFS), both of which mandate the use of renewable fuels including bio-methane or RNG from biogas. Purified biogas injected into a section of natural gas pipeline in Iowa can be measured and matched against an equivalent amount of Renewable Natural Gas used as vehicle fuel elsewhere in the country. The primary market for this vehicle fuel is currently in California, but it is developing in other regions as well. Below is an example of how the value one million British Thermal Units (BTUs) of natural gas used for transportation fuel in California is almost eight times more valuable after the environmental aspects are monetized.

Value of energy credit per one million BTU of biogas



In the above example, $20.49 is the value of the reduction of carbon in tailpipe emissions resulting from switching from diesel to compressed natural gas systems within the state of California. Outside California, the emissions reduction will be worth $11.78 per million BTUs. It is the availability of environmental credits that are currently driving investments into biogas systems at municipal and agricultural settings.

Biogas Systems

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% methane, 30-40% carbon dioxide, and trace amounts of other constituents, such as hydrogen sulfide, hydrogen, nitrogen, and siloxanes. Biogas is produced at landfills and at anaerobic digesters where wastewater bio-solids, animal manure, and other organic are processed. A biogas system includes both the infrastructure to manage the organic wastes as well as the equipment to generate energy from the resulting biogas.

Key Insights

It is the availability of environmental credits that are currently driving investments into biogas systems at municipal and agricultural settings.

Primary biogas system feedstocks include:

1. Industrial wastewater – organic-rich by-products of water recovery treatment at commercial food processing industries
2. Livestock manure – cattle, dairy, hog, poultry
3. Municipal wastewater, solid waste (separated organics) & food waste
4. Agricultural biomass

Successful biogas systems capture and re-use the energy in the biogas. There are several different options for converting biogas to energy. Unlike intermittent renewable energy alternatives such as wind and solar power, biogas delivers a continuous source of energy with a very high capacity factor. Specific commercially proven energy uses for biogas include:

1. Thermal applications: Biogas is used directly on-site to heat digesters and buildings/maintenance shops, to fuel boilers or kilns, and to generate heat or steam.
2. Power generation: Electricity is produced through an internal combustion engine, gas turbine, or micro-turbine technologies for on-site use or sale to the electric grid. Combined heat and power (CHP) systems increase overall energy efficiency of electricity systems by producing heat and electricity at the same time.
3. Vehicle fuels: Upgraded biogas can be converted to fuels including compressed natural gas, liquefied natural gas, hydrogen, and liquid transportation fuels. This can happen through fueling locally where the biogas is produced, or injecting it into the pipeline to be used and credited elsewhere through incentives.

There are a number of sites, including some in Iowa, which already use biogas for thermal applications and power generation. However, there is a growing trend towards integrated, regional biogas systems that are built to produce energy and high-value products such as renewable fertilizer. These systems can be municipally owned and/or privately owned, offering a good opportunity for public-private partnerships. Biogas systems have a variety of benefits for local industry and the environment. These can be broken out into the following general categories.

Infrastructure benefits:

- Improved waste management systems and distributed energy delivery
- Lower wastewater pre-treatment costs for area food processing industries
- Potential to create superior network of gas pipelines in underserved areas

Economic benefits:

- Investments in new infrastructure, job creation and money circulation
- Production of high-quality, concentrated liquid organic fertilizer for improved

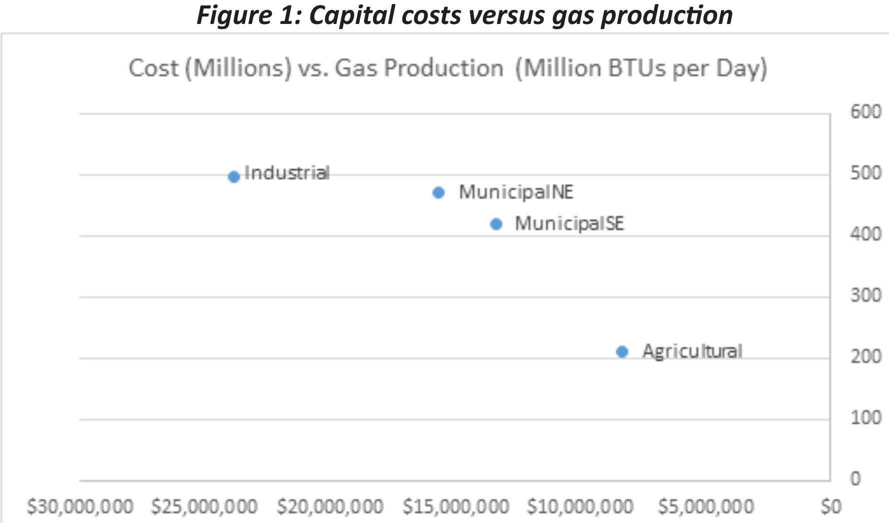
land management and increased crop yield

- Reduced operational expenses or increased revenue for livestock producers through the production and sale of animal bedding by using the separated fibers from the effluent stream.
- Reduced trade imbalance from local production of fuel and fertilizer and more efficient application of nutrients through digestate management.
- Lower wastewater treatment costs and resulting expansion of existing industry and recruitment of new industry.
- Increased revenues to farmers from the sale of biomass.

Environmental and social benefits

- Improved quality of life through superior manure management practices, including reduced odor and pathogen levels from manure treated through an anaerobic digestion system.
- Improved soil and water quality resulting from growing perennial energy crops.
- Increased recreational use of the watershed and higher property values from less nutrient runoff.
- Bio diversity from planting perennials or native prairie grasses
- Decrease in air pollutants achieved through the end use of Renewable Natural Gas as a substitute for diesel.

Figure 1: Capital costs versus gas production



Key Insights

There is a growing trend towards integrated, regional biogas systems that are built to produce energy and high-value products such as renewable fertilizer.

These systems can be municipally owned and/or privately owned, offering a good opportunity for public-private partnerships.

B. Potential Economic Impacts

A more comprehensive understanding of all the benefits of AD systems will help guide policy that could support the development of these projects. Four sites were selected in Iowa and detailed site analyses were conducted to evaluate the economics of installing AD systems and gas purification units. Two of the sites were municipal wastewater treatment plants with large industrial client bases. One site was dedicated to process industrial waste from two private companies. The last site was a conceptual agricultural digester designed to process manure and energy crops.

At each site, the study conducted a detailed waste shed analysis to determine the amount of organics that is readily available to be processed into biogas. The organics were sampled and tested for bio-methane potential individually and in a co-mingled recipe to arrive at an accurate estimate of bio-methane that could be produced at each site. Subsequently, detailed cost analyses were conducted to determine capital and operating costs at each site. Finally, revenue estimates were calculated from the sale of purified bio-methane (renewable natural gas or RNG) into the utility pipeline and associated environmental attributes.

The boost to regional economy from investments in new biogas infrastructure and revenue from ongoing operations was analyzed using IMPLAN's I-RIMs model by Goss & Associates. A detailed description of the methodology is provided in Section III.

1. Municipal-Industrial Model

A robust and reliable municipal wastewater treatment plant processing industrial waste streams is a regional economic development tool. A biogas system processing industrial waste will spur economic development by providing industry a reliable place to send their wastewater for a low cost; lower wastewater treatment costs will stimulate expansion of existing industry and recruitment of new industry. Distributed generation of natural gas injected into utility pipelines also have the potential of creating new pipeline infrastructure in underserved regions.

Average per site benefits for the three sites processing industrial wastes (2 municipal facilities serving both municipal and industrial clients and the 3rd a conceptual private facility serving industrial wastewater only), are below with site specific summary details in Table 2.

- Average cost of $17.6 million to construct or upgrade an anaerobic treatment facility and gas upgrading.
- Average 462 million BTUs produced per day per site. Average gross annual revenue of $4.3 million.
- Average $158 million per site in total economic output from capital investment and 20-year operations.
- Average 188 jobs created per site during the construction phase.

Key Insights

On Average...

$17.6 million
To construct an AD facility and gas upgrading Primary Feedstock is high strength industrial waste

188 jobs
Created per site during construction phase

9 permanent jobs

$2.7 million
per site in tax receipts over project life

462 million
BTUs per day per site (4000 GGEs)

$158 million
Total economic output over 20 -year project life

- Average 9 jobs created per site from the project operations and revenues.
- Average $2.7 million increase per site in tax receipts over project life.

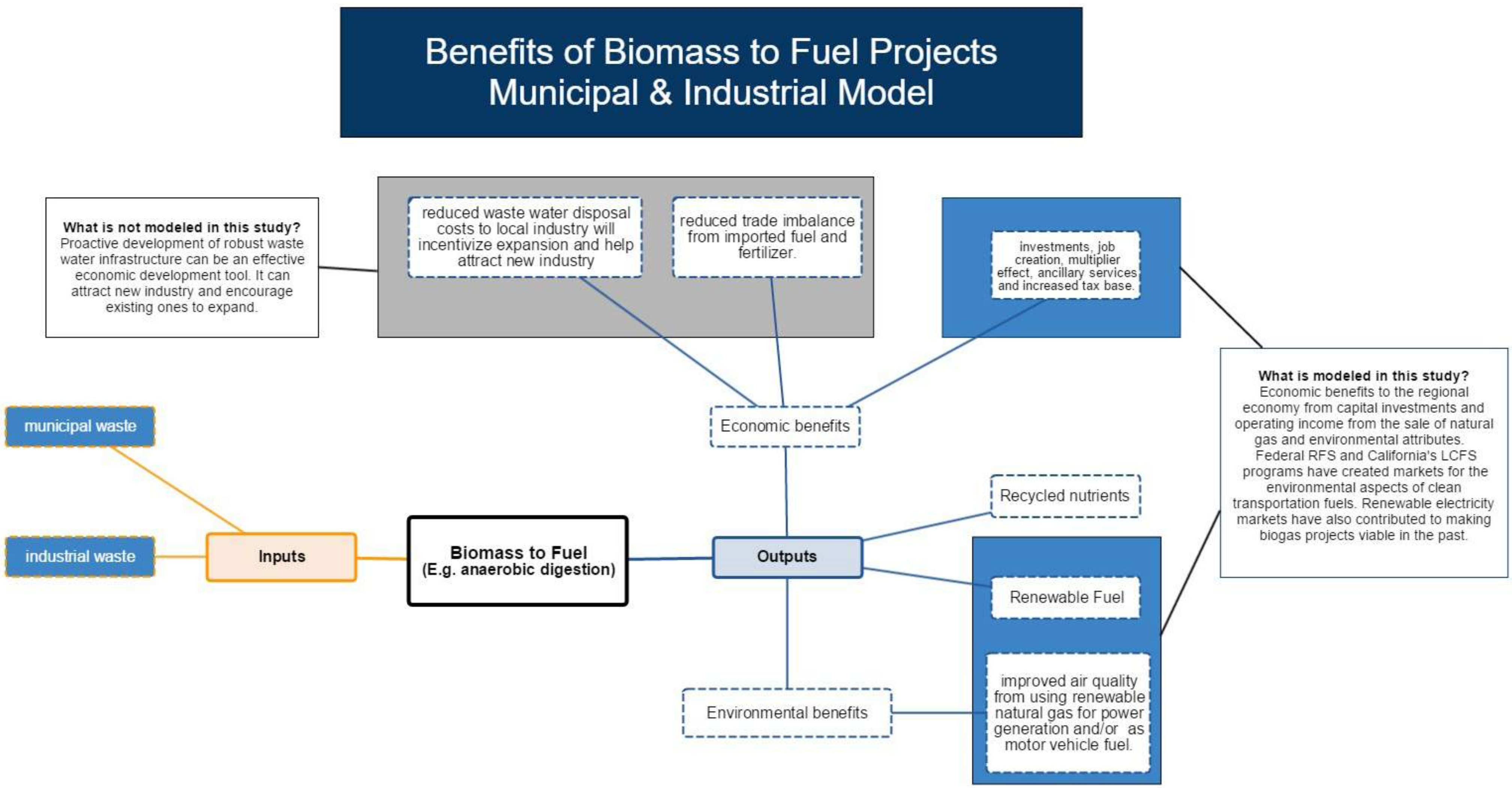
Table 2: Total output and labor earnings at the 3 sites processing industrial waste.

	Municipal Site Serving Industrial Clients - NE		Municipal Site Serving Industrial Clients - SE		Private Industrial Wastewater Site	
	Construction phase (18 mos.)	Operations Phase (20 years)	Construction phase (18 mos.)	Operations Phase (20 years)	Construction phase (18 mos.)	Operations Phase (20 years)
Initial investment	$23,845,388		$13,379,000		$15,662,768	
Potential annual gross revenues from operations		$4,500,000 (annual)		$3,500,000 (annual)		$4,962,144 (annual)
Total output including spillover effect	$28,443,198	$130,506,585	$19,562,234	$110,672,036	$26,662,250	$159,279,126
Earnings component	$9,556,986	$21,288,703	$6,330,317	$18,053,220	$10,800,000	$14,489,607
Total employment created	223	8	168	8	172	10
Total increase in tax collections	$979,964	$2,182,922	$649,105	$1,720,729	$1,111,349	$1,485,571

Many Iowa wastewater treatment plants are projected to spend significant resources to upgrade their facilities and/or bring them into compliance with Iowa DNR's Nutrient Reduction Plan, the total costs of which is estimated to be around $2.5 billion. **If Iowa needs to spend $2.5 billion in overhauling its wastewater treatment plants, then each of those projects should conduct a detailed examination of the regional waste shed and the potential to be a producer of biogas. Anaerobic Digestion (AD), a robust and technically reliable wastewater treatment system, could be the desired outcome at many projects**. Efficiently managing the organic waste shed in the region served by the POTW could allow these treatment plants to operate like a profit center as opposed to a cost center. Revenues from the sale of biogas and associated environmental attributes could compress the payback period for the investments in infrastructure and increase economic output in the region.

Pro-actively taking advantage of the available energy credits for clean vehicle fueling through the Renewable Fuels Standard and California's Low Carbon Fuel Standard can boost needed investments in wastewater infrastructure across Iowa. It will expedite the construction of these projects and the upgrading of the State wastewater infrastructure.

Figure 2: Benefits of Biomass to Fuel Projects at Municipal Wastewater Treatment Plants.



2. The Agricultural Model

An agricultural digester is different from a municipal digester for several reasons, the most relevant one being the different feedstock that is processed. Whereas the primary purpose of a municipal-industrial digester is to process municipal and industrial waste, agricultural digesters primarily process manure; they can also process crop residues, cover crops and energy crops. Agricultural digesters are almost always privately owned and the State does not have an obligation to invest in the infrastructure, as it would with its publicly owned treatment works facilities. However, as discussed further below, Iowa has adopted goals of reducing nutrients in its watersheds and has a commitment to invest in practices and infrastructure that will lead to the desired goal. Agricultural digesters could potentially play a critical role in reaching nutrient reduction goals due to Iowa's abundant availability of crop biomass, potential to grow energy crops and concentration of livestock industry.

This study included an agricultural digester as a potential investment type and evaluated its impact on a rural economy. Finding a solution for non-point source nutrient runoff into Iowa's watersheds was addressed in the agricultural digester model. The following feedstock were included:

1. Manure waste from a small hog operation
2. Manure waste from a small dairy operation
3. Biomass in the form of Miscanthus grass

Methane output was estimated at 211 million BTUs per day. Methane output at an agricultural digester can vary as a function of the feedstock inputs; for example, increasing dairy manure can significantly increase the amount of methane without a corresponding proportionate increase in the costs. Summary inputs for this site are below. Additional costs related to biomass collection and processing were included. In addition to revenues from the sale of biogas into clean vehicle fuel markets, the study placed a value on Nitrogen displaced from watersheds as a result of growing energy crops.

Table 3: Summary inputs for agricultural digester.

ITEM	Site 4 (Agricultural)
Cost of the land developed.	$ 0
Area of land required	16 acre
Cost of the land development	$308,700
Cost of building construction.	$657,738
Cost of the capital equipment.	$6,459,815
Costs of biomass processing	$886,738
TOTAL CAPITAL COST	**$8,312,991**
Operating budget (annual).	$1,551,272
Direct permanent jobs created	3 FTE
Time period of construction.	18 months
Time period of operations.	20 years
Potential Gas Production (MMBTUs/day)	**211**
Potential gross annual revenues	$2,456,615

The agricultural model assumes a supply of Miscanthus at a $80 / dry ton cost. This is revenue to the local farmer suppliers. In a recent study, Iowa State University agronomists showed that significant portions of Iowa farmland are consistently unprofitable[7]. According to the report from ISU, in the county where the conceptual agricultural digester is sited, there is an estimated 2,700 acres of unprofitable farmland or about 8% of the total land in production. **This study assumed 1,200 acres of the unprofitable farmland around the proposed site of the agricultural digester would be converted from corn and bean production into Miscanthus production,** and this will have an impact on other environmental factors, the most important of which is the level of Nitrogen fertilizer applied on those acres.

An annual 30 lb. per acre reduction in Nitrogen loss was estimated (further details provided in Section C2). This is Nitrogen that will not enter subsurface systems in the form of nitrates. Although, there is no value currently attached to the reduction of this Nitrogen from Iowa's waterways, this study assumed a range of values from $7.5/lb. to $22.5/lb. of Nitrogen removed to understand the impact of such a market on the regional economy. The resulting economic impacts are summarized below. The portion of the overall economic impact that will flow towards Miscanthus cultivation is shown separately.

- Investment of $8.3 million to construct an anaerobic treatment facility and gas upgrading.
- Production of 211 million BTUs per day per site and an average gross annual revenue of $1.9 million from gas sales and sale of carbon credits from use of biogas as vehicle fuel
- $528,000 will annually flow through to Miscanthus suppliers

$69.5 million in total economic output from capital investment and 20-year operations.

- $20 million of the total economic output will flow through to the farm economy for Miscanthus cultivation.
- 97 jobs created during the construction phase.
- 7 jobs created from the project operations and revenues, of which 2 jobs will be dedicated to Miscanthus cultivation.
- $1.6 million increase in tax receipts over project life.

7 http://iopscience.iop.org/article/10.1088/1748-9326/11/1/014009

Key Insights

Agricultural digesters could potentially play a critical role in reaching nutrient reduction goals due to Iowa's abundant availability of crop biomass, potential to grow energy crops and concentration of livestock industry.

Methane output at an agricultural digester can vary as a function of the feedstock inputs; for example, increasing dairy manure can significantly increase the amount of methane without a corresponding proportionate increase in the costs.

Table 4: Impact on local economy from installation and operation of a digester processing manure and biomass crops.		
	Agricultural Biogas Site	
	Construction phase (18 mos.)	Operations Phase (20 years)
Initial investment	$8,312,991	
Potential annual gross revenues from operations (gas & environmental credits only)		$1,911,000 (annual)
Total output including spillover effect	$11,659,376	$73,120,145
Earnings component	$4,180,255	$11,319,719
Total employment created	97	7
Total increase in tax collections	$428,639	$1,160,712

Table 5: Impact on rural economy from Miscanthus cultivation.	
	Operations Phase (20 years)
Potential annual gross revenues to Miscanthus cultivators	$528,000 (annual)
Total output including spillover effect	$17,730,760
Earnings component	$2,284,404
Total employment created	2

Finally, the study looked at the economic impact of creating a market for Nitrogen reduction, which does not currently exist in Iowa. Potential revenues from the sale of Nitrogen reduction credits would flow to the farmer-suppliers of the biomass who implement the reduction plan- in this case switching from corn and beans to Miscanthus. Assuming a range of values for the credits, the study calculated the range of impacts as shown below.

As a reference for policy discussion, three values were used for Nitrogen displacement credits: $7.5 per pound removed, $15 per pound, and $22.5 per pound. These are hypothetical numbers since there is no actual market to compare them against.

Table 6: Hypothetical values for Nitrogen reduction credits.			
	At $7.5 per pound	At $15 per pound	At $22.5 per pound
Year 1 revenues from Nitrogen removal	$272,666	$545,333	$817,999

We can apply these Nitrogen removal revenue estimates to arrive at potential economic and fiscal impacts should a policy exist that allows for the monetization of Nitrogen displacement. Table 7 provides a summary of output, earnings and employment for each of the revenue levels in Table 6. As seen below, even a low value of $7.5 per pound,

revenues from the displaced Nitrogen add significant value to the project. The annual output impacts range from between $300,107 and $900,322; the earnings impacts range from between $48,955 and $146,864. The displacement revenue could support between 0.3 and 0.9 jobs.

Table 7: Estimated potential annual impacts from Nitrogen removal revenues			
Year 1 Revenue	Output	Earnings	Employment
$272,666 (@ $7.5 per pound)	$300,107	$48,955	0.3
$545,333 (@$15 per pound)	$600,215	$97,909	0.6
$817,999 (@$22.5 per pound)	$900,322	$146,864	0.9

The displacement revenue will continue to impact the economy for the duration of the project. Table 8 provides a summary of the potential sales growth over the 20-year project period. Sales activity could potentially increase from between $7.9 million and $23.7 million, depending on the value placed on Nitrogen removal.

Table 8: Projected sales growth due to Nitrogen displacement revenue (2017-2036)			
Year 1 Revenue	2017	2018-2036	Total
$272,666 (@ $7.5 per pound)	$300,107	$7,601,816	$7,901,923
$545,333 (@$15 per pound)	$600,215	$15,203,658	$15,803,873
$817,999 (@$22.5 per pound)	$900,322	$22,805,474	$23,705,796

Table 9 provides a summary of the potential earnings growth over the 20-year project period. Earnings could potentially grow by $1.3 million and $3.9 million over the life of the project.

Table 9: Projected earnings growth due to Nitrogen displacement revenue (2017-2036)			
Year 1 Revenue	2017	2018-2036	Total
$272,666 (@ $7.5 per pound)	$48,955	$1,240,047	$1,289,002
$545,333 (@$15 per pound)	$97,909	$2,480,070	$2,577,979
$817,999 (@$22.5 per pound)	$146,864	$3,720,117	$3,866,981

The potential increase in economic activity generated by the monetized Nitrogen removal will contribute to state and local tax collections. Table 10 provides a summary of the potential fiscal impacts of a Nitrogen removal valuation policy. A policy that allows for the monetization of Nitrogen removal could potentially add between $132,767 and $398,299 million to state and local tax coffers, helping to offset the cost of such a policy.

Key Insights

Providing a price for displaced Nitrogen will quantify and monetize an important environmental benefit of these projects and give project developers a better risk-return profile for their investments.

Potential revenues from the sale of Nitrogen reduction credits would flow to the farmer-suppliers of the biomass who implement the reduction plan- in this case switching from corn and beans to Miscanthus.

Table 10: Projected tax revenue growth due to Nitrogen displacement valuation policy (2017-2036)			
Sector	Nitrogen Removal		Total
	2017	2018-2036	
$272,666 (@ $7.5 per pound)	$5,042	$127,725	$132,767
$545,333 (@$15 per pound)	$10,085	$255,447	$265,532
$817,999 (@$22.5 per pound)	$15,127	$383,172	$398,299

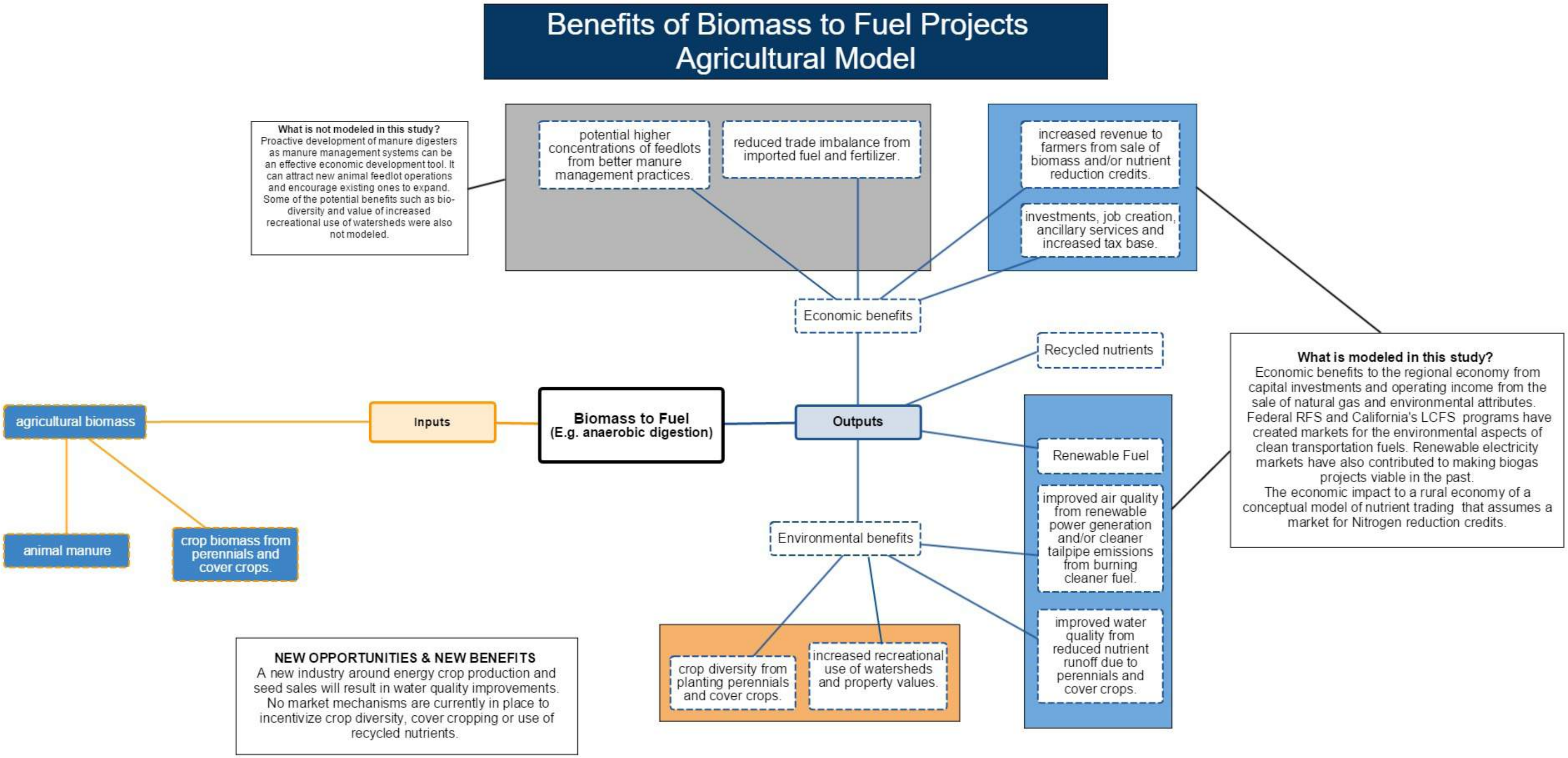
- Over the 20-year life of the project, for the assumed range of **values, revenues** from Nitrogen removal credits could increase sales activity in the local economy by $7.9 million to $23.7 million.
- Earnings could range between $1.3 million and $3.9 million over the life of the project.
- Revenues from Nitrogen removal could increase state and local tax collections by up to $400,000.
- For each 1,200 acres of farmland that is removed from corn and bean production and utilized for energy crop cultivation, there could be a reduction of approximately 36,000 lbs. Nitrogen leaked into subsurface systems. According to estimates from the Iowa Nutrient Reduction Strategy, the State will have to plant perennials on 6.5 million acres to meet the goals of the Gulf Hypoxia Plan. Applying the same calculations, the total increase in economic activity resulting from Nitrogen trading if all these acres were planted with perennials could be over $100 billion over the life of these projects.

Providing a price for displaced Nitrogen will quantify and monetize an important environmental benefit of these projects and give project developers a better risk-return profile for their investments. It is a risk management tool that will ultimately attract more developers to the sector and result in more projects being launched.

Regulated point and non-point sources and private parties can voluntarily commit to purchasing the displaced Nitrogen motivated by their sustainability goals or for higher discharge limits resulting from purchased offsets. Downstream water treatment **bodies** could also sponsor projects by applying the cost of Nitrogen removal to Nitrogen mitigation. The full range of policy recommendations that can support this concept is beyond the scope of this study, but is a logical next step.

Finally, stimulation of the livestock industry is also an economic development goal for Iowa. Manure digesters can function as effective manure management systems, and can ease the environmental and social burden of animal agriculture by reducing odor, eliminating methane releases from lagoons and reducing the pathogen in waterways from manure application. This long-term impact of attracting additional feedlots to the State was not included in this study. By some estimates, each hog contributes about $1,300 to the total output of the animal farming industry in Iowa and each head of cattle contributes about $1,800.

Figure 3: Benefits of Biomass to Fuel Projects using manure and energy crops.



C. Broader Impacts

Key Insights

Regional municipal AD systems that can serve industrial food production and commercial livestock production would be a comprehensive solution that will address multiple objectives with one solution.

1. Biogas Systems, POTWs and the Livestock Industry

The cost of maintaining robust municipal wastewater treatment facilities is very important to Iowa's economic development. Iowa is home to 36 of the largest 100 food manufacturers and processors and the number one in the nation in corn, soybean, pork and egg production. 21% of Iowa's manufacturing GDP comes from the food processing industry. In 2013, Iowa's food industry invested over $997 million in capital investment to expand operations. Due to the area's concentration of food processing companies, Iowa needs to ensure continuous and affordable access to abundant water, wastewater treatment and energy. Robust publicly owned wastewater treatment systems are a critical infrastructure need for Iowa's food processing industries that generate significant volumes of wet waste with high organic contents.

The 2012 USEPA Clean Watersheds Needs Survey (CWNS) Report to Congress estimates the capital investment necessary to ensure that the nation's publicly owned treatment works (POTWs) can meet the water quality objectives of the Clean Water Act (CWA). This report places the total costs faced by POTWS in the State of Iowa to attain a level of treatment that meets secondary treatment standards or a level more stringent than secondary treatment at $945 million.[8] Nutrient removal costs were not included in the CWNS Report. This is a cost currently faced by cities across Iowa, many of whom have to replace aging infrastructure with upgraded ones. Additionally, many Iowa POTWs will be required to upgrade their facilities to meet the tighter requirements of the Iowa Nutrient Reduction Strategy.

According to the Iowa Nutrient Reduction Strategy, a total of 102 major municipal facilities serve the wastewater treatment needs of 55-60% of Iowa's population and treat more than 80% of the volume of all wastewater handled by Iowa cities. Discharge permits issued to these 102 facilities will require implementation of technically and economically feasible process changes for nutrient removal. If successful, this strategy will reduce by at least 11,000 tons per year the amount of nitrogen and 2,170 tons per year the amount of phosphorus discharged annually by municipal facilities alone. This approach is estimated to have a total present worth cost (includes capital costs and operation and maintenance cost over a 20-year period) of approximately $1.5 billion if implemented in full. The annual cost of this approach is approximately $114 million.[9]

The sum of the above two suggests that the total costs to upgrade wastewater infrastructure in Iowa could reach $2.5 billion. Anaerobic Digestion (AD) is one of the most robust and technically reliable wastewater treatment systems available. If Iowa needs to spend approximately $2.5 billion in overhauling its publicly owned water treatment plants, then each of those improvement projects should conduct a more detailed examination of the regional waste shed and the potential to be a producer of biogas. Revenues from the sale of biogas and associated environmental attributes could allow the cities to run these treatment plants like a profit center as opposed to viewing them as a cost center. This will expedite the construction of these projects and

8 https://www.epa.gov/sites/production/files/2015-12/documents/cwns_2012_report_to_congress-508-opt.pdf
9 http://www.nutrientstrategy.iastate.edu/sites/default/files/documents/NRS1-141001.pdf

the upgrading of wastewater infrastructure.

Manure digesters co-located with effective manure management systems can ease environmental and social impacts of livestock production by reducing odor, eliminating methane releases from lagoons and reducing the pathogen in waterways from manure application, while still retaining and returning the nutrient value of the manure to the farmer.

According to Decision Innovation Solutions' report, *2016 Iowa Animal Agriculture Economic Contribution Study*, the total output of Iowa's animal agriculture industry was $38 billion in 2013[10]. Of this, $33.6 billion originated in hog and cattle industries with hogs dominating with $26.7 billion in output. The animal industry also contributed $1.2 billion in state and local taxes and sustained over 160,000 jobs. The report further details an inventory of 21 million hogs and 3.9 million heads of cattle in Iowa. The above numbers suggest that each hog contributes about $1,300 and each head of cattle contributes about $1,800 to the total output of the animal farming industry.

Agriculture is a major contributor to climate change, accounting for about 9% of U.S. greenhouse gas emissions, and the farming sector has not succeeded in reducing its output as much as the transportation and energy industries have. For example, in the production and consumption of a gallon of milk, the equivalent of 17.6 pounds of carbon dioxide is emitted. At the same time, farms are among the biggest victims of weather associated with climate disruption. In 2014 alone, the U.S. Department of Agriculture paid out $10 billion in disaster programs and crop insurance.

Assisting the installation of AD systems that process manure could be an attractive incentive that promote the development of livestock facilities in Iowa and it may pay for itself through biogas production and sale. Low interest loans to construct agricultural manure digesters could be an example of a policy support that would spur the development of this industry.

Regional municipal AD systems that can serve industrial food production and commercial livestock production would be a comprehensive solution that will address multiple objectives with one solution. As municipalities across Iowa plan to upgrade their wastewater facilities, they should do it in conjunction with a regional economic development plans that takes into account the expansion of the livestock facilities and food processing in their region. Many regions within Iowa have concentrations of food processors, an affinity for the dairy industry and high concentrations of hog lots.. These are all prime areas to strategically explore the installation of systems that can process manure and industrial wet waste from food processing.

2. Biogas Systems and Nutrient Reduction from Non-Point Sources

Biogas systems can accept agricultural biomass as feedstock and can thus create a market for energy crops, which in turn can have a direct impact on reducing nutrients in Iowa

10 http://www.decision-innovation.com/webres/File/docs/2016%20Iowa%20Animal%20Agriculture%20Economic%20Contribution%20Study%20160202.pdf

11 The pricing of Miscanthus is based on anecdotal data from research projects. The Department of Energy's Billion Ton Study provides detailed analysis of biomass availability at different price points. At $80/dt, the study estimates a national production capacity of about 146 million tons of Miscanthus by 2022 - https://bioenergykdf.net

water sheds.
For the purpose of this study, we assumed unprofitable cropland in Iowa would be re-purposed and marginal land harnessed to grow energy crops if there were a market for the crop. The study assumed Miscanthus to be the energy crop although almost any other crop could be substituted and minor adjustments to the assumptions could be made. The plant gate price of the Miscanthus was assumed to be $80 per dry ton delivered[11].

In order to measure the reduction in Nitrates, the study assumed a very simple model where sub-profitable farmland dedicated to corn and bean production was converted to Miscanthus production. Field scale measurements from corn and soybean systems on research farms suggest that the average Nitrogen loss to subsurface systems is about 30 pounds per acre[12]. Switching away from corn or beans will result in this 30 lbs. of Nitrogen being removed from the subsurface system. This is Nitrogen that will not enter Iowa watersheds in the form of Nitrates. The presence of perennial grasses will also reduce runoff from adjacent fields dedicated to corn-bean production; however, the amount of prevented N runoff from adjacent fields can vary from project to project and from year to year and was therefore not considered in this study. Finally, the study also did not try to measure the amount of Phosphorus retained in the soil as a result of crop switching due to inherent complexities in the way Phosphorus moves through the soil ecosystem.

The 2008 Hypoxia Action Plan calls for states along the Mississippi River to develop nutrient reduction strategies to reduce, mitigate, and control hypoxia in the Gulf of Mexico and improve overall water quality. In October 2010, the Iowa Department of Agriculture and Land Stewardship and the College of Agriculture and Life Sciences at Iowa State University partnered to conduct a technical assessment needed for the development of a statewide strategy to reduce nutrient to streams and the Gulf of Mexico. The team working on this effort consisted of 23 individuals representing five agencies or organizations (Science Team). Within the overall team, sub-group science teams were formed to focus on Nitrogen, Phosphorus and hydrology.

The goals of the above process were to assess nutrient loading from Iowa to the Mississippi River and the potential practices needed to achieve desired environmental goals. As per the 2008 Gulf Hypoxia Action Plan, these goals are a 45% reduction in N and P load. In conjunction with this non-point source assessment, the Iowa Department of Natural Resources (IDNR) has been conducting an assessment of nutrient loads from point sources. Based on IDNR estimates, nonpoint source load reductions for Nitrate-N would need to achieve 41% load reduction in Nitrate-N with the remaining 4% coming from point sources. For phosphorus, the nonpoint source load reductions would need to achieve 29%, with the remaining 16% coming from point sources.

The report from the Science Team recommended nutrient reduction best practices for non-point sources. The best practices include a range of activities including a) improved

12 hhttp://agwatermgmt.ae.iastate.edu/content/gilmore-city-research-and-demonstration-site

Key Insights

Biogas systems can accept agricultural biomass as feedstock and can thus create a market for energy crops, which in turn can have a direct impact on reducing nutrients in Iowa water sheds.

According to the report from the Science Assessment Team, “There is substantial Nitrate-N reduction potential [from growing energy crops], with the research summary indicating 72% Nitrate-N reduction with conversion from row-crop production.”

management practices, such as nutrient application rate, timing, and method, use of cover crops, etc.; b) improved land use practices including perennial energy crops, extended rotations, tillage methods, etc.; and c) edge-of-field practices such as drainage water management, wetlands, bioreactors, buffer, etc. The scientific assessment demonstrated that a combination of practices will be needed to reach desired load reductions in Iowa. To that end, the science team developed scenarios of practice combinations that could potentially achieve the goals.

According to the report from the Science Assessment Team, "There is substantial Nitrate-N reduction potential [from growing energy crops], with the research summary indicating 72% Nitrate-N reduction with conversion from row-crop production. Additional benefits include increased wildlife habitat, reduced soil erosion, and enhanced soil physical properties."

They further developed three example scenarios that meet both the N and P reduction objectives. Initial investment costs of the three scenarios range from $1.2 billion to $4 billion. Alternatively, annual costs, including initial investment and operating cost, range from $77 million per year to $1.2 billion per year resulting in a reduction of 125,870 tons of Nitrogen per year from non-point sources. For point sources, as noted earlier, the report indicated a total present worth cost of approximately $1.5 billion or approximately $114 million per year for a reduction of 11,000 tons of Nitrogen per year.

The analysis by the Science Team only addressed the costs associated with putting in place practices that reduce nutrient runoff. It did not address the value of N removal to downstream parties, such as benefits derived from the recreational use of streams or increase in property values along water sheds.

Currently, there is no value attached to the reduction of this Nitrogen from Iowa's waterways. However, this study assumed a range of values from $7.5/lb. to $22.5/lb. of displaced N to understand the impact of such a market on the regional economy.

D. Key Conclusions

- Given the extensive investment of $2.5 billion required to overhaul Iowa's municipal wastewater treatment infrastructure, these projects should conduct a detailed examination of the regional waste shed and the potential to be a producer of biogas. Revenues from the sale of biogas and associated environmental attributes could allow these treatment plants to subsidize all or some of the costs. This will expedite the construction of these projects and the upgrading of the State wastewater infrastructure.

- On average, for the three sites that treated industrial wastewater, an average $17.6 million investment per site and revenues from the sale of renewable natural gas and associated environmental attributes will result in:
  - 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.
  - $2.7 million increase per site in tax receipts over project life.

- Given the estimated 1.2 billion to $4 billion that needs to be spent in Iowa to put in place nutrient control systems for non-point sources, the State should conduct a thorough review of the agricultural digester model and the potential to produce biogas from a mixture of energy crops and manure. Revenues from the sale of biogas and associated environmental attributes could incentivize investments into these projects and increase economic output in the region. Proactively managing land use and the organic waste shed in Iowa's watersheds could create a new market for biomass.

- The agricultural model utilizes 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 and an average gross annual revenue of $1.9 million from sale of gas and environmental attributes ($528,000 will flow through to Miscanthus suppliers)
  - $69.5 million in total economic output from capital investment and 20-year operations. $20 million will flow through to the farm economy for Miscanthus cultivation.
  - 97 jobs created during the construction phase.
  - 6 jobs created from the project operations and revenues, of which 2 jobs will be dedicated to Miscanthus cultivation.
  - $1.3 million increase in tax receipts over project life.

- Since agricultural biogas systems that process biomass crops will have an ancillary beneficial impact on regional watersheds by reducing Nitrogen loss, assigning a price for the displaced Nitrogen will quantify and monetize this important environmental benefit. Revenues from trading in Nitrogen credits will have a direct impact on the farm economy.

- Over the 20-year life of the project, the revenues from Nitrogen removal (assuming a range of $7.5/lb. to $22.5/lb. of displaced Nitrogen) could increase local economic output by $7.9 million to $23.7 million. State and local tax collections could go up by $400,000.

- Maintaining and growing a livestock industry is also an economic development goal for Iowa. Manure digesters co-located as effective manure management systems can ease the environmental and social burden of animal agriculture by reducing odor, eliminating methane releases from lagoons and reducing the pathogen in waterways from manure application.

- Given the likelihood of public dollars being spent on infrastructure projects to improve wastewater treatment and reduce nutrients in watersheds, there are several policy considerations for evaluation. Nutrient trading programs, revolving loan funds and loan guarantees are a few examples of how the State could pro-actively support investments and invite public-private partnerships into this sector. Private parties can voluntarily commit to purchasing the displaced Nitrogen motivated by their sustainability goals or in exchange for higher discharge limits resulting from purchased offsets. Downstream water treatment bodies could also sponsor projects by applying the cost of Nitrogen removal to Nitrogen mitigation. The full range of policy recommendations that can support this concept is beyond the scope of this study, and is recommended for further study.

- A key next step would be to support the installation of a pilot project to closely study the full environmental, social and economic impact of Anaerobic Digestion systems.

Key Insights

AD systems are at the heart of the Water Energy Nexus

- Municipal Wastewater Treatment Facilities face up to $2.5 billion in capital projects

- Watersheds face nutrient mitigation costs of up to $4 billion

- There could be a business case for installing AD systems to address above needs

- Installing AD systems and maximizing revenues from environmental attributes can reduce payback periods

III.
Future Needs

A. Opportunities for Further Study

- As particular projects or Iowa's biogas industry as a whole move forward, the beneficial outputs of a biogas system listed below need to be considered further:

  - Leveraging economic development from robust municipal wastewater treament facilities
  - Alternate uses of capital resulting from lower wastewater treatment costs to area industry
  - Potential of creating new gas pipeline infrastructure and its benefits
  - Economic and environmental benefits of planting perennials
  - Economic and social benefits of reduced nutrient runoff, such as increased recreational use
    of the watershed and higher property values
  - Potential to stimulate an expansion of the livestock industry through provision of manure management services

- Key regions need to be identified where Publicly Owned Treatment Works (POTWs) can serve as anchors facilitating regional industrial development. Detailed studies need to be conducted on how existing assets in these regions can be re-positioned as resource recovery centers.

- The availability of marginal land and economics of energy crop cultivation need to be further studied. Preliminary designs for biomass cultivation, collection, storage and maceration need to be understood in more detail.

- Clear system boundaries, methodologies and evaluation and monitoring systems need to be developed to quantify the reduction in Nitrate runoff and Phosphorus loss resulting from switching from corn-bean rotation to perennial crop cultivation.

- A more precise carbon footprint of municipal, industrial and agricultural digesters need to be developed.

- Miscanthus is a non-native species that likely has little benefit for native wildlife. It might be useful to consider stacked benefits such as pollinator and bird habitat and forage. There would be economic value that could be derived from resulting recreational opportunities and value from avoiding listing species like the Monarch butterfly on the federal endangered species list.

- Economic development, protecting Iowa's watersheds and maintaining municipal wastewater infrastructure are all concerns of public policy. Policy considerations need to be studied further and recommendations need to be made on effective policies that can attract infrastructure investments, promote economic development and protect air and water quality.

IV.
Appendices

A. Economic Modeling Methodology

1. Methodology Behind the Economic Impact Analysis

The boost to regional economy from investments in new AD infrastructure and revenue from ongoing operations, was conducted using IMPLAN's I-RIMs model by Goss & Associates. Economic impacts can be divided into direct, indirect and induced as described below.

- *Direct Economic Impacts.* Operating revenues from an AD system flowing into the area have direct economic effects on the local economy by making expenditures for goods and services and by paying employee salaries.
- *Indirect Economic Impacts.* The project operations will also produce indirect economic effects on the area economy. E.g., lodging establishments that house remote employees and guests who buy merchandise from area wholesalers. New investment and related expenditures also encourage the startup and expansion of other businesses. Operations can generate indirect effects by increasing (a) the number of firms drawn to a community, (b) the volume of deposits in local financial institutions and, (c) economic development. This is particularly important due to Iowa's leadership role in alternative energy production.
- *Induced Economic Impacts.* Induced impacts in the county and region occur as the initial spending feeds back to industries in the region when workers in the area purchase additional output from local firms in a second round of spending. Spending is re-circulated, creating overall spending that is a multiple of the initial expenditure.

Input-Output (I-O) Models. I-O models are the most frequently used types of analysis tools for economic impact assessment. Input-output is a simple general equilibrium approach based on an accounting system of injections and leakages. Input-Output analysis assumes that each sector purchases supplies from other sectors and then sells its output to other sectors and/or final consumers. Input-Output systems were originally developed by Wassily Leontief (1941) to assist in planning a national economy. Input-Output represents an effective method for depicting and investigating the underlying processes that bind industries of a region. It provides a technique to project into the future the magnitude of important additions or injections into the local economy.

Input-Output models are composed of three basic tables. The first, the Transactions Table, traces inter-industry sales and purchases within a defined region. The next table, the Direct Requirements Table, answers the question, "If a certain dollar value of intermediate requirements is present for a total dollar value of gross output, what are the intermediate requirements for each industry per dollar of gross output?" The manipulation of these two tables results in the final and most important of the tables, the Industrial Multiplier Table. This table is then used to calculate overall impacts. Chief problems involved in the use of multipliers are:

- *Selection of industries*. For which industries will impacts be estimated? The selection is generally dictated by definitions used by government agencies that collect the data. For example, most government data do not distinguish employment in a cardiac center or clinic from that in a hospital.
- *Selection of a region.* Again, government agencies collect aggregate data by county, thus requiring the analysis to take place at the county level, or combination of counties. Most developers of "ready-made" multipliers use the County Business Patterns as the primary data source. For this study, Plymouth County is the area of analysis.

2. Major assumptions of the I-O model

- *Constant production coefficients.* For example, it is assumed that "x" dollars of new revenues flowing to Plymouth County will produce "y" dollars of output regardless of the scale of operations. In other words, the I-O model assumes constant returns to scale.
- *Constant technological relationships between inputs and outputs*. Thus I-O multipliers assume that technology remains the same between the time the multipliers are calculated and the period for which impacts are estimated.
- *Old purchasing patterns are the same as new purchasing patterns.* Thus, it is assumed that purchasing patterns between ADS operations and its suppliers in Plymouth County will be the same as other firms in the industry in the area.
- *No supply constraints.* I-O models do not take into consideration the problem of finding an adequate supply of workers to fill new jobs brought about by the relay services contract.[13]

Despite their weaknesses and somewhat restrictive assumptions, I-O multipliers are the tools most often used for impact analysis. Due to their documented effectiveness and relatively low cost, the I-O multipliers used in this study are those produced by the U.S. Forestry Service and marketed by the Minnesota IMPLAN Group Inc. (www.implan.com). The next section describes these multipliers—Regional Input-Output Modeling System (RIMS).

3. I-RIMS Multipliers Used in this Study

The U.S. Bureau of Economic Analysis (BEA), a division of the U.S. Commerce Department created RIMS (regional input-output modeling system) in the 1970s. Recently, IMPLAN updated the RIMS approach and for this study we use their I-RIMS I-O modeling methodology.

I-RIMS Multipliers are created from IMPLAN input-output models for local and regional

13 Bartik (1991) estimated that 75% of the net new jobs resulting from a business expansion or business re-location go to in-migrants.

economies. These models use data collected for individual regions, not national averages. I-RIMS uses IMPLAN'S proprietary *Trade Flow Model* which tracks the flows of goods and services between every county in the nation.
I-RIMS produces four final-demand multipliers. Final-demand multipliers for output, for earnings, for employment and value-added. These multipliers measure the economic impact of a change in final demand, in earnings, or in employment on a region's economy.

To effectively use the I-RIMS multipliers for impact analysis, users must provide geographically and industrially detailed information on the initial changes in output, earnings, or employment that are associated with the project or program under study. To provide this information, the user must answer five questions about the project or program.

What is the affected region?

- Which industries are initially affected?
- Is there more than one phase of the project or program?
- What are the initial changes in output, earnings, or employment?
- Should the initial changes be separated into production costs, transportation costs, and trade margins?

This study uses three of the I-RIMS four final-demand multipliers as described below.

Type of Multiplier	Description
Output Multipliers	Total industry output per $1 change in final demand
Earnings (labor income) Multipliers	Total household earnings per $1 change in final demand
Employment Multipliers	Total number of jobs per $1 million change in final demand

B. Detailed Economic Impact Results

1. The Economic Impact of an Anaerobic Digestive System – Industrial Model, 2017-2036

Executive Summary

By applying investment data for the construction and operations of an anaerobic digestive system (ADS) to Input-Output models,[3] it is estimated that the Industrial Model project produces the following direct, indirect and induced contributions to the county:

To the Industrial Model economy for construction phase (18 months) and operations phase 2017-2036.

Construction Phase (18 months):

- The ADS project will produce a $15,662,768 investment in the construction phase.
- Spending for land development will exceed $2.8 million.
- Building construction spending will total $835,000.
- Spending for capital equipment and installation will result in increased expenditures of approximately $12.0 million, impacting engineering services and wholesale trade.
- The project will drive spillover impacts of nearly $11.0 million, resulting in a total increase in output (sales) for the Industrial Model county of $26,662,250.[4]
- Earnings (labor income) will increase by more than $10.8 million.[5]
- The project will support 172 jobs.

Operations Phase (annual impact and 20-year impact):[6]

- The project's on-going operations, maintenance and revenue will increase local annual economic output by nearly $6.0 million.
- The project's operations will increase local annual earnings by approximately $550,301.[7]
- The project's operations will support 10.1 jobs annually.
- During the 20 years covered in this study, sales activity (output) in the local economy will increase by $159.3 million.
- During the same 20-year period, earnings (labor income) will increase by $14.5 million.

3 This study was completed using IMPLAN's new I-RIMS methodology. I-RIMS is a modification of the RIMS Input- Output methodology used by the Bureau of Economic Analysis. The results generated in the I-RIMS model are consistent with IMPLAN's previous regional models. An explanation of this methodology is contained in Appendix A.

4 Spillover impacts represent 'ripple' impacts in related businesses as the initial contract dollars are re-spent in the community. For example, project's and construction contractors' workers will spend a portion of their earnings in local grocery stores. This spending creates sales, earnings and jobs, termed spillover impacts, for businesses in the retail trade sector. Output reflects the change in total industry output (sales at all stages of production) resulting from the change in demand produced by the project.

5 Throughout this document earnings (labor income) are total household earnings, including wages and salaries as well as self-employment income.

State & local tax collections construction phase and operations phase (2017 to 2036):

- It is estimated that the project will generate $2.6 million in state and local tax collections during the construction phase and the operations phase (2017 to 2036).
- Property tax collections will increase by an estimated $882,283.
- State and gross receipts will increase by an estimated $782,542.
- Personal income tax collections will increase by approximately $666,853.

Summary of Annual Impacts

Table 1 provides a summary of the project's potential investment and annual revenue generated from annual sales at its Industrial Model facility. Table 2 provides a summary of the economic impacts of both the construction and operational components of the project. The assumptions and methodology used to produce these estimates are contained in the accompanying appendices.

Table 21: Direct Impacts of the Industrial Model project (does not include spillover impacts)		
Type of impact	Amount	Sector Code
Cost of land development (sewage, rail, highways, etc.)	$2,842,953	233293
Cost of building construction	$835,000	233230
Cost of capital equipment (installation and purchase)	$11,984,815	420000 & 541300
Total (18 months)	$15,662,768	
Operating revenues (annual)		
Natural gas revenues	$515,745	325190
RIN revenues	$2,025,159	325190
LCFS revenues	$1,411,240	325190
Fiber bedding revenues	100,000	325190
Fertilizer revenues	$910,000	325190
Total	$4,962,144	

6 All impacts are expressed in 2015 dollars.

7 Earnings include wages, salaries, and self-employment income.

Table 22: Projected total impacts of the Industrial Model project		
	Project construction (18 months)	On-Going Operations (annual)
Sales (output)	$26,662,250	$6,049,259
Earnings (labor income)	$10,838,306	$550,301
Employment	172.2	10.1

Table 3 provides a summary of the fiscal impacts from the Industrial Model project. The project has the potential to boost state and local tax revenue by approximately $2.6 million during the construction and 20-year operations phases. Property tax collections will increase by $882,283 and sales and gross receipts will increase by $782,542. Individual income tax collections will receive a boost of $666,853. In addition, tax collections for corporate income tax, motor vehicle licenses and other taxes will increase by approximately $265,423.

Table 23: Summary of Fiscal Impacts from the Industrial Model project

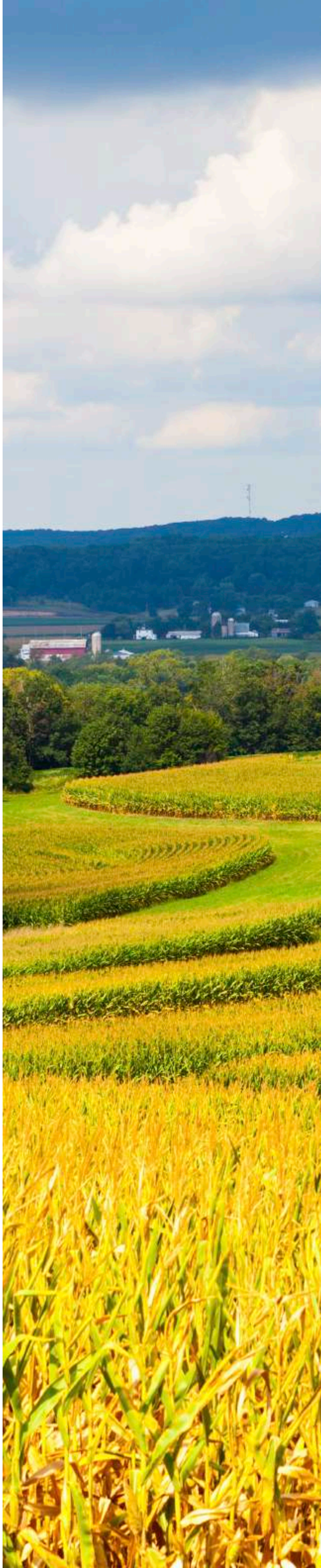
Sector	**Construction Phase (18 months)**	**Operations Phase**		**Total All Phases**
		2017	**2018-2036**	
Property tax	$377,546	$19,169	$485,568	$882,283
Sales and gross receipts	$334,865	$17,002	$430,675	$782,542
Individual income tax	$285,359	$14,489	$367,005	$666,853
Corporate income tax	$34,544	$1,754	$44,428	$80,727
Motor vehicle license	$45,291	$2,300	$58,249	$105,839
Other taxes	$33,744	$1,713	$43,399	$78,857
Total:	**$1,111,349**	**$56,427**	**$1,429,324**	**$2,597,101**

Table 24: Economies at a glance, POTW SE, Iowa and U.S. compared	
Population July 1, 2015	
Industrial Model	219,916
Iowa	3,123,899
U.S.	321,418,820
Population growth, 2010-15	
Industrial Model	4.1%
Iowa	2.5%
U.S.	4.1%
Percent white, 2015	
Industrial Model	90.1%
Iowa	91.3%
U.S.	77.1%
Percent of population over 16 in labor force	
Industrial Model	
Iowa	70.6%
U.S.	63.5%
Retail sales per capita, 2012	
Industrial Model	$20,824
Iowa	$14,607
U.S.	$13,443
Percent of population over 25 with high school diploma	
Industrial Model	94.1%
Iowa	91.3%
U.S.	86.3%
Percent of population over age 25 with bachelor's degree	
Industrial Model	**31.7%**
Iowa	**26.4%**
U.S.	**29.3%**
Median household income, 2014	
Industrial Model	**$59,560**
Iowa	**$52,716**
U.S.	**$53,482**
Percent of population in poverty, 2014	
Industrial Model	**9.3%**
Iowa	**12.2%**
U.S.	**14.8%**
Source: U.S. Census and Bureau of Economic Analysis	

Detailed Economic Impacts The construction phase of the Industrial Model project will impact all 20 industry sectors in the county. The top 3 impacted sectors, outside of construction and wholesale trade, will likely be (1) Professional, Scientific and Technical Services ($8.2 million); (2) Real Estate and Rental and Leasing Services ($2.1 million) and (3) Finance and Insurance ($1.1 million) sectors. Table 5 provides the detailed impacts from the construction phase.

Table 5: Impact of construction in the Industrial Model

Sector	Output	Earnings	Employment
Professional, scientific, and technical services	$8,240,550	$4,720,918	56.9
Wholesale trade	$5,324,064	$1,907,467	23.6
Construction	$3,815,729	$1,321,499	22.4
Real estate and rental and leasing	$2,053,113	$119,903	2.6
Finance and insurance	$1,124,547	$312,485	5.3
Health care and social assistance	$1,104,842	$614,096	11.2
Information	$1,073,311	$196,467	2.7
Administrative and waste management services	$697,954	$412,168	11.4
Retail trade	$626,410	$294,709	8.8
Transportation and warehousing	$620,962	$234,700	5.0
Food services and drinking places	$484,122	$176,436	9.8
Other services	$420,547	$232,611	5.5
Manufacturing	$288,882	$82,132	0.9
Utilities	$273,734	$31,431	0.3
Arts, entertainment, and recreation	$147,243	$32,477	2.4
Educational services	$139,140	$69,184	2.2
Management of companies and enterprises	$119,932	$53,010	0.7
Mining	$101,059	$24,424	0.4
Agriculture, forestry, fishing, and hunting	$3,542	$1,505	0.0
Accommodation	$2,567	$683	0.0
Total	**$26,662,250**	**$10,838,306**	**172.2**



The annual operations of the Industrial Model project will impact all 20 industry sectors in the county. The following sectors will likely experience the greatest impact: (1) Manufacturing ($5.0 million); (2) Wholesale Trade ($176,700) and (3) Transportation and Warehousing ($152,098). Table 6 provides the detailed impacts from the operations phase.

Table 6: Impact of operations in the Industrial Model (annual)

Sector	Output	Earnings	Employment
Manufacturing	$4,977,806	$199,931	3.0
Wholesale trade	$176,700	$63,307	0.8
Transportation and warehousing	$152,098	$47,372	1.0
Real estate and rental and leasing	$108,843	$6,251	0.1
Utilities	$80,537	$9,395	0.1
Retail trade	$76,166	$35,713	1.1
Information	$68,993	$12,464	0.2
Administrative and waste management services	$65,887	$30,482	0.8
Finance and insurance	$59,749	$17,329	0.3
Health care and social assistance	$56,098	$31,181	0.6
Professional, scientific, and technical services	$47,270	$25,859	0.4
Other services	$41,427	$21,357	0.4
Management of companies and enterprises	$39,048	$17,259	0.2
Construction	$36,805	$12,690	0.2
Food services and drinking places	$26,223	$9,117	0.5
Agriculture, forestry, fishing, and hunting	$13,441	$4,889	0.2
Arts, entertainment, and recreation	$8,732	$1,951	0.1
Educational services	$7,129	$3,550	0.1
Mining	$6,183	$170	0.0
Accommodation	$124	$33	0.0
Total	**$6,049,259**	**$550,301**	**10.1**

While the construction phase will have an impact on the local economy for approximately 18 months, the operations phase will have an ongoing impact on the local economy.

Table 7 provides a summary of the anticipated growth in sales activity for the county. Sales will grow by an estimated $159.3 million during the 20-year period. Manufacturing output will increase by approximately $131.1 million from 2017 to 2036. During the same time period, receipts in the Wholesale Trade sector will grow by $4.7 million.

Table 7: Summary of the anticipated growth in sales activity for the county

Sector	2017	2018-2036	Total
Agriculture, forestry, fishing, and hunting	$13,441	$340,462	$353,903
Mining	$6,183	$156,607	$162,790
Utilities	$80,537	$2,040,023	$2,120,560
Construction	$36,805	$932,293	$969,099
Manufacturing	$4,977,806	$126,089,582	$131,067,387
Wholesale trade	$176,700	$4,475,886	$4,652,586
Retail trade	$76,166	$1,929,314	$2,005,480
Transportation and warehousing	$152,098	$3,852,704	$4,004,802
Information	$68,993	$1,747,612	$1,816,604
Finance and insurance	$59,749	$1,513,466	$1,573,215
Real estate and rental and leasing	$108,843	$2,757,028	$2,865,871
Professional, scientific, and technical services	$47,270	$1,197,361	$1,244,631
Management of companies and enterprises	$39,048	$989,091	$1,028,138
Administrative and waste management services	$65,887	$1,668,951	$1,734,838
Educational services	$7,129	$180,585	$187,714
Health care and social assistance	$56,098	$1,420,974	$1,477,072
Arts, entertainment, and recreation	$8,732	$221,175	$229,907
Accommodation	$124	$3,147	$3,271
Food services and drinking places	$26,223	$664,233	$690,456
Other services	$41,427	$1,049,372	$1,090,800
Total	**$6,049,259**	**$153,229,867**	**$159,279,126**

Table 8 provides a summary of the anticipated growth in earnings (labor income) for the county. Earnings will grow by an estimated $14.5 million during the 20 years studied. The Manufacturing sector will likely see earnings increase by approximately $5.3 million from 2017 to 2036. During the same time period, both the Wholesale Trade ($1.7 million) and the Transportation and Warehousing ($1.2 million) sectors will likely see substantial earnings growth.

Table 8: Summary of the anticipated growth in earnings (labor income) for the county

Sector	2017	2018-2036	Total
Agriculture, forestry, fishing, and hunting	$4,889	$123,839	$128,728
Mining	$170	$4,318	$4,488
Utilities	$9,395	$237,981	$247,376
Construction	$12,690	$321,445	$334,135
Manufacturing	$199,931	$5,064,315	$5,264,246
Wholesale trade	$63,307	$1,603,588	$1,666,895
Retail trade	$35,713	$904,610	$940,323
Transportation and warehousing	$47,372	$1,199,942	$1,247,314
Information	$12,464	$315,713	$328,176
Finance and insurance	$17,329	$438,960	$456,289
Real estate and rental and leasing	$6,251	$158,338	$164,588
Professional, scientific, and technical services	$25,859	$655,023	$680,882
Management of companies and enterprises	$17,259	$437,179	$454,438
Administrative and waste management services	$30,482	$772,123	$802,605
Educational services	$3,550	$89,918	$93,468
Health care and social assistance	$31,181	$789,818	$820,999
Arts, entertainment, and recreation	$1,951	$49,424	$51,375
Accommodation	$33	$838	$871
Food services and drinking places	$9,117	$230,947	$240,065
Other services	$21,357	$540,989	$562,346
Total	**$550,301**	**$13,939,306**	**$14,489,607**

The project will grow the local tax base. Table 9 presents the assumptions used in making the fiscal impact estimates:

Table 9: Fiscal impact assumptions, tax type as percentage of state personal income	
Property tax	3.5%
Sales and gross receipts	3.1%
Individual income tax	2.6%
Corporate income tax	0.3%
Motor vehicle license	0.4%
Other taxes	0.3%

The Industrial Model project has the potential to boost state and local tax revenue by approximately $2.6 million during the construction and 20-year operations phases. Property tax collections will increase by $882,283 and sales and gross receipts will increase by over $782,542. Individual income tax collections will receive a boost of $666,853. In addition, tax collections for corporate income tax, motor vehicle licenses and other taxes will increase by approximately $265,423.

Table 10 provides the state and local fiscal impacts, below.

Table 10: Fiscal Impacts

Sector	Construction Phase (18 months)	Operations Phase		Total All Phases
		2017	2018-2036	
Property tax	$377,546	$19,169	$485,568	$882,283
Sales and gross receipts	$334,865	$17,002	$430,675	$782,542
Individual income tax	$285,359	$14,489	$367,005	$666,853
Corporate income tax	$34,544	$1,754	$44,428	$80,727
Motor vehicle license	$45,291	$2,300	$58,249	$105,839
Other taxes	$33,744	$1,713	$43,399	$78,857
Total:	**$1,111,349**	**$56,427**	**$1,429,324**	**$2,597,101**

3. The Economic Impact of an Anaerobic Digestive System POTW NE Model, 2017-2036

The Economic Impact of an Anaerobic Digestive System – POTW NE Model, 2017-2036

Executive Summary

By applying investment data for the construction and operations of an anaerobic digestive system (ADS) to Input-Output models, it is estimated that the POTW NE project produces the following direct, indirect and induced contributions to the county:

Construction Phase (18 months):

- The ADS project will produce a $23,845,388 investment in the construction phase.
- Spending for land development will exceed $5.9 million.
- Building construction spending will total nearly $800,000.
- Spending for capital equipment and installation will result in increased expenditures of more than $17.1 million, impacting engineering services and wholesale trade.
- The project will drive spillover impacts of nearly $4.6 million, resulting in a total increase in output (sales) for the POTW NE county of $28,443,198.
- Earnings (labor income) will increase by $9.6 million.
- The project will support 223 jobs.

Operations Phase (annual impact and 20-year impact):

- The project's on-going operations, maintenance and revenue will increase local annual economic output by nearly $5.0 million.
- The project's operations will increase local annual earnings by approximately $808,507.
- The project's operations will support 8.1 jobs annually.
- During the 20 years covered in this study, sales activity (output) in the local economy will increase by $130.5 million.
- During the same 20-year period, earnings (labor income) will increase by $21.3 million.

State & local tax collections construction phase and operations phase (2017 to 2036):

- It is estimated that the POTW NE project will generate $3.2 million in state and local tax collections during the construction phase and the operations phase (2017 to 2036).
- Property tax collections will increase by an estimated $1.1 million.
- State and gross receipts will increase by an estimated $953,008.
- Personal income tax collections will increase by approximately $812,118.

Summary of Annual Impacts

Table 11 provides a summary of the potential investment and annual revenue generated from annual sales at the POTW NE facility. Table 12 provides a summary of the economic impacts of both the construction and operational components of the project. The assumptions and methodology used to produce these estimates are contained in the accompanying appendices.

Table 11: Direct Impacts of the POTW NE Model project (does not include spillover impacts)

Type of impact	Amount	Sector Code
Cost of land development (sewage, rail, highways, etc.)	$5,936,791	233293
Cost of building construction	$796,361	233230
Cost of capital equipment (installation and purchase)	$17,112,235	420000 & 541300
Total (18 months)	$23,845,388	
Operating revenues (annual)		
Natural gas revenues	$542,025	325190
RIN revenues	$2,128,352	325190
LCFS revenues	$1,573,956	325190
Fertilizer revenues	$258,875	325190
Total	$4,503,208	

Table 12: Projected total impacts of the POTW NE Model project

	Project construction (18 months)	On-Going Operations (annual)
Sales (output)	$28,443,198	$4,956,506
Earnings (labor income)	$9,556,986	$808,507
Employment	223.3	8.1

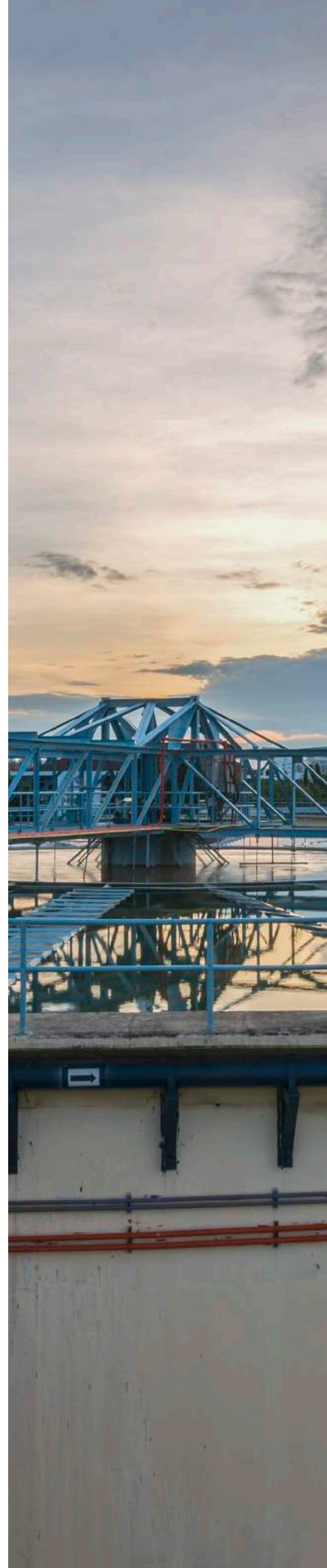


Table 13 provides a summary of the fiscal impacts from the POTW NE project. The project has the potential to boost state and local tax revenue by approximately $3.2 million during the construction and 20-year operations phases. Property tax collections will increase by $1.1 million and sales and gross receipts will increase by nearly $1.0 million. Individual income tax collections will receive a boost of $812,118. In addition, tax collections for corporate income tax, motor vehicle licenses and other taxes will increase by approximately $323,242.

Table 13: Projected impacts of the POTW NE Model project on state and local taxes8

Sector	Construction Phase (18 months)	Operations Phase		Total All Phases
		2017	2018-2036	
Property tax	$332,912	$28,164	$713,400	$1,074,476
Sales and gross receipts	$295,277	$24,980	$632,752	$953,008
Individual income tax	$251,624	$21,287	$539,207	$812,118
Corporate income tax	$30,461	$2,577	$65,274	$98,312
Motor vehicle license	$39,936	$3,379	$85,580	$128,895
Other taxes	$29,755	$2,517	$63,763	$96,035
Total:	**$979,964**	**$82,904**	**$2,099,976**	**$3,162,843**

Tax data from the U.S. Census Annual Survey of Government, 2012-2013 fiscal year.

Table 14: Economies at a glance, POTW NE, Iowa and U.S. compared	
Population July 1, 2015	
POTW NE	24,800
Iowa	3,123,899
U.S.	321,418,820
Population growth, 2010-15	
POTW NE	-0.7%
Iowa	2.5%
U.S.	4.1%
Percent white, 2015	
POTW NE	97.1%
Iowa	91.3%
U.S.	77.1%
Percent of population over 16 in labor force	
POTW NE	70.6%
Iowa	67.9%
U.S.	63.5%
Retail sales per capita, 2012	
POTW NE	$10,842
Iowa	$14,607
U.S.	$13,443
Percent of population over 25 with high school diploma	
POTW NE	92.3%
Iowa	91.3%
U.S.	86.3%
Percent of population over age 25 with bachelor's degree	
POTW NE	20.0%
Iowa	26.4%
U.S.	29.3%
Median household income, 2014	
POTW NE	$57,583
Iowa	$52,716
U.S.	$53,482
Percent of population in poverty, 2014	
POTW NE	7.6%
Iowa	12.2%
U.S.	14.8%
Source: U.S. Census and Bureau of Economic Analysis	

Detailed Economic Impacts The construction phase of the POTW NE project will impact

19 of the 20 industry sectors in the county. The top 3 impacted sectors, outside of construction and wholesale trade, will likely be

(1) Professional, Scientific and Technical Services ($11.0 million);
(2) Real Estate and Rental and Leasing Services ($578,741) and (3) Transportation and Warehousing ($503,864) sectors. Table 15 provides the detailed impacts from the construction phase.

Table 15: Impact of construction in the POTW NE Model			
Sector	**Output**	**Earnings**	**Employment**
Professional, scientific, and technical services	$11,009,450	$3,760,463	111.6
Wholesale trade	$7,224,168	$2,831,263	32.3
Construction	$6,846,641	$1,709,323	46.6
Real estate and rental and leasing	$578,741	$123,230	4.2
Transportation and warehousing	$503,864	$201,912	4.4
Finance and insurance	$425,969	$150,562	2.7
Management of companies and enterprises	$331,766	$181,897	1.4
Administrative and waste management services	$316,784	$159,738	6.9
Other services	$261,987	$153,649	2.8
Food services and drinking places	$216,116	$67,987	5.0
Information	$202,554	$43,404	0.8
Utilities	$139,927	$12,578	0.1
Mining	$136,348	$28,148	0.7
Retail trade	$114,853	$47,936	2.0
Manufacturing	$93,683	$74,643	0.1
Arts, entertainment, and recreation	$36,345	$8,982	1.5
Accommodation	$1,844	$445	0.0
Agriculture, forestry, fishing, and hunting	$1,511	$402	0.0
Educational services	$647	$425	0.0
Health care and social assistance	$0	$0	0.0
Total	**$28,443,198**	**$9,556,986**	**223.3**

The annual operations of the POTW NE project will impact 19 of the 20 industry sectors in POTW NE. The following sectors will likely experience the greatest impact: (1) Manufacturing ($4.5 million); (2) Wholesale Trade ($87,163) and (3) Transportation and Warehousing ($71,305). Table 16 provides the detailed impacts from the operations phase.

Table 16: Impact of operations in the POTW NE Model (annual)

Sector	Output	Earnings	Employment
Manufacturing	$4,504,569	$655,445	5.0
Wholesale trade	$87,163	$34,161	0.4
Transportation and warehousing	$71,305	$24,303	0.6
Management of companies and enterprises	$67,468	$36,991	0.3
Utilities	$50,450	$5,538	0.0
Administrative and waste management services	$36,314	$10,221	0.4
Construction	$24,651	$6,608	0.2
Retail trade	$23,908	$9,885	0.4
Other services	$17,728	$9,522	0.2
Agriculture, forestry, fishing, and hunting	$15,103	$3,208	0.0
Professional, scientific, and technical services	$12,706	$4,241	0.2
Mining	$12,036	$176	0.1
Real estate and rental and leasing	$9,871	$1,929	0.1
Finance and insurance	$9,483	$3,094	0.1
Information	$7,075	$1,449	0.0
Food services and drinking places	$5,460	$1,458	0.1
Arts, entertainment, and recreation	$1,056	$250	0.0
Accommodation	$32	$8	0.0
Educational services	$29	$20	0.0
Health care and social assistance	$0	$0	0.0
Total	**$4,956,406**	**$808,507**	**8.1**

While the construction phase will have an impact on the local economy for approximately 18 months, the operations phase will have an ongoing impact on the local economy.

Table 17 provides a summary of the anticipated growth in sales activity for the county. Sales will grow by an estimated $130.5 million during the 20-year period. Manufacturing output will increase by approximately $118.6 million from 2017 to 2036. During the same time period, receipts in the Wholesale Trade sector will grow by $2.3 million.

Table 17: Summary of the anticipated growth in sales activity for the county			
Sector	**2017**	**2018-2036**	**Total**
Agriculture, forestry, fishing, and hunting	$15,103	$382,557	$397,660
Mining	$12,036	$304,882	$316,919
Utilities	$50,450	$1,277,908	$1,328,358
Construction	$24,651	$624,408	$649,059
Manufacturing	$4,504,569	$114,102,327	$118,606,897
Wholesale trade	$87,163	$2,207,872	$2,295,035
Retail trade	$23,908	$605,589	$629,496
Transportation and warehousing	$71,305	$1,806,171	$1,877,476
Information	$7,075	$179,208	$186,283
Finance and insurance	$9,483	$240,201	$249,684
Real estate and rental and leasing	$9,871	$250,045	$259,916
Professional, scientific, and technical services	$12,706	$321,851	$334,557
Management of companies and enterprises	$67,468	$1,708,991	$1,776,459
Administrative and waste management services	$36,314	$919,848	$956,162
Educational services	$29	$736	$765
Health care and social assistance	$0	$0	$0
Arts, entertainment, and recreation	$1,056	$26,739	$27,795
Accommodation	$32	$813	$846
Food services and drinking places	$5,460	$138,304	$143,764
Other services	$17,728	$449,061	$466,789
Total	**$4,956,406**	**$125,547,513**	**$130,503,919**

Table 18 provides a summary of the anticipated growth in earnings (labor income) for the county. Earnings will grow by an estimated $21.3 million during the 20 years studied. The Manufacturing sector will likely see earnings increase by approximately $17.3 million from 2017 to 2036. During the same time period, both the Management of Companies and Enterprises ($973,976) and the Wholesale Trade ($899,460) sectors will likely see a substantial increase in earnings.

Table 18: Summary of the anticipated growth in earnings (labor income) for the county			
Sector	**2017**	**2018-2036**	**Total**
Agriculture, forestry, fishing, and hunting	$3,208	$81,255	$84,463
Mining	$176	$4,456	$4,632
Utilities	$5,538	$140,288	$145,827
Construction	$6,608	$167,373	$173,980
Manufacturing	$655,445	$16,602,647	$17,258,092
Wholesale trade	$34,161	$865,299	$899,460
Retail trade	$9,885	$250,399	$260,285
Transportation and warehousing	$24,303	$615,592	$639,895
Information	$1,449	$36,705	$38,155
Finance and insurance	$3,094	$78,381	$81,475
Real estate and rental and leasing	$1,929	$48,873	$50,803
Professional, scientific, and technical services	$4,241	$107,438	$111,679
Management of companies and enterprises	$36,991	$936,985	$973,976
Administrative and waste management services	$10,221	$258,913	$269,134
Educational services	$20	$502	$522
Health care and social assistance	$0	$0	$0
Arts, entertainment, and recreation	$250	$6,324	$6,574
Accommodation	$8	$196	$204
Food services and drinking places	$1,458	$36,941	$38,399
Other services	$9,522	$241,192	$250,714
Total	**$808,507**	**$20,479,761**	**$21,288,268**

The POTW NE project will grow the local tax base. Table 19 presents the assumptions used in making the fiscal impact estimates:

Table 19: Fiscal impact assumptions, tax type as percentage of state personal income	
Property tax	3.5%
Sales and gross receipts	3.1%
Individual income tax	2.6%
Corporate income tax	0.3%
Motor vehicle license	0.4%
Other taxes	0.3%

The POTW NE project has the potential to boost state and local tax revenue by approximately $3.2 million during the construction and 20-year operations phases.

Property tax collections will increase by $1.1 million and sales and gross receipts will increase by nearly $1.0 million. Individual income tax collections will receive a boost of $812,118. In addition, tax collections for corporate income tax, motor vehicle licenses and other taxes will increase by approximately $323,242. Table 20 provides the state and local fiscal impacts, below.

Table 20: Fiscal Impacts

Sector	Construc-tion Phase (18months)	Operations Phase		Total All Phases
		2017	2018-2036	
Property tax	$332,912	$28,164	$713,400	$1,074,476
Sales and gross receipts	$295,277	$24,980	$632,752	$953,008
Individual income tax	$251,624	$21,287	$539,207	$812,118
Corporate income tax	$30,461	$2,577	$65,274	$98,312
Motor vehicle license	$39,936	$3,379	$85,580	$128,895
Other taxes	$29,755	$2,517	$63,763	$96,035
Total:	**$979,964**	**$82,904**	**$2,099,976**	**$3,162,843**

3. The Economic Impact of an Anaerobic Digestive System –POTW SE Model, 2017-2036

The Economic Impact of an Anaerobic Digestive System – POTW SE Model, 2017-2036

Executive Summary

By applying investment data for the construction and operations of an anaerobic digestive system (ADS) to Input-Output models, it is estimated that the POTW SE project produces the following direct, indirect and induced contributions to the county:

Construction Phase (18 months):

- The ADS project will produce a $13,379,000 investment in the construction phase.
- Spending for land development will exceed $846,000
- Building construction spending will total $922,000.
- Spending for capital equipment and installation will result in increased expenditures of approximately $11.6 million, impacting engineering services and wholesale trade.
- The project will drive spillover impacts of $6.2 million, resulting in a total increase in output (sales) for the POTW SE county of $19,562,234.
- Earnings (labor income) will increase by more than $6.3 million.
- The project will support 168 jobs.

Operations Phase (annual impact and 20-year impact):

- The project’s on-going operations, maintenance and revenue will increase local annual economic output by $3.9 million.
- The project’s operations will increase local annual earnings by approximately $637,333.
- The project’s operations will support 7.5 jobs annually.
- During the 20 years covered in this study, sales activity (output) in the local economy will increase by $102.9 million.
- During the same 20-year period, earnings (labor income) will increase by $16.8 million.

State & local tax collections construction phase and operations phase (2017 to 2036):

- It is estimated that the project will generate $2.4 million in state and local tax collections during the construction phase and the operations phase (2017 to 2036).
- Property tax collections will increase by an estimated $805,076.
- State and gross receipts will increase by an estimated $714,063.
- Personal income tax collections will increase by approximately $608,498.

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Summary of Annual Impacts

Table 21 provides a summary of the project’s potential investment and annual revenue generated from annual sales at the POTW SE facility. Table 22 provides a summary of the economic impacts of both the construction and operational components of the project. The assumptions and methodology used to produce these estimates are contained in the accompanying appendices.

Table 21: Direct Impacts of the POTW SE Model project (does not include spillover impacts)

Type of impact	Amount	Sector Code
Cost of land development (sewage, rail, highways, etc.)	$846,000	233293
Cost of building construction	$922,000	233230
Cost of capital equipment (installation and purchase)	$11,611,000	420000 & 541300
Total (18 months)	$13,379,000	
Operating revenues (annual)		
Natural gas revenues	$453,330	325190
RIN revenues	$1,780,076	325190
LCFS revenues	$1,316,399	325190
Total	$3,549,805	

Table 22: Projected total impacts of the POTW SE Model project		
	Project construction (18 months)	On-Going Operations (annual)
Sales (output)	$19,562,234	$3,907,053
Earnings (labor income)	$6,330,317	$637,333
Employment	167.5	7.5

Table 23 provides a summary of the fiscal impacts from the POTW SE project. The project has the potential to boost state and local tax revenue by approximately $2.4 million during the construction and 20-year operations phases. Property tax collections will increase by $805,076 and sales and gross receipts will increase by $714,063. Individual income tax collections will receive a boost of $608,498. In addition, tax collections for corporate income tax, motor vehicle licenses and other taxes will increase by approximately $242,196.

Table 23: Projected impacts of the POTW SE Model project on state and local taxes

Sector	**Construction Phase (18 months)**	**Operations Phase**		**Total All Phases**
		2017	**2018-2036**	
Property tax	$220,513	$22,201	$562,362	$805,076
Sales and gross receipts	$195,584	$19,691	$498,788	$714,063
Individual income tax	$166,669	$16,780	$425,048	$608,498
Corporate income tax	$20,176	$2,031	$51,455	$73,662
Motor vehicle license	$26,453	$2,663	$67,461	$96,578
Other taxes	$19,709	$1,984	$50,263	$71,956
Total:	**$649,105**	**$65,352**	**$1,655,377**	**$2,369,833**

Table 24: Economies at a glance, POTW SE, Iowa and U.S. compared	
Population July 1, 2015	
POTW SE	35,173
Iowa	3,123,899
U.S.	321,418,820
Population growth, 2010-15	
POTW SE	-1.3%
Iowa	2.5%
U.S.	4.1%
Percent white, 2015	
POTW SE	94.1%
Iowa	91.3%
U.S.	77.1%
Percent of population over 16 in labor force	
POTW SE	62.9%
Iowa	70.6%
U.S.	63.5%
Retail sales per capita, 2012	
POTW SE	$15,224
Iowa	$14,607
U.S.	$13,443
Percent of population over 25 with high school diploma	
POTW SE	84.0%
Iowa	91.3%
U.S.	86.3%
Percent of population over age 25 with bachelor's degree	
POTW SE	15.3%
Iowa	26.4%
U.S.	29.3%
Median household income, 2014	
POTW SE	$41,519
Iowa	$52,716
U.S.	$53,482
Percent of population in poverty, 2014	
POTW SE	16.7%
Iowa	12.2%
U.S.	14.8%
Source: U.S. Census and Bureau of Economic Analysis	

Detailed Economic Impacts The construction phase of the POTW SE project will impact all 20 industry sectors in the county. The top 3 impacted sectors, outside of construction and wholesale trade, will likely be :

(1) Professional, Scientific and Technical Services ($7.5 million);
(2) Real Estate and Rental and Leasing Services ($779,005) and (3) Administrative and Waste Management Services ($703,736) sectors. Table 25 provides the detailed impacts from the construction phase.

Table 25: Impact of construction in the POTW SE Model

Sector	Output	Earnings	Employ-ment
Professional, scientific, and technical services	$7,470,234	$2,502,653	73.9
Wholesale trade	$4,871,450	$1,316,246	27.2
Construction	$1,899,185	$722,390	12.2
Real estate and rental and leasing	$779,005	$25,247	1.7
Administrative and waste management services	$703,736	$414,270	12.4
Health care and social assistance	$667,934	$346,548	7.3
Finance and insurance	$634,916	$180,639	3.8
Transportation and warehousing	$536,338	$215,564	5.2
Other services	$415,569	$176,780	5.7
Food services and drinking places	$371,540	$108,261	7.7
Retail trade	$353,323	$147,166	5.6
Information	$295,545	$57,405	1.6
Utilities	$292,832	$30,308	0.2
Management of companies and enterprises	$91,435	$37,316	0.6
Arts, entertainment, and recreation	$68,085	$11,813	1.4
Educational services	$46,674	$24,520	0.8
Manufacturing	$32,797	$6,275	0.1
Mining	$25,472	$5,429	0.1
Accommodation	$4,601	$1,009	0.1
Agriculture, forestry, fishing, and hunting	$1,564	$480	0.0
Total	**$19,562,234**	**$6,330,317**	**167.5**

The annual operations of the POTW SE project will impact 19 of the 20 industry sectors in the county. The following sectors will likely experience the greatest impact: (1) Manufacturing ($3.6 million); (2) Wholesale Trade ($68,709) and (3) Transportation and Warehousing ($56,208). Table 26 provides the detailed impacts from the operations phase.

Table 26: Impact of operations in the POTW SE Model (annual)

Sector	Output	Earnings	Employment
Manufacturing	$3,550,878	$516,676	5.0
Wholesale trade	$68,709	$26,928	0.3
Transportation and warehousing	$56,208	$19,157	0.5
Management of companies and enterprises	$53,184	$29,159	0.2
Utilities	$39,769	$4,366	0.0
Administrative and waste management services	$28,626	$8,057	0.3
Construction	$19,432	$5,209	0.1
Retail trade	$18,846	$7,792	0.3
Other services	$13,975	$7,506	0.1
Agriculture, forestry, fishing, and hunting	$11,905	$2,529	0.0
Professional, scientific, and technical services	$10,016	$3,343	0.2
Mining	$9,488	$139	0.1
Real estate and rental and leasing	$7,781	$1,521	0.1
Finance and insurance	$7,475	$2,439	0.1
Information	$5,577	$1,142	0.0
Food services and drinking places	$4,304	$1,150	0.1
Arts, entertainment, and recreation	$832	$197	0.0
Accommodation	$25	$6	0.0
Educational services	$23	$16	0.0
Health care and social assistance	$0	$0	0.0
Total	**$3,907,053**	**$637,333**	**7.5**

While the construction phase will have an impact on the local economy for approximately 18 months, the operations phase will have an ongoing impact on the local economy.

Table 27 provides a summary of the anticipated growth in sales activity for the county. Sales will grow by an estimated $102.9 million during the 20-year period. Manufacturing output will increase by approximately $93.5 million from 2017 to 2036. During the same time period, receipts in the Wholesale Trade sector will grow by $1.8 million.

Table 27: Summary of the anticipated growth in sales activity for the county

Sector	2017	2018-2036	Total
Agriculture, forestry, fishing, and hunting	$11,905	$301,563	$313,469
Mining	$9,488	$240,334	$249,822
Utilities	$39,769	$1,007,354	$1,047,123
Construction	$19,432	$492,211	$511,642
Manufacturing	$3,550,878	$89,944,993	$93,495,871
Wholesale trade	$68,709	$1,740,429	$1,809,138
Retail trade	$18,846	$477,376	$496,222
Transportation and warehousing	$56,208	$1,423,775	$1,479,983
Information	$5,577	$141,267	$146,844
Finance and insurance	$7,475	$189,347	$196,822
Real estate and rental and leasing	$7,781	$197,106	$204,888
Professional, scientific, and technical services	$10,016	$253,710	$263,726
Management of companies and enterprises	$53,184	$1,347,169	$1,400,353
Administrative and waste management services	$28,626	$725,101	$753,727
Educational services	$23	$580	$603
Health care and social assistance	$0	$0	$0
Arts, entertainment, and recreation	$832	$21,078	$21,910
Accommodation	$25	$641	$667
Food services and drinking places	$4,304	$109,023	$113,327
Other services	$13,975	$353,987	$367,962
Total	**$3,907,053**	**$98,967,045**	**$102,874,099**

Table 28 provides a summary of the anticipated growth in earnings (labor income) for the county. Earnings will grow by an estimated $16.8 million during the 20 years studied.

The Manufacturing sector will likely see earnings increase by approximately $13.6 million from 2017 to 2036. During the same time period, both the Management of Companies and Enterprises ($767,769) and Wholesale Trade ($709,029) sectors will likely see substantial earnings growth.

Table 28: Summary of the anticipated growth in earnings (labor income) for the county

Sector	2017	2018-2036	Total
Agriculture, forestry, fishing, and hunting	$2,529	$64,052	$66,581
Mining	$139	$3,513	$3,652
Utilities	$4,366	$110,587	$114,953
Construction	$5,209	$131,937	$137,146
Manufacturing	$516,676	$13,087,594	$13,604,271
Wholesale trade	$26,928	$682,101	$709,029
Retail trade	$7,792	$197,386	$205,178
Transportation and warehousing	$19,157	$485,261	$504,418
Information	$1,142	$28,934	$30,077
Finance and insurance	$2,439	$61,786	$64,225
Real estate and rental and leasing	$1,521	$38,526	$40,047
Professional, scientific, and technical services	$3,343	$84,691	$88,035
Management of companies and enterprises	$29,159	$738,610	$767,769
Administrative and waste management services	$8,057	$204,097	$212,154
Educational services	$16	$396	$412
Health care and social assistance	$0	$0	$0
Arts, entertainment, and recreation	$197	$4,985	$5,182
Accommodation	$6	$155	$161
Food services and drinking places	$1,150	$29,120	$30,269
Other services	$7,506	$190,128	$197,634
Total	**$637,333**	**$16,143,860**	**$16,781,193**

The POTW SE project will grow the local tax base. Table 29 presents the assumptions used in making the fiscal impact estimates:

Table 29: Fiscal impact assumptions, tax type as percentage of state personal income	
Property tax	3.5%
Sales and gross receipts	3.1%
Individual income tax	2.6%
Corporate income tax	0.3%
Motor vehicle license	0.4%
Other taxes	0.3%

- The POTW SE project has the potential to boost state and local tax revenue by approximately $2.4 million during the construction and 20-year operations phases. Property tax collections will increase by $805,076 and sales and gross receipts will increase by $714,063. Individual income tax collections will receive a boost of $608,498. In addition, tax collections for corporate income tax, motor vehicle licenses and other taxes will increase by approximately $242,196. Table 30 provides the state and local fiscal impacts, below.

Table 30: Fiscal Impacts

Sector	Construction Phase (18 months)	Operations Phase		Total All Phases
		2017	2018-2036	
Property tax	$220,513	$22,201	$562,362	$805,076
Sales and gross receipts	$195,584	$19,691	$498,788	$714,063
Individual income tax	$166,669	$16,780	$425,048	$608,498
Corporate income tax	$20,176	$2,031	$51,455	$73,662
Motor vehicle license	$26,453	$2,663	$67,461	$96,578
Other taxes	$19,709	$1,984	$50,263	$71,956
Total:	**$649,105**	**$65,352**	**$1,655,377**	**$2,369,833**

4. The Economic Impact of an Anaerobic Digestive System – Agricultural Model, 2017-2036

<u>The Economic Impact of an Anaerobic Digestive System – Agricultural Model, 2017-2036</u>

Executive Summary

By applying investment data for the construction and operations of an anaerobic digestive system (ADS) to Input-Output models, it is estimated that the Agricultural Model project produces the following direct, indirect and induced contributions to the county:

Construction Phase (18 months):

- The ADS project will produce an $8,312,991 investment in the construction phase.
- Spending for land development will total $308,700.
- Building construction spending will total $657,738.
- Spending for capital equipment and installation will result in increased expenditures of approximately $7.3 million, impacting engineering services and wholesale trade.
- The project will drive spillover impacts of $3.3 million, resulting in a total increase in output (spending) for the Agricultural Model county of $11.7 million.
- Earnings (labor income) will increase by more than $4.2 million.
- The project will support 97 jobs.

Operations Phase (total annual impact and 20-year impact – includes Miscanthus production):

- The project's on-going operations, maintenance and revenue will increase local annual economic output by nearly $2.8 million.
- The project's operations will increase local annual earnings by approximately $429,911.
- The project's operations will support 6.5 jobs annually.
- During the 20 years covered in this study, sales activity (output) in the local economy will increase by $73.1 million.
- During the same 20-year period, earnings (labor income) will increase by $11.3 million.

Miscanthus production (annual impact and 20-year impact – included in operations phase total):

- Miscanthus production revenue will increase local annual economic output by approximately $673,396.
- The project's operations will increase local annual earnings by approximately $86,759.
- The project's operations will support 2.2 jobs annually.

- During the 20 years covered in this study, sales activity (output) in the local economy will increase by $17.7 million.
- During the same 20-year period, earnings (labor income) will increase by $2.3 million.

State & local tax collections construction phase and operations phase:

- It is estimated that the project will generate $1.6 million in state and local tax collections during the construction phase and the operations phase (2017 to 2036).
- Property tax collections will increase by an estimated $539,932.
- State and gross receipts will increase by an estimated $478,894.
- Personal income tax collections will increase by approximately $408,095.

Potential impact from Nitrogen removal (annual and 2017-2036):

- Monetization of Nitrogen removal has the potential to increase sales activity between
- $300,107 and $900,322, annually.
- Over the 20-year life of the project, monetized Nitrogen removal values could results in between $7.9 million and $23.7 million in increased sales activity.
- Earnings could range between $48,955 and $146,864, annually.
- For the 20-year operations period, earnings could total between $1.3 million and $3.9 million.
- With the monetization of Nitrogen removal, state and local taxes could increase by up to $398,299, helping to offset the cost of such a policy.

Summary of Annual Impacts

Table 31 provides a summary of the project's potential investment and annual revenue generated from annual activity at the Agricultural Model facility. Table 32a provides a summary of the economic impacts of the construction, operational and Miscanthus production components of the project. Table 32b provides the total impacts monetized Nitrogen removal values at varying first year revenue levels. The assumptions and methodology used to produce these estimates are contained in the accompanying appendices.

Table 31: Direct Impacts of the Agricultural Model (does not include spillover impacts)		
Type of impact	Amount	Sector Code
Cost of land development (sewage, rail, highways, etc.)	$308,700	233293
Cost of building construction	$657,738	233230
Cost of capital equipment (installation and purchase)	$7,346,553	420000 & 541300
Total (18 months)	$8,312,991	
Operating revenues (annual)		
Natural gas revenues	$231,045	325190
RIN revenues	$907,237	325190
LCFS revenues	$773,001	325190
Total	$1,911,283	
Miscanthus production revenues (annual)		
Miscanthus producer revenues	$528,000	1111B0

Table 32a: Projected total impacts of the Agricultural Model

	Project construction (18 months)	On-Going Operations (annual, includes Miscanthus production)	Miscanthus Production (annual, included in operations total)
Sales (output)	$11,659,376	$2,777,029	$673,396
Earnings (labor income)	$4,180,255	$429,911	$86,759
Employment	97.3	6.5	2.2

Table 32b: Estimated total annual impacts of monetized Nitrogen displacement values

Year 1 Revenue	Output	Earnings	Employment
$272,666 (@ $7.5 per pound)	$300,107	$48,955	0.3
$545,333 (@$15 per pound)	$600,215	$97,909	0.6
$817,999 (@$22.5 per pound)	$900,322	$146,864	0.9

Table 33a provides a summary of the fiscal impacts from the Agricultural Model project. The project has the potential to boost state and local tax revenue by approximately $1.6 million during the construction and 20-year operations phases. Property tax collections will increase by $539,932 and sales and gross receipts will increase by $478,894. Individual income tax collections will receive a boost of $408,095. In addition, tax collections for corporate income tax, motor vehicle licenses and other taxes will increase by approximately $163,431.

Table 33a: Projected impacts of the Agricultural Model on state and local taxes (2017-2036)

Sector	Construction Phase (18 months)	Operations Phase*		Total All Phases
		2017	2018-2036	
Property tax	$145,617	$14,976	$379,339	$539,932
Sales and gross receipts	$129,155	$13,283	$336,456	$478,894
Individual income tax	$110,061	$11,319	$286,715	$408,095
Corporate income tax	$13,324	$1,370	$34,709	$49,402
Motor vehicle license	$17,468	$1,796	$45,506	$64,771
Other taxes	$13,015	$1,339	$33,905	$48,258
Total:	**$428,639**	**$44,083**	**$1,116,629**	**$1,589,351**

**Includes revenue to Miscanthus producers*

Table 33b provides a summary of the potential fiscal impacts to state and local tax collections from the monetization of Nitrogen removal during the 20-year project life. The positive impact on the tax coffers could range between $132,767 and $398,299, helping to offset the cost of such a policy.

Table 33b: Projected tax revenue growth due to Nitrogen displacement valuation policy

Year 1 Revenue	Nitrogen Removal		Total
	2017	2018-2036	
$272,666 (@ $7.5 per pound)	$5,042	$127,725	$132,767
$545,333 (@$15 per pound)	$10,085	$255,447	$265,532
$817,999 (@$22.5 per pound)	$15,127	$383,172	$398,299

Table 34: Economies at a glance, Agricultural Model, Iowa and U.S. compared

Population July 1, 2015	
Agricultural Model	20,709
Iowa	3,123,899
U.S.	321,418,820
Population growth, 2010-15	
Agricultural Model	-1.7%
Iowa	2.5%
U.S.	4.1%
Percent white, 2015	
Agricultural Model	96.9%
Iowa	91.3%
U.S.	77.1%
Percent of population over 16 in labor force	
Agricultural Model	71.9%
Iowa	70.6%
U.S.	63.5%
Retail sales per capita, 2012	
Agricultural Model	$13,911
Iowa	$14,607
U.S.	$13,443
Percent of population over 25 with high school diploma	
Agricultural Model	93.7%
Iowa	91.3%
U.S.	86.3%
Percent of population over age 25 with bachelor's degree	
Agricultural Model	26.8%
Iowa	26.4%
U.S.	29.3%
Median household income, 2014	
Agricultural Model	$53,735
Iowa	$52,716
U.S.	$53,482
Percent of population in poverty, 2014	
Agricultural Model	9.4%
Iowa	12.2%
U.S.	14.8%
Source: U.S. Census and Bureau of Economic Analysis	

Detailed Economic Impacts The construction phase of the Agricultural Model project will impact all 20 industry sectors in the county. The top 3 impacted sectors, outside of construction and wholesale trade, will likely be

(1) Professional, Scientific and Technical Services ($4.8 million);

(2) Real Estate and Rental and Leasing Services ($506,161) and (3) Finance and Insurance ($271,089) sectors. Table 35 provides the detailed impacts from the construction phase.

Table 35: Impact of construction in the Agricultural Model

Sector	Output	Earnings	Employment
Professional, scientific, and technical services	$4,805,529	$1,984,111	43.8
Wholesale trade	$3,213,917	$983,360	16.7
Construction	$1,038,180	$370,266	7.8
Real estate and rental and leasing	$506,161	$6,295	1.8
Finance and insurance	$271,089	$89,815	1.9
Transportation and warehousing	$252,791	$101,245	2.4
Administrative and waste management services	$242,593	$132,859	5.0
Health care and social assistance	$237,848	$140,349	3.4
Retail trade	$223,299	$103,927	3.3
Food services and drinking places	$205,958	$77,219	4.4
Other services	$189,124	$91,583	3.2
Information	$166,605	$26,764	0.8
Utilities	$116,286	$11,685	0.1
Educational services	$60,380	$28,154	0.8
Arts, entertainment, and recreation	$47,672	$8,039	1.4
Manufacturing	$42,215	$13,851	0.2
Mining	$17,479	$3,021	0.1
Management of companies and enterprises	$12,677	$4,590	0.1
Agriculture, forestry, fishing, and hunting	$5,576	$1,924	0.0
Accommodation	$3,995	$1,197	0.0
Total	**$11,659,376**	**$4,180,255**	**97.3**

The annual operations of the Agricultural Model project will impact all of the 20 industry sectors in the county. The following sectors will likely experience the greatest impact: (1) Manufacturing ($1.9 million); (2) Agriculture ($568,289) and (3) Wholesale Trade ($61,187). Table 36a provides the detailed impacts from the operations phase.

Table 36a: Impact of operations in the Agricultural Model, including Miscanthus production (annual)			
Sector	**Output**	**Earnings**	**Employment**
Manufacturing	$1,913,130	$279,118	3.0
Agriculture, forestry, fishing, and hunting	$568,289	$55,004	1.3
Wholesale trade	$61,187	$21,901	0.3
Transportation and warehousing	$40,719	$14,218	0.3
Management of companies and enterprises	$28,742	$15,738	0.1
Utilities	$28,377	$3,216	0.0
Real estate and rental and leasing	$21,716	$1,058	0.2
Construction	$19,418	$5,424	0.1
Administrative and waste management services	$17,428	$5,344	0.2
Finance and insurance	$16,773	$5,837	0.1
Retail trade	$15,618	$6,722	0.3
Other services	$11,059	$5,732	0.1
Professional, scientific, and technical services	$8,815	$3,413	0.1
Mining	$7,407	$494	0.0
Food services and drinking places	$5,202	$1,702	0.1
Information	$4,831	$907	0.0
Health care and social assistance	$4,821	$2,839	0.1
Educational services	$1,913	$881	0.0
Arts, entertainment, and recreation	$1,251	$263	0.0
Accommodation	$333	$99	0.0
Total	**$2,777,029**	**$429,911**	**6.5**

Looking at the impact of Miscanthus production as a subset of the facility's operations, we find all 20 of the industry sectors in the county will be impacted. The following sectors will likely experience the greatest impact: (1) Agriculture ($561,879); (2) Wholesale Trade ($24,193) and (3) Real Estate and Rental Leasing ($17,526). Table 36b provides the detailed impacts from the Miscanthus production.

Table 36b: Impact of Miscanthus production in the Agricultural Model (annual)			
Sector	**Output**	**Earnings**	**Employment**
Agriculture, forestry, fishing, and hunting	$561,879	$53,642	1.3
Wholesale trade	$24,193	$7,402	0.1
Real estate and rental and leasing	$17,526	$239	0.1
Finance and insurance	$12,748	$4,524	0.1
Transportation and warehousing	$10,456	$3,903	0.1
Construction	$8,955	$2,620	0.1
Utilities	$6,965	$865	0.0
Retail trade	$5,470	$2,527	0.1
Health care and social assistance	$4,821	$2,839	0.1
Other services	$3,535	$1,691	0.1
Professional, scientific, and technical services	$3,422	$1,613	0.0
Food services and drinking places	$2,885	$1,083	0.1
Mining	$2,299	$420	0.0
Administrative and waste management services	$2,016	$1,006	0.0
Educational services	$1,901	$872	0.0
Information	$1,828	$292	0.0
Manufacturing	$1,269	$930	0.0
Arts, entertainment, and recreation	$803	$157	0.0
Accommodation	$319	$96	0.0
Management of companies and enterprises	$107	$39	0.0
Total	**$673,396**	**$86,759**	**2.2**

While the construction phase will have an impact on the local economy for approximately 18 months, the operations phase and Miscanthus production will have an ongoing impact on the local economy.

Table 37a provides a summary of the anticipated growth in sales activity for the Agricultural Model resulting from the operations at the facility. Sales will grow by an estimated $73.1 million during the 20-year period.

Manufacturing output will increase by approximately $50.4 million from 2017 to 2036. During the same time period, receipts in the Agriculture sector will likely grow by nearly $15 million.

Table 37a: Projected sales growth in the Agricultural Model, Operations and maintenance, including Miscanthus production (2017-2036)			
Sector	**2017**	**2018-2036**	**Total**
Agriculture, forestry, fishing, and hunting	$568,289	$14,394,972	$14,963,261
Mining	$7,407	$187,632	$195,039
Utilities	$28,377	$718,802	$747,179
Construction	$19,418	$491,855	$511,273
Manufacturing	$1,913,130	$48,460,254	$50,373,384
Wholesale trade	$61,187	$1,549,899	$1,611,087
Retail trade	$15,618	$395,598	$411,215
Transportation and warehousing	$40,719	$1,031,430	$1,072,149
Information	$4,831	$122,365	$127,196
Finance and insurance	$16,773	$424,861	$441,633
Real estate and rental and leasing	$21,716	$550,074	$571,790
Professional, scientific, and technical services	$8,815	$223,275	$232,089
Management of companies and enterprises	$28,742	$728,046	$756,788
Administrative and waste management services	$17,428	$441,470	$458,898
Educational services	$1,913	$48,453	$50,366
Health care and social assistance	$4,821	$122,122	$126,943
Arts, entertainment, and recreation	$1,251	$31,678	$32,928
Accommodation	$333	$8,423	$8,755
Food services and drinking places	$5,202	$131,772	$136,974
Other services	$11,059	$280,136	$291,196
Total	**$2,777,029**	**$70,343,116**	**$73,120,145**

Table 37b provides a summary of the anticipated growth in sales activity for Agricultural Model resulting from the Miscanthus production. Farm product sales derived from supplying inputs to the facility will drive economic activity that will likely result in $17.7 million in sales activity. Local farmers will likely see approximately $14.8 million in additional sales activity.

Table 37b: Projected sales growth in the Agricultural Model, Miscanthus production (2017- 2036)			
Sector	**2017**	**2018-2036**	**Total**
Agriculture, forestry, fishing, and hunting	$561,879	$14,232,604	$14,794,484
Mining	$2,299	$58,232	$60,531
Utilities	$6,965	$176,424	$183,389
Construction	$8,955	$226,839	$235,795
Manufacturing	$1,269	$32,147	$33,416
Wholesale trade	$24,193	$612,819	$637,012
Retail trade	$5,470	$138,570	$144,040
Transportation and warehousing	$10,456	$264,842	$275,298
Information	$1,828	$46,305	$48,133
Finance and insurance	$12,748	$322,913	$335,661
Real estate and rental and leasing	$17,526	$443,949	$461,475
Professional, scientific, and technical services	$3,422	$86,673	$90,094
Management of companies and enterprises	$107	$2,704	$2,811
Administrative and waste management services	$2,016	$51,061	$53,077
Educational services	$1,901	$48,140	$50,041
Health care and social assistance	$4,821	$122,122	$126,943
Arts, entertainment, and recreation	$803	$20,329	$21,132
Accommodation	$319	$8,078	$8,397
Food services and drinking places	$2,885	$73,072	$75,956
Other services	$3,535	$89,543	$93,078
Total	**$673,396**	**$17,057,364**	**$17,730,760**

Table 38a provides a summary of the anticipated growth in earnings (labor income) for the county. Earnings will grow by an estimated $11.3 million during the 20 years studied.

The Manufacturing sector will likely see earnings increase by approximately $7.3 million from 2017 to 2036. During the same time period, both the Agriculture ($1.4 million) and Wholesale Trade ($576,661) sectors will likely see substantial earnings growth.

Table 38a: Projected earnings growth in the Agricultural Model, Operations and maintenance, including Miscanthus production (2017-2036)			
Sector	**2017**	**2018-2036**	**Total**
Agriculture, forestry, fishing, and hunting	$55,004	$1,393,267	$1,448,271
Mining	$494	$12,525	$13,020
Utilities	$3,216	$81,454	$84,670
Construction	$5,424	$137,397	$142,821
Manufacturing	$279,118	$7,070,157	$7,349,275
Wholesale trade	$21,901	$554,760	$576,661
Retail trade	$6,722	$170,280	$177,002
Transportation and warehousing	$14,218	$360,142	$374,360
Information	$907	$22,985	$23,892
Finance and insurance	$5,837	$147,850	$153,687
Real estate and rental and leasing	$1,058	$26,799	$27,857
Professional, scientific, and technical services	$3,413	$86,462	$89,876
Management of companies and enterprises	$15,738	$398,661	$414,399
Administrative and waste management services	$5,344	$135,360	$140,703
Educational services	$881	$22,311	$23,192
Health care and social assistance	$2,839	$71,918	$74,757
Arts, entertainment, and recreation	$263	$6,659	$6,922
Accommodation	$99	$2,504	$2,603
Food services and drinking places	$1,702	$43,113	$44,815
Other services	$5,732	$145,204	$150,937
Total	**$429,911**	**$10,889,808**	**$11,319,719**

Table 38b provides a summary of the anticipated growth in earnings for the Agricultural Model resulting from the Miscanthus production. Farm income derived from supplying product to the facility will drive economic activity that will likely result in $2.3 million in earnings. Local farmers will likely receive a boost to income of nearly $1.4 million.

Table 38b: Projected earnings growth in the Agricultural Model, Miscanthus production (2017-2036)			
Sector	**2017**	**2018-2036**	**Total**
Agriculture, forestry, fishing, and hunting	$53,642	$1,358,781	$1,412,423
Mining	$420	$10,634	$11,053
Utilities	$865	$21,912	$22,777
Construction	$2,620	$66,359	$68,979
Manufacturing	$930	$23,545	$24,475
Wholesale trade	$7,402	$187,504	$194,906
Retail trade	$2,527	$64,004	$66,530
Transportation and warehousing	$3,903	$98,868	$102,771
Information	$292	$7,406	$7,698
Finance and insurance	$4,524	$114,583	$119,107
Real estate and rental and leasing	$239	$6,056	$6,295
Professional, scientific, and technical services	$1,613	$40,863	$42,476
Management of companies and enterprises	$39	$979	$1,018
Administrative and waste management services	$1,006	$25,470	$26,475
Educational services	$872	$22,098	$22,970
Health care and social assistance	$2,839	$71,918	$74,757
Arts, entertainment, and recreation	$157	$3,975	$4,131
Accommodation	$96	$2,421	$2,516
Food services and drinking places	$1,083	$27,435	$28,518
Other services	$1,691	$42,836	$44,527
Total	**$86,759**	**$2,197,645**	**$2,284,404**

The project will grow the local tax base. Table 39 presents the assumptions used in making the fiscal impact estimates:

Table 39: Fiscal impact assumptions, tax type as percentage of state personal income	
Property tax	3.5%
Sales and gross receipts	3.1%
Individual income tax	2.6%
Corporate income tax	0.3%
Motor vehicle license	0.4%
Other taxes	0.3%

Table 40 provides a summary of the fiscal impacts from the Agricultural Model project. The project has the potential to boost state and local tax revenue by approximately $1.6 million during the construction and 20-year operations phases. Property tax collections will increase by $539,932 and sales and gross receipts will increase by $478,894.Individual income tax collections will receive a boost of $408,095. In addition, tax collections for corporate income tax, motor vehicle licenses and other taxes will increase by approximately
$162,431.

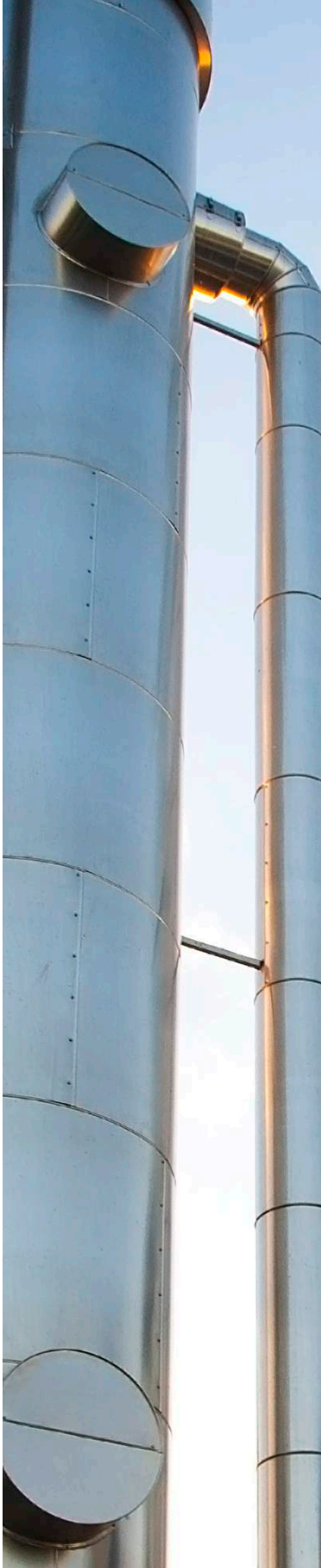
Table 40: Fiscal Impacts

Sector	Construction Phase (18 months)	Operations Phase*		Total All Phases
		2017	2018-2036	
Property tax	$145,617	$14,976	$379,339	$539,932
Sales and gross receipts	$129,155	$13,283	$336,456	$478,894
Individual income tax	$110,061	$11,319	$286,715	$408,095
Corporate income tax	$13,324	$1,370	$34,709	$49,402
Motor vehicle license	$17,468	$1,796	$45,506	$64,771
Other taxes	$13,015	$1,339	$33,905	$48,258
Total:	**$428,639**	**$44,083**	**$1,116,629**	**$1,589,351**

**Includes revenue to Miscanthus producers*

Potential Nitrogen Removal Impact

Iowa has a window of opportunity to utilize strong carbon markets to subsidize projects that will have an ancillary beneficial impact on its watersheds. Providing a price for displaced Nitrogen will give project developers an added assurance that their investments will not be victim to the vagaries of carbon markets. It is a risk management tool that will ultimately attract more developers to the sector and result in more projects being launched. Private parties can also voluntarily commit to purchasing the displaced



Nitrogen motivated by their sustainability goals or they could be given compliance status for higher discharge limits for purchased offsets. Downstream water treatment bodies could also sponsor projects by applying the cost of Nitrogen removal to Nitrogen mitigation.

Table 41 provides the potential year 1 revenues for Nitrogen displacement, based on varying scenarios and applies a value to the Nitrogen displacement. As a reference for policy discussion, we use three values for Nitrogen displacement: $7.5 per pound, $15 per pound, and $22.5 per pound. Further, we assume 6,600 dry tons Miscanthus are required and the acquisition price per ton is $80. These are hypothetical numbers since there is no actual market to compare them against. As seen below, even a low value of $5 per pound for the displaced Nitrogen adds significant value to the project.

Table 41: Nitrogen removal revenue estimates at various price points per pound removed

	At $7.5 per pound	At $15 per pound	At $22.5 per pound
Nitrogen removal values	$272,666	$545,333	$817,999

We can apply these Nitrogen removal revenue estimates to arrive at potential economic and fiscal impacts should a policy exist that allows for the monetization of Nitrogen displacement. Table 42 provides a summary of output, earnings and employment for each of the revenue levels from table 11, above. The annual output impacts range from between $300,107 and $900,322; the earnings impacts range from between $48,955 and $146,864. The displacement revenue could support between 0.3 and 0.9 jobs.

Table 42: Estimated potential annual impacts from Nitrogen removal revenues

Year 1 Revenue	Output	Earnings	Employment
$272,666 (@ $7.5 per pound)	$300,107	$48,955	0.3
$545,333 (@$15 per pound)	$600,215	$97,909	0.6
$817,999 (@$22.5 per pound)	$900,322	$146,864	0.9

The displacement revenue will continue to impact the economy for the duration of the project. Table 43 provides a summary of the potential sales growth over the 20-year project period. Sales activity could potentially increase from between $7.9 million and $23.7 million, depending on the value placed on Nitrogen removal.

Table 43: Projected sales growth due to Nitrogen displacement revenue (2017-2036)			
Year 1 Revenue	**2017**	**2018-2036**	**Total**
$272,666 (@ $7.5 per pound)	$300,107	$7,601,816	$7,901,923
$545,333 (@$15 per pound)	$600,215	$15,203,658	$15,803,873
$817,999 (@$22.5 per pound)	$900,322	$22,805,474	$23,705,796

Table 44 provides a summary of the potential earnings growth over the 20-year project period. Earnings could potentially grow by $1.3 million and $3.9 million over the life of the project.

Table 44: Projected earnings growth due to Nitrogen displacement revenue (2017-2036)			
Year 1 Revenue	**2017**	**2018-2036**	**Total**
$272,666 (@ $7.5 per pound)	$48,955	$1,240,047	$1,289,002
$545,333 (@$15 per pound)	$97,909	$2,480,070	$2,577,979
$817,999 (@$22.5 per pound)	$146,864	$3,720,117	$3,866,981

The potential increase in economic activity generated by the monetized Nitrogen removal will likely contribute to state and local tax collections. Table 45 provides a summary of the potential fiscal impacts of a Nitrogen removal valuation policy. A policy that allows for the monetization of Nitrogen removal could potentially add between $132,767 and $398,299 million to state and local tax coffers, helping to offset the cost of such a policy.

Table 45: Projected tax revenue growth due to Nitrogen displacement valuation policy (2017-2036)			
Sector	**Nitrogen Removal**		**Total**
	2017	**2018-2036**	
$272,666 (@ $7.5 per pound)	$5,042	$127,725	$132,767
$545,333 (@$15 per pound)	$10,085	$255,447	$265,532
$817,999 (@$22.5 per pound)	$15,127	$383,172	$398,299

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City of Le Mars
Luther College
Roger Ruhland
Jerry Haack

And everyone else who made themselves available to share information and discuss solutions.

The information, data, or work presented herein was funded in part by the Office of Energy Efficiency and Renewable Energy (EERE), U.S. Department of Energy, under Award Number DE- DE-EE0006209.

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