MEMORANDUM

CITY OF BLOOMINGTON
UTILITIES

To: Mayor John Hamilton
From: Vic Kelson
Date: 6 March 2020
Re: Phase 1 Waste-to-Energy Analysis

Please find attached the draft of our findings regarding the feasibility of a waste-to-energy project at the Dillman Road Wastewater Treatment Plant. This report was primarily researched at CBU, with input from members of the Task Force and two outside consultants.

This draft is still undergoing revisions. Please let me know if you have any questions.

Waste-to-Energy Task Force

Phase 1 Report

Vic Kelson and Brad Schroeder
City of Bloomington Utilities
December 10, 2019

Task Force Members

Gwen White
Nancy Obermeyer
Brian Noojin
Keith Thompson
Dave Rollo
Tom McGlasson
Adam Wason
Lew May
Vic Kelson

Executive Summary

In 2019, Mayor John Hamilton appointed the Waste-to-Energy Task Force for the purpose of assessing the feasibility of a biogas-generating facility at the Dillman Road Wastewater Treatment Plant. The anaerobic digester would replace the aerobic digester that is presently in service at the plant. The anaerobic digester would be configured to digest

- Sludge from wastewater treatment from one or both City treatment plants,
- Fats, oils and grease (FOG) collected from grease interceptors and from sewer maintenance, and
- The organic fraction of the solid-waste stream, e.g. food waste from IU and other food-service establishments.

This report provides the results of our Phase I investigation. It is a technical evaluation only, intended to examine the feasibility of constructing the facility, the costs of construction, the quantity of gas generated, and the savings for operations and maintenance at the Dillman plant.

We specifically have not examined other benefits such as the potential for collecting tipping fees collected from waste haulers, the size of the market we might serve for FOG disposal, the possibile revenue generated by earning and trading renewable energy certificates, the dollar value of intangibles such as the reduction in carbon emissions, or the benefits that might be gained by developing a land-application program for digested sludge.

CBU staff have worked in consultation with two consulting firms, Donohue & Associates and Johnson Controls, to update and improve our estimates of the potential rate of biogas generation, examine the pros and cons of the various options for utilizing the biogas, and the economic costs and benefits. This memo describes findings from the first phase of the evaluation process, which is a technical assessment of project feasibility, the amount of biogas that might be generated, and the financial impact of such a project.

Summary of Conclusions

In summary, our analysis offers the following conclusions:

1. Construction of an AD facility at Dillman can be accomplished. The AD facility can be configured to receive FOG and food waste from outside generators, such as the City of Bloomington Sanitation Division, the Monroe County Solid Waste District, Indiana University, and private haulers.

    a. The AD facility will require the addition of primary clarifiers and other enhancements Dillman, adding additional costs.

    b. Overall, modification of Dillman and construction of the anaerobic digester facility will cost roughly $30-35 million. Assuming a 30-year, $35 million bond at 3.5%, principal and interest costs will be about $1.9 million annually. This represents about 8% of the 2020 Sewer Works budget of $24 million. Thus we should anticipate a rate increase of about 8% to pay for the project.

2. If an AD facility were constructed, sale of treated biogas onto the pipeline may be the most desirable option.

    a. Based upon our best estimates for loading to the AD facility, we should expect about 110 cubic feet per minute of biogas generation, of which 20-30% would need to be utilized for heat generation at the digester facility.

    b. Assuming that 75% of the generated biogas were available, co-generation would generate approximately 325 kW of electricity, which is about 36% of the plant's average electrical consumption. Based on our current annual $800,000 cost for electricity at Dillman, this would save about $290,000 per year in operating costs.

    c. Sale of the gas onto the pipeline would allow for the fuel to be utilized as vehicle fuel if the City moved to a fleet powered by compressed natural gas.

    d. Johnson Controls suggests that it may be possible to earn renewable energy certificates that can be sold on the open market. They suggest that the earnings from selling certificates could be sufficient to make the project pay for itself.

3. We should proceed with further analysis of the complete waste-to-energy picture. This will require a multidisciplinary approach. Specifically, we need to assess the following items:

    a. What is our community's willingness to pay a premium of up to 8% more for sewer, in order to achieve the benefits of AD and co-digestion of organic wastes?

    b. How much food waste and other organic waste can we realistically expect to collect and send to the digester?

c. What is the possibility that anaerobically digested sludge could be utilized for land application? How could/would that affect our local food economy and sustainability?

d. What is the potential of a renewable energy certificate market for biogas in Indiana? The City Controller is presently investigating this question with a colleague who has expertise in this area.

e. What is the potential for land application of digested sludge? Besides the savings in hauling costs, how much would that benefit the community?

f. What is the possibility of receiving renewable-energy certificates? Is there a market for renewable natural gas certificates in Indiana? What would the potential revenue gain be?

g. What is the willingness of our community to pay an additional 8% on their sewer bill, about $2.50-$3.00/month for the average residential customer?

h. If we are going to invest $30 million in our wastewater system for reduced carbon emissions, is this the most effective way to do it? What reduction in emissions and other environmental benefits might be achieved by a similar investment in our collection system?

Introduction

The Dillman Road Wastewater Treatment Plant (Dillman) began operations in 1983. The plant was modified in 1999, and is configured as a “single-stage aeration” facility, with an aerobic digester to reduce the volume of sludge that must be hauled away for disposal. In 2016, CBU received a warning letter from the Indiana Department of Environmental Management (IDEM) indicating that plant utilization exceeded 90% of the rated capacity of 15 million gallons per day (mgd) for three consecutive years. As a result, IDEM expects CBU to take steps to increase the plant capacity in anticipation of future demand growth. CBU staff have met with IDEM to discuss our needs, and we are presently in the engineering design process for expanding capacity to 20 mgd. At the current rates of demand growth, we anticipate that a 20 mgd plant would be sufficient to meet CBU’s demand for 15–18 years.

During the execution of the recent ESG guaranteed savings contract, CBU did a cursory examination of replacing the aerobic digester with an anaerobic digester. At that time, it was found that an anaerobic facility would be very costly, and is not necessary to achieve CBU’s 20 mgd capacity goal. However, it was also found that constructing an anaerobic digester would allow CBU to repurpose the aerobic digester basins for additional aeration, allowing an eventual plant capacity of up to 25 mgd.

As the City of Bloomington (City) works to reduce its contribution to global warming, anaerobic digestion may play a useful role. As it emits significantly less carbon dioxide, an anaerobic digester (AD) could reduce the carbon footprint of the Dillman operation. Anaerobic digesters generate methane, or ‘biogas’, that can replace natural gas. The biogas can be burned in an electrical generator (‘co-generation’), utilized for other needs at the plant facility, or cleaned up for use as vehicle fuel or sold and injected into the natural gas pipeline near Dillman. Moreover, AD facilities can be configured to digest other organic wastes, such as food waste or fats, oils and grease (FOG), which could increase biogas generation and reduce the size of the waste stream. Also, anaerobically digested sludge can be more-easily composted for land application, improving agricultural soils. In his 2019 State of the City address, Mayor John Hamilton called for an investigation of the feasibility of anaerobic digestion (AD) as a technology for reducing our carbon footprint by generating biogas and utilizing it for vehicle fuel or other purposes. He created a Waste-to-Energy Task Force, charged with evaluating the potential for implementing AD at Dillman.

CBU staff have worked in consultation with two consulting firms, Donohue & Associates and Johnson Controls, to update and improve our estimates of the potential rate of biogas generation, examine the pros and cons of the various options for utilizing the biogas, and the economic costs and benefits. This memo describes findings from the first phase of the evaluation process, which is a technical assessment of project feasibility, the amount of biogas that might be generated, and the financial impact of such a project.

A Brief Primer on Wastewater Treatment

Prior to the development of wastewater treatment, organic material that was contained within the wastewater was discharged directly into the receiving surface water stream. Microorganisms in the stream consume the organic material, and as they do, they consume the dissolved oxygen in the stream, which kills fish. The amount of organic material in a wastewater is expressed as biochemical oxygen demand (BOD), the amount of oxygen that would be removed from the waste expressed in milligrams per liter (mg/L BOD).

Traditional wastewater treatment is a two-stage process. “Primary treatment” removes BOD from the wastewater by allowing the water to reside in a clarifier; organic-containing solids settle to the bottom as a sludge that is later disposed of in some manner. “Secondary treatment” removes additional BOD by accelerating the natural process of BOD being consumed by microorganisms, utilizing air that is injected into the wastewater in an aeration basin. At both of Bloomington’s plants, an “activated sludge” process is used for secondary treatment.

Two-Stage Process at Blucher Poole WWTP (built in 1968)

Figure 1 shows the process flow diagram for a traditional, two-stage plant, Bloomington’s Blucher Poole WWTP (Blucher). Sludge from the primary clarifier (dark brown line) is removed by settling; this accounts for 35-40% of the total BOD that arrives at the plant in raw sewage. Primary sludge has a very high concentration of BOD, because it has not been through an aeration process yet.

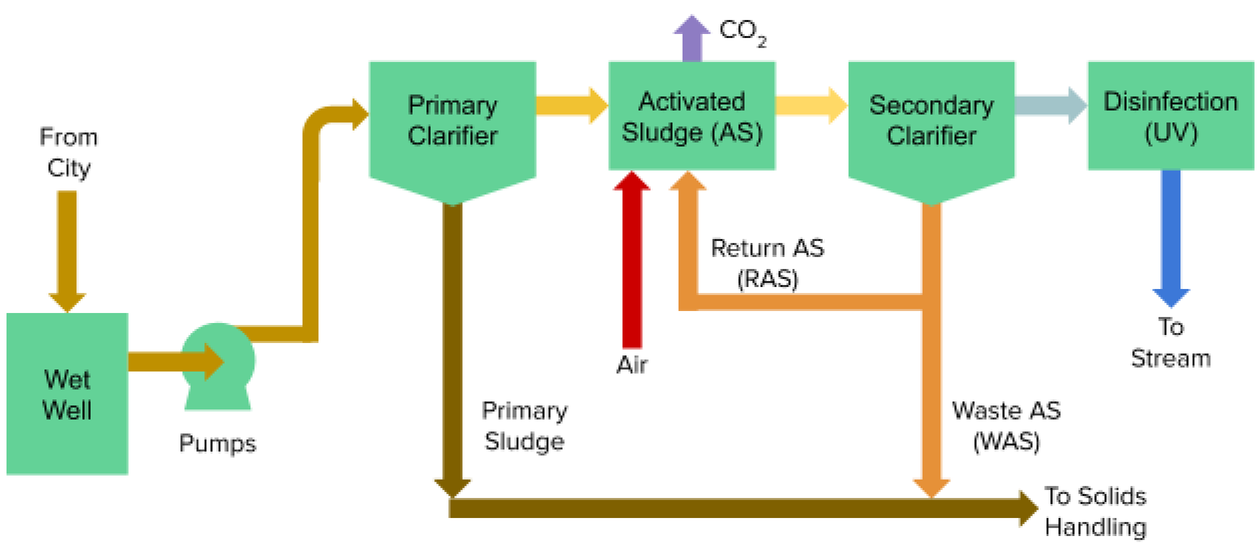

Figure 1. A traditional, two-stage, wastewater treatment plant, e.g. Bloomington’s Blucher Poole wastewater treatment plant built in 1968.

The activated sludge process requires that air be diffused through the wastewater in a large treatment basin. Organisms in the sludge particles consume BOD utilizing oxygen from the process air by the biological respiration process, emitting CO_2. Essentially, the activated sludge process carries out the same biochemical reactions that would take place in the stream if the raw wastewater were simply discharged there. Water that overflows from the activated sludge aeration basin is sent to a secondary clarifier. Most of this "secondary" sludge is returned to the aeration basin as "return activated sludge" (RAS). As the treatment organisms grow, the total volume of sludge will accumulate in the system. The amount of sludge in the treatment system is managed by removing some sludge as "waste activated sludge" (WAS). The WAS is mixed with the primary sludge and sent to the solids handling process.

At Blucher, all of the sludge is mechanically dewatered using a belt press. The pressed sludge is then hauled to a landfill in Western Indiana, near Terre Haute.

Single-Stage Process at Dillman Road WWTP (built in 1983)

Figure 2 shows the process flow diagram for Bloomington's Dillman Road WWTP. At Dillman, there is no primary clarifier; influent wastewater is sent directly to aeration. While this is an effective treatment process, it produces none of the high-BOD primary sludge stream that Blucher does.

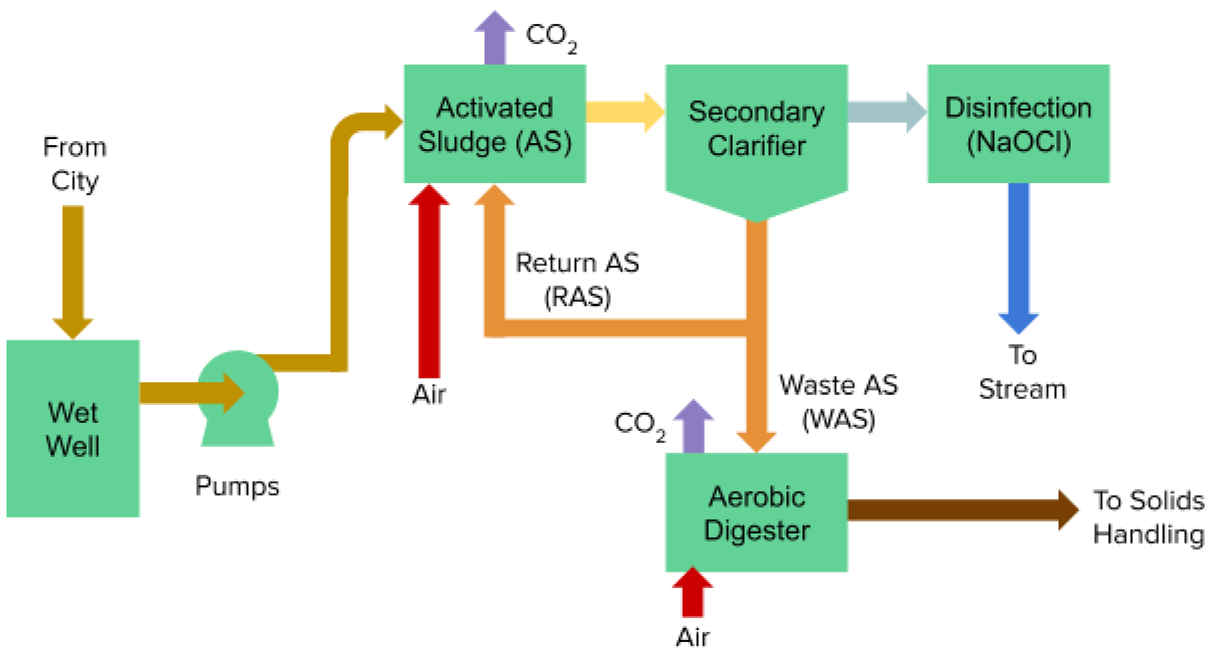

Figure 2. Single-stage wastewater treatment plant, e.g. Bloomington's Dillman Road wastewater treatment plant built in 1983.

Beyond the lack of primary clarifiers, the Dillman process differs from the Blucher process by the presence of an aerobic digester. The aerobic digester reduces the volume of sludge by continuing to aerate the sludge without providing any additional "food" in the form of untreated wastewater. The result is that the organisms in the sludge die and consume one another. The result of digestion is that a smaller amount of sludge must be managed via solids handling and hauling to the landfill.

The Dillman plant manages wasted sludge by the use of outdoor drying beds in summer and dry weather, and utilizing a belt press in wet weather and winter (Figure 10).

Future Anaerobic Digestion at Dillman WWTP?

Figure 3 provides a conceptual process flow diagram for the Dillman plant with anaerobic digestion. While an aerobic digester utilizes air to reduce the sludge volume, generating CO_2, anaerobic digestion takes place in the absence of oxygen, and generates methane biogas. The amount of biogas that can be produced depends on the amount of BOD in the feedstock to the digester. As discussed above, primary wastewater sludge contains far more BOD than waste sludge from the activated sludge process, so to viably convert Dillman to AD, the construction of primary clarifiers would be required. This greatly increases the expense of an AD project.

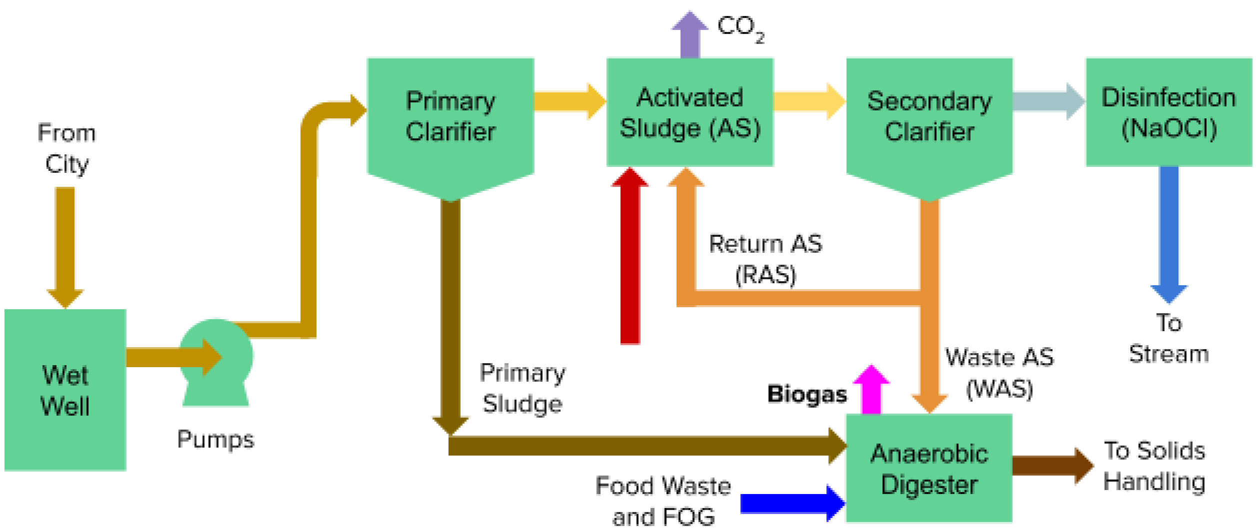

Figure 3. Proposed process flow diagram for the Dillman plant after construction of primary clarifiers and an anaerobic digester.

The following sections discuss the technical and financial feasibility of an AD project at Dillman, with reuse of the biogas produced in the process.

Technical Feasibility

The evaluation of technical feasibility is based on an analysis performed by Energy Systems Group (ESG) and their subcontractor, Donohue and Associates. This analysis produced a conceptual design (10% - 15% complete) and a rough cost estimate for the project.

The project requires significant additional infrastructure to be added to the plant. The entire system would be located on the northeast side of the existing plant complex (Figure 4). Major components of the system include;

- A new grit removal system (2 vortex units)
- Three primary clarifiers, splitter box, and building
- Two anaerobic digesters
- Digester control building
- High Strength Waste (HSW) receiving station
- Blend tank
- Digested sludge storage tank
- Pumping, electrical, and control systems
- Piping back and forth to existing plant processes
- New service road

The ESG study assumed that the biogas from the digesters would be sent to a flare, and did not include provisions for putting the gas to beneficial use. Gas conditioners, storage, and distribution would be required to make the gas usable for energy consumption. Electrical generation units would also be required if the gas was to be used for generation of electricity.

The ESG study did not assume using sludge from the Blucher Poole WWTP due to concerns with transporting the sludge to the plant and feeding it to the AD system. In order to evaluate a best case scenario we have included this sludge in our energy calculations. However, the technical feasibility of using this sludge would still need to be studied and confirmed if we proceed to the next phase of the project.

The proposed system offers the opportunity to increase the capacity of the WWTP, potentially up to 25 mgd average day. The primary clarifiers will remove 25% - 50% of the BOD loading entering the plant that is currently removed in the activated sludge process, and moving digestion to the anaerobic digesters will make the existing aerobic digester tanks available for other processes like additional activated sludge. Conversion of the aerobic digesters was not included in this study and there would still be a significant amount of cost to convert these processes and bring the rest of the plant to 25 mgd. Figure 4 shows the major facility changes that would need to be constructed at Dillman.

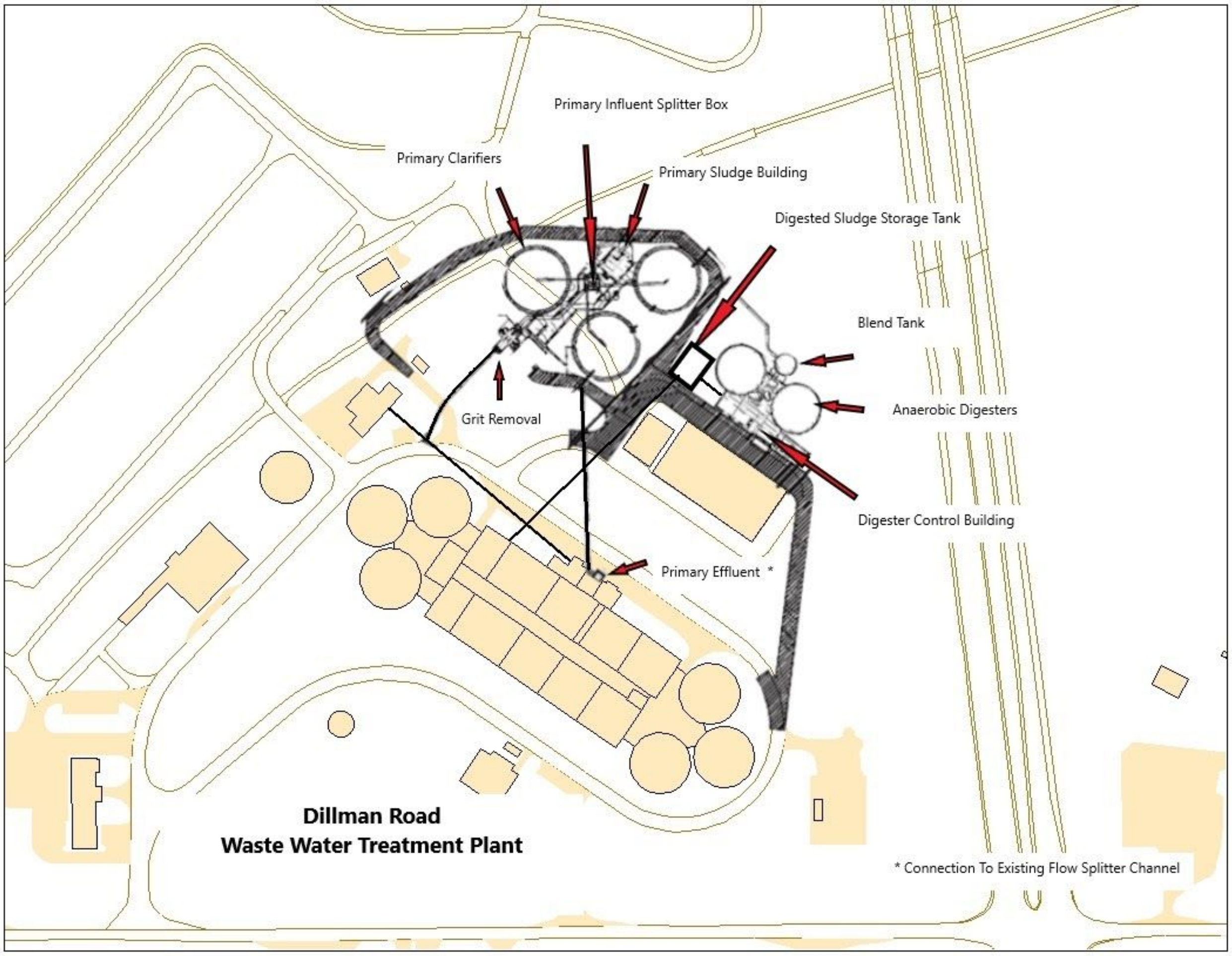

Figure 4. Preliminary layout of Dillman plant modifications for anaerobic digestion (from Energy Systems Group, 2017)

Anaerobic Digester Feedstocks

The primary source of loading to the anaerobic digesters would be from primary and waste activated sludge generated at the Dillman plant. This represents over 60% of the total loading possible. This would be sent directly to the digesters as part of the normal treatment process at the plant. The remainder of the loading will come from external sources which would be hauled to the plant and loaded at the receiving station. The additional sources include:

- Fats, Oils and Grease (FOG), primarily from food service establishments;
- Blucher Poole WWTP waste sludge;
- Indiana University food waste;
- "Food waste from restaurants, businesses, and residences in the City of Bloomington;

- Food waste collected by the Monroe County Waste Management District

Fats, Oils and Grease (FOG) are the simplest to incorporate into the new process. FOG is currently received at the Dillman plant, where it is dried in beds and sent to a landfill. This would now be routed to the AD receiving station. The Blucher Poole waste sludge is currently pressed dry and sent to a landfill. In the new process the pressed sludge would be trucked to Dillman AD receiving station instead of the landfill. Food waste would be collected from three sources. IU food waste is already separated and hauled and would be the easiest to incorporate into the new process. A separate collection system would need to be developed for both City and County food waste. There is a lot of uncertainty around how much of the potential food waste can be collected so we estimated best- and worst-case scenarios to evaluate how much energy can be obtained from these sources. Total loading values are shown in Table 1.

Table 1. Anaerobic Digester Loading

Waste Source	Total Loading		Total VSS[9] or COD Load (lbs/d)		Best-Case Scenario (lbs/d)[14]	Worst-Case Scenario (lbs/d)[15]
Dillman Road Primary Activated Sludge[1]	10,944	lbs/d	8,755	VSS	8,755	8,755
Dillman Road Waste Activated Sludge[2]	8,515	lbs/d	6,386	VSS	6,386	6,386
Blucher Poole Primary Activated Sludge[3]	3,199	lbs/d	2,559	VSS	2,559	2,559
Blucher Poole Waste Activated Sludge[4]	2,489	lbs/d	1,867	VSS	1,867	1,867
Indiana University Food Waste[5]	2,279	lbs/d	650	COD (10)	650	650
City of Bloomington Food Waste[6]	11,803	lbs/d	3,069	COD (11)	1,228	614
Monroe County Food Waste[7]	4,721	lbs/d	944	COD (12)	378	0
Fats, Oils and Greases (FOG)[8]	995	gpd	498	COD (13)	498	498

Notes on data sources and Study Update assumptions:

(1) ESG Report - 21,888 lbs/day average TSS load, 50% primary removal

(2) ESG Report - 16,219 lbs/day average BOD load, 30% primary removal and 0.75 WAS/BOD yield

(3) Based on ADF ratio of 3.8 MGD/13 MGD for Blucher/Dillman provided by CBU and Dillman Loadings

(4) Based on ADF ratio of 3.8 MGD/13 MGD for Blucher/Dillman provided by CBU and Dillman Loadings

(5) CBU: 20,000 lbs/wk school year (9 months), 4,000 lbs/wk summer (3 months); averaged over 365 days

(6) CBU: 600 tons/month, assumed 70% moisture content

(7) CBU: 240 tons/month, assumed 70% moisture content

(8) CBU: 363,000 gallons received in 2018

(9) Assumed VSS Ratios: Primary = 80%, WAS = 75%

(10) Food waste is assumed to be 95% recoverable to account for dinnerware with a 70% moisture content

(11) City waste is assumed to be 26% food waste

(12) County waste is assumed to be 20% food waste

(13) Assumed COD Loading of FOG based on a concentration of 60,000 mg/L

(14) Best Case Scenario = Dillman + Blucher + IU + 0.4*City+0.4*County+FOG

(15) Worst Case Scenario = Dillman + Blucher + IU + 0.2*City+FOG

Gas and Energy production

The model used for the original ESG analysis was updated to incorporate modifications in the assumed feedstock and was expanded to estimate energy production. The estimated energy production is shown in Table 2.

Table 2. Estimated Biogas and Electricity Generated from the AD system

Scenario	**Biogas Generated**	**Electricity Generated[(1)]**
Best Case	110 cfm	3,940,000 kWh/yr
Worst Case	107 cfm	3,840,000 kWh/yr

1.Biogas is 60% quality of natural gas, efficiency to convert gas to electricity is 40% and 3% electricity is lost during generation

Not all the energy will be available for external consumption. Anaerobic digesters require external heat for operation, so some of the gas is typically used for this purpose.

Potential Energy Uses

The electrical energy produced represents approximately 36% of the energy consumed at the plant. There are significant efficiency losses converting the gas to electricity so it may be more efficient to consume the gas directly . However, the plant has very little direct demand for the gas, so it would be necessary to identify other uses, including, for example, CNG vehicles that might replace conventional vehicles in the City fleet, or selling the renewable natural gas.

Potential uses of the gas are:

- Cogeneration of electricity to be utilized at the Dillman Plant
- Vehicle fuel
- Sell fuel onto the pipeline

All three options should be evaluated during the next phase of the waste-to-energy analysis.

Financial feasibility

Here we discuss the cost-benefit analysis for the conversion to AD at Dillman.

Estimated System Cost

The original ESG analysis estimated the system cost to be $25,000,000. However this system flared the gas produced and did not include provisions for loading the Blucher Poole sludge. In order to make the gas usable for CNG or selling into the market, a gas conditioning system, storage and distribution piping would also be required. To convert the gas to offset plant operating costs, an electrical power generation system would be required. Table 3 shows the estimated capital equipment cost of the key system elements.

Table 3. Estimated AD system cost

Element	**Estimated Cost**
AD system at Dillman WWTP	$25,000,000
Modifications for Blucher waste	$1,000,000
Gas Conditioning and Handling	$500,000
Electrical Energy Production Equipment	$1,000,000
Contingency (20%)	$5,500,000
Total AD system	**$32,500,000**
Additional Dillman plant Modifications for capacity expansion beyond 20 MGD	$10,000,000

Operational Costs and Benefits

There are both additional operational costs and benefits that would come from implementing this system. For this analysis, it is not possible to quantify these in dollar terms, but they are important for the operation of the Dillman facility. Some cost savings would come from the following:

- Reduced BOD loading to the aeration basins can result in efficient mixed liquor aeration. This reduces the amount of air that needs to be provided by the blowers.

- AD reduces the sludge volume more effectively than the existing aerobic system. This means that less sludge will need to be hauled away. In addition, anaerobically digested sludge can be more rapidly composted and made suitable for land application; we may be able to reduce hauling even more by creating a land-application program.

Additional operational costs would come from:

- Manpower, training, and maintenance of the AD system (these are more complicated to operate than aerobic digestion systems, and we may require a third operator on all shifts).

- Hauling pressed sludge from Blucher Poole to Dillman, should we implement that option. We will need to balance any increase in gas production with the amount of fuel we will save by hauling a shorter distance.

It is difficult to estimate the operational cost impacts of the system until its design is further specified. Our current modernization projects and our solar installation, will provide significant energy savings and carbon-emission reductions. Thus, we believe the savings potential from AD is smaller than estimated by the consultants.

Based upon our best estimates for loading to the AD facility, we should expect about 110 cubic feet per minute of biogas generation, of which 20-30% would need to be utilized for heat generation at the digester facility.

Assuming that 75% of the generated biogas were available, co-generation would generate approximately 325 kW of electricity, which is about 36% of the plant’s 2018 average electrical consumption. Based on our current annual $800,000 cost for electricity at Dillman, this would save about $290,000 per year in operating costs.

- Sale of the gas onto the pipeline would allow for the fuel to be utilized as vehicle fuel if the City transitioned to a fleet (wholly or partially) powered by compressed natural gas.

- Johnson Controls suggests that it may be possible to earn renewable energy certificates that can be sold on the open market. They suggest that the earnings from selling certificates could be sufficient to make the project pay for itself.

Additional revenue is possible from charging for receiving food waste, additional FOG, and selling gas. Further analysis is required to see if this would be significant when compared with the cost of the system.

Cost to Ratepayers

Overall, modification of Dillman and construction of the anaerobic digester facility will cost roughly $30-35 million. Assuming a 30-year, $35 million bond at 3.5%, principal and interest costs will be about $1.9 million annually. This represents about 8% of the 2020 Sewer Works budget of $24 million. Thus we should anticipate a rate increase of about 8% to pay for the project.

Discussion and conclusions

- Construction of an AD facility at Dillman can be accomplished. The AD facility can be configured to receive FOG and food waste from outside generators, such as the City of Bloomington Sanitation Division, the Monroe County Solid Waste District, Indiana University, and private haulers.
    - The AD facility will require the addition of primary clarifiers and other enhancements at Dillman, adding additional costs.
    - Overall, modification of Dillman and construction of the anaerobic digester facility will cost roughly $30-35 million. Assuming a 30-year, $35 million bond at 3.5%, principal and interest costs will be about $1.9 million annually. This represents about 8% of the 2020 Sewer Works budget of $24 million. Thus we should anticipate a rate increase of about 8% to pay for the project.
- If an AD facility were constructed, sale of treated biogas onto the pipeline may be the most desirable option.
    - Based upon our best estimates for loading to the AD facility, we should expect about 110 cubic feet per minute of biogas generation, of which 20-30% would need to be utilized for heat generation at the digester facility.
    - Assuming that 75% of the generated biogas were available, co-generation would generate approximately 325 kW of electricity, which is about 36% of the plant's average electrical consumption. Based on our current annual $800,000 cost for electricity at Dillman, this would save about $290,000 per year in operating costs.

    - Sale of the gas onto the pipeline would allow for the fuel to be utilized as vehicle fuel if the City transitioned to a fleet powered by compressed natural gas.
    - Johnson Controls suggests that it may be possible to earn renewable energy certificates that can be sold on the open market. They suggest that the earnings from selling certificates could be sufficient to make the project pay for itself.
- We should proceed with further analysis of the complete waste-to-energy picture. This will require a multidisciplinary approach. Specifically, we need to assess the following items:
    - What is our community's willingness to pay a premium of up to 8% more for sewer, in order to achieve the benefits of AD and co-digestion of organic wastes?
    - How much food waste and other organic waste can we realistically expect to collect and send to the digester?
    - What is the possibility that anaerobically digested sludge could be utilized for land application? How could/would that affect our local food economy and sustainability?
    - What is the potential of a renewable energy certificate market for biogas in Indiana? The City Controller's office is presently investigating this question with a subject matter expert.
    - What is the potential for land application of digested sludge? Besides the savings in hauling costs, how much would that benefit the community?
    - What is the possibility of receiving renewable-energy certificates? Is there a market for renewable natural gas certificates in Indiana? What would be the potential revenue gain?
    - What is the willingness of our community to pay an additional 8% on their sewer bill, about $2.50-$3.00 for the average residential customer?
    - If we are going to invest $30 million in our wastewater system for reduced carbon emissions, is this the most effective way to do it? What reduction in emissions and other environmental benefits might be achieved by a similar investment in our collection system?

Glossary

What is BOD?

BOD stands for Biochemical Oxygen Demand. It is a measure of the amount of organic material in a wastewater. If released into a stream, aquatic microorganisms oxidize the BOD, removing oxygen from the stream. This degrades water quality and kills fish.

What is municipal wastewater treatment?

Municipal wastewater treatment oxidizes BOD into CO_2, generating a waste "sludge" as a byproduct.

What is primary wastewater treatment?

Primary wastewater treatment is a means of removing solids from wastewater by gravity settling or direct filtration. Sludge from primary digesters is a very good source of biogas.

What is secondary, or biological, wastewater treatment?

Biological treatment is the process of removing BOD by using aeration to cultivate a community of aquatic microorganisms. The organisms consume the BOD "food", reducing the BOD concentration to a level that is safe for discharge to a stream. Secondary treatment may or may not be preceded by a primary settling step. One secondary treatment process is called "activated sludge", in which particles of "sludge" that contain the treatment organisms are moved through the water by aeration. Sludge from secondary treatment is far less effective as a biogas source than primary sludge.

What is digestion?

Digestion is the process of reducing the volume of waste sludge that must be disposed of. This is achieved by cultivating a community of organisms that consume the sludge materials. Digestion may be done aerobically (which generates carbon dioxide), or anaerobically (which generates methane, or "biogas").

What is FOG?

FOG stands for "fats, oils, and grease". These materials have a very high energy content and generate large volumes of biogas (carbon dioxide or methane) when digested or composted.

What is codigestion?

Codigestion adds compostable solid wastes and FOG to an anaerobic wastewater-sludge digester. Codigestion reduces the volume of the various solid-waste streams and increases the amount of biogas that is generated.

What is cogeneration?

Cogeneration is the generation of electric power by burning the biogas that is generated in an anaerobic digester or composting facility.

What is RNG?

RNG stands for Renewable Natural Gas. This is digester biogas that has been treated and made appropriate for distribution in natural gas pipelines.

What is CNG?

CNG stands for Compressed Natural Gas, typically referring to a fuel source for internal combustion engines. CNG may be composed of natural gas, treated biogas, or a mixture of the two.

Photographs from Bloomington Facilities

Figure 5. A primary clarifier at the Blucher Poole WWTP.

Figure 6. Aeration and overflow of activated sludge at the Blucher Poole WWTP.

Figure 7. Treated effluent exiting the secondary clarifier at the Blucher Poole WWTP.

Figure 8. Aeration of activated sludge at the Dillman Road WWTP.

Figure 9. Aerobic digestion of wasted sludge at Dillman Road WWTP.

Figure 10. Waste sludge leaving the belt press at Dillman Road WWTP.