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BIOGAS MARKET STUDY

UNDERSTANDING THE ALBERTA ANAEROBIC DIGESTION LANDSCAPE

Prepared For: The Climate Change Emission Management Corporation (CCEMC)

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ABBREVIATIONS

Symbol	Description
AD	Anaerobic Digestion
ADR	Activities Designation Regulation
AESO	Alberta Electric System Operator
AI-Bio	Alberta Innovates - BioSolutions
AIES	Alberta Interconnected Electric System
AI-EES	Alberta Innovates Energy and Environment Solutions
AITF	Alberta Innovates Technology Futures
AOPA	Agriculture Operation Practices Act
AUC	Alberta Utilities Commission
C&D	Construction and Demolition
CCEMC	Climate Change Emissions Management Corporation
CCEMF	Climate Change and Emissions Fund
CO_2	Carbon Dioxide
COP	Conference of Parties
CO_2e	Carbon Dioxide Equivalent
EPEA	Environmental Protection Enhancement Act
FIT	Feed in tariff
GHG	Greenhouse Gas
IC&I	Institutional, Commercial and Industrial
kwh	Kilowatt per hour – Unit of Energy
MSW	Municipal solid waste
MW	Megawatt – Unit of Power
MWh	Megawatt hour –Unit of Energy
NRCB	Natural Resources Conservation Board
PJ	Petajoule – Unit of Energy
SSO	Source Separated Organics
TEC	TEC Edmonton

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1.0. EXECUTIVE **SUMMARY**

1.1. PURPOSE

This market study was prepared for the Climate Change and Emissions Management (CCEMC) Corporation to aid discussion, and open engagement opportunities about the progression of the biogas industry in Alberta with industry participants and government policy and regulation makers. The market study:

- Highlights the biogas industry, focusing on anaerobic digestion
- Outlines why anaerobic digestion is needed in Alberta
- Explains how anaerobic digestion fits into the current regulatory framework in Alberta
- Shows barriers in Alberta regarding the economic viability of anaerobic digestion

Many of the opportunities identified in this report are interlinked and require engagement between multiple parties, including industry participants, policy makers and strategic partners. The CCEMC has the ability to develop relationships and share information and perspectives to emphasize the importance of biogas and anaerobic digestion and support the industry's development within Alberta. If the CCEMC and industry participants apply the key considerations in this report it is possible that there can be a meaningful change in the Alberta industry, and the chances of meeting the 2020 emission reduction targets set out by Alberta in the 2008 Climate Change Strategy will be enhanced. The assistance and support from government at all levels is paramount to advance the biogas industry and, in turn, reduce GHG emissions.

1.2. OVERVIEW

Anaerobic Digestion (AD) is a "*biological process that uses microbes to breakdown organic materials in the absence of oxygen. Digestion takes place in a special reactor, or enclosed chamber, where critical environmental conditions, such as moisture content, temperature and pH levels, can be controlled to maximize microbe generation, gas generation, and waste decomposition rates*"[1]. "*AD is a net energy-producing process.*"[2]

AD principles are fairly well understood, however in Canada the economics behind an AD project is the biggest disadvantage[3]. There are alternatives available for waste disposal in Canada (i.e. landfill, compost), and since Canada has an abundance of land space, finding and/or using new technologies, which cost more than existing options (i.e. landfilling), has significantly slowed down the adoption rate of AD as an alternative method of energy and waste disposal.

As Alberta looks to meet the 2020 emission reduction targets outlined in the 2008 Climate Change Strategy, there are opportunities that can be drawn upon:

1. **Alberta is the highest generator of residential waste per capita in Canada**[4] at 1,052 kg per person. Residential waste, a component of municipal solid waste (MSW), is one of the two main feedstock for AD
2. **Alberta has prominent agricultural feedstock** – manure, agricultural residue, and forest by-products – which is the second main feedstock for AD
   a. 4.99 million head of cattle and 1.5 million hogs[5]
   b. Approximately 6 million dry tonnes of agriculture residue [6]

[1] *Solid Waste as a Resource. Review of Waste Technologies*. Federation of Canadian Municipalities. Data accessed on April 24, 2015 (URL: https://www.fcm.ca/Documents/tools/GMF/Solid_Waste_as_a_Resource_Review_of_Waste_Technologies_EN.pdf)
[2] *Solid Waste as a Resource. Review of Waste Technologies.* Federation of Canadian Municipalities. Data accessed on April 24, 2015 (URL: https://www.fcm.ca/Documents/tools/GMF/Solid_Waste_as_a_Resource_Review_of_Waste_Technologies_EN.pdf)
[3] *Solid Waste as a Resource. Review of Waste Technologies*. Federation of Canadian Municipalities. Data accessed on April 24, 2015 (URL: https://www.fcm.ca/Documents/tools/GMF/Solid_Waste_as_a_Resource_Review_of_Waste_Technologies_EN.pdf)
[4] *Waste Management Industry Survey: Business and Government Sectors.* Statistics Canada. 2010. Catalogue no. 16F0023X. Data accessed on April 23, 2015 (URL: http://www.statcan.gc.ca/pub/16f0023x/16f0023x2013001-eng.pdf)
[5] *Agri-Food Statistics Update.* Government of Alberta. February 24, 2012. Issue No: LS12-01. Data accessed on April 21, 2015 (URL: http://www1.agric.gov.ab.ca/$Department/deptdocs.nsf/all/sdd13897/$FILE/agrifoodupdatels12-01.pdf)

c. Over 9 million dry tonnes of roadside forest residue and whole forest biomass[7]

3. **Alberta elected a new government into power on May 5, 2015** – this creates a unique opportunity for renewed dialogue with government leaders who indicated that finding alternative energy sources is one of the priorities for their mandate.[8]

There are four main benefits of AD

1. **Reduced physical footprint:** AD facilities occupy considerably less space than a traditional landfill site
2. **Employment opportunities:** It is expected that if a 366,032 tonne / year greenfield AD facility were to be constructed there would be an estimated 200 full-time construction jobs created during the span of construction, and approximately 30-40 permanent operational facility positions[9].
3. **Reduced GHG emissions:** AD facilities produce energy with lower GHG emissions than fossil fuels.
4. **Additional electricity generation:** Biomass energy production, which includes biogas production from both AD and wastewater treatment plants, accounts for 2.86% of electricity generation in the province[10]

There currently are no biogas specific regulations or policies in place in Alberta. AD has applicability in four different departments of government – i) Municipal/County, ii) Alberta Agriculture and Forestry, iii) Alberta Environment and Parks, and iv) Alberta Energy. Each of these divisions has differing policies and processes in place to try and accommodate biogas facilities. In addition, the Canadian Food Inspection Agency (CFIA) is responsible for regulations associated with agricultural products[11].

Therefore, biogas producers have to meet the requirements of all four government departments when constructing a facility. Based on our research with biogas industry participants, there is minimal harmonization or coordination among the four government departments, making the process for obtaining a permit for a biogas facility to take a minimum of three years.

1.3. KEY INITIATIVES

TEC Edmonton's observations are opportunities for the CCEMC to provide information to the province and industry participants who can then, in turn, engage with government to help guide the industry through the barriers and hurdles that are perceived to exist. There are three overarching activities that underlie each consideration: i) partnership and collaboration, ii) policy and legislation, and iii) education and promotion. Keeping each of these in mind, TEC has identified three major initiatives that could assist in advancing progress:

1. Creation of a Biogas Association
2. Providing information to industry participants who can engage Policy Makers
3. Engaging with Individuals and Organizations who are Advocates of Alternative Energy

Each of these initiatives has supporting suggestions that break out specific details identified as critical and important to industry participants (Table 1).

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[6] *Biogas Energy Potential in Alberta.* Government of Alberta. Revised May 2011. Agri-Facts Agdex 768-3. Data accessed on April 22, 2015 (URL: http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex11397/$file/768-3.pdf?OpenElement)

[7] *Biogas Energy Potential in Alberta.* Government of Alberta. Revised May 2011. Agri-Facts Agdex 768-3. Data accessed on April 22, 2015 (URL: http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex11397/$file/768-3.pdf?OpenElement)

[8] *NDP Platform 2015. Diversified Economy.* Alberta's NDP Party. Data accessed on May 7, 2015 (URL: https://web.archive.org/web/20150423162547/http://www.albertandp.ca/platform)

[9] *Phase 3, Task 7: Capital and Operating Costs. An assessment of life-cycle costs and benefits associated with potential development of an energy from waste facility.* Prepared by HDR. Approved by SAEWA. January 27, 2012. Project#147454. Data accessed on April 23, 2015 (URL: http://www.saewa.ca/pdf/engineering_study/Task7.pdf)

[10] *Electricity Statistics.* Alberta Energy. Data accessed on April 28, 2015 (URL: http://www.energy.alberta.ca/Electricity/682.asp)

[11] Additional details on the CFIA regulations for fertilizers can be found on the Government of Canada Canadian Food Inspection Agency website (http://www.inspection.gc.ca/plants/fertilizers/eng/1299165827648/1299165914316)

Table 1: Summary of Key Initiatives

	Key Consideration	Time to Implement	Cost to Implement	Complexity to Implement
1	CREATE A BIOGAS ASSOCIATION			
	1.1. Facilitate the co-operation of global biogas associations	◑	○	◑
2	ENGAGE POLICY MAKERS			
	2.1. Consider the review of landfill tipping fees	◑	◑	●
	2.2. Consider the review of the Micro-Generation Policy of the Alberta Government	◑	◑	●
	2.3. Consider the review of the carbon credit program	◑	◑	●
3	ENGAGE SUPPORTERS OF ALTERNATIVE ENERGY			
	3.1. Leverage pilot project sites for public education	◑	●	◑
	3.2. Continue partnership creation with feedstock providers	◑	○	◑
	3.3 Identify municipalities who are interested in diverting waste from landfills	○	○	●

As the CCEMC determines the best course of action to move forward with the above potential initiatives , it is important to note that AD is still in its infancy in Alberta. The execution and progression of AD will take time and capital investments to further the expansion of the industry in Alberta. Although high level financial information is present in Section 3.4, TEC stresses that additional work will need to be completed to fully understand the economic impact and feasibility of AD in Alberta.

2.0. PROJECT BACKGROUND & **RATIONALE**

2.1. THE CLIMATE CHANGE EMISSION MANAGEMENT CORPORATION (CCEMC)

The Climate Change and Emissions Management Corporation (CCEMC) is a not-for-profit organization with a mandate to establish or participate in funding initiatives that reduce greenhouse gas emissions and improve Alberta's ability to adapt to climate change (http://ccemc.ca).

The CCEMC's mission is to achieve actual and sustainable reductions in greenhouse gas emissions and facilitate climate change adaptation by stimulating transformative change through investments in innovative projects (http://ccemc.ca)

Project areas of focus reflect the direction established by the province's Climate Change Strategy and include

- Carbon capture and storage
- Renewable energy
- Clean energy production
- Energy efficiency
- Adaptation
- Biological

2.2. TEC EDMONTON

TEC Edmonton (TEC) is a business accelerator, helping to transform technologies into business opportunities. TEC's goal is to capture the value of the innovation.

TEC is a unique not-for-profit, joint venture between the University of Alberta and Edmonton Economic Development Corporation (EEDC). Its mission is to accelerate economic and social benefit from innovation by catalyzing the commercialization process. It does this by partnering with innovators to help launch and grow technology-based start-up companies and by providing access to expert advice, facilities, financing and other vital resources.

2.3. PROJECT SCOPE

With several CCEMC proponents developing technologies within the biogas space, TEC and the CCEMC identified the benefit of a market research project focused on:

- Availability of necessary large scale feedstock
- Alberta and Canadian markets for by-products such as organic fertilizer
- Opportunities to increase the speed of deployment through understanding and/or modification of Alberta regulations and policies

This market study was prepared for industry participants and the CCEMC to share information and open engagement opportunities for industry participants with government policy and regulation makers to discuss the progression of the biogas industry in Alberta. The market study:

- Highlights the biogas industry, focusing on anaerobic digestion
- Outlines why anaerobic digestion is needed in Alberta
- Explains how anaerobic digestion fits into the regulatory framework in Alberta
- Shows how perceptions need to shift in Alberta regarding the economic viability of anaerobic digestion

2.4. METHODOLOGY

This report contains information from both primary and secondary research. Secondary research information was gathered from multiple sources including internet, research and journal database searches, company marketing materials, regulatory filings, and media articles.

Primary research was conducted through interviews with industry experts and participants, including key CCEMC proponents, stakeholders, and specialists.

A questionnaire guide was created to address the objectives of the market assessment using information gathered from secondary research, the proponents, and industry experts.

For the key initiatives section of this report, TEC developed a ranking system to prioritize each opportunity for the CCEMC. The ranking system is based on three criteria, listed below, and are subjective assessments that are represented by the below legend.

Table 2: Assessment Criteria Ranking System

	Legend		
Assessment Criteria	Low	Medium	High
Time to Implement	○ *Short-term*	◑ *Medium-term*	● *Long-term*
Cost to Implement	○	◑	●
Complexity to Implement	○	◑	●

2.5. PURPOSE OF REPORT

This report is being compiled as an information and education document for audiences selected by the CCEMC, along with guidance opportunities for the CCEMC itself to assist with the progression and acceptance of biogas and anaerobic digestion in Alberta.

3.0. INDUSTRY **OVERVIEW**

Climate change is becoming more and more prevalent in the news, as governments from around the globe will meet later this year to work on new international agreements and targets to keep emissions in check[12]. The main driver of climate change is greenhouse gas (GHG) emissions from the use of fossil fuels[13].

One way Alberta is reducing GHG emissions is through innovation, engaging with climate change technologies through the Climate Change Emissions Management Fund and the CCEMC. The CCEMC is committed to support Alberta in meeting the emission reduction targets.

ALBERTA'S 2008 CLIMATE CHANGE STRATEGY

ACTION TO BE TAKEN IN THREE AREAS:

1. **Conserving and using energy efficiently** → GOAL: To reduce greenhouse gas emissions by transforming how we use energy, applying energy efficient solutions, and conserving energy.
2. **Implementing carbon capture and storage** → GOAL: To store quantities of CO_2 in Alberta's geological formations rather than releasing it into the atmosphere
3. **Greening energy production** → GOAL: To transform the way we produce energy and to introduce cleaner, more sustainable approaches to energy production

TARGETS

Year	Emission Reduction Target
2010	**20 megatonnes** (meet intensity targets set in 2002)
2020	**50 megatonnes** (stabilization of GHG emissions)
2050	**200 megatonnes** (50% reduction)

Source: Alberta's 2008 Climate Change Strategy Responsibility/Leadership/Action, Alberta Government, 2008

Figure 1: Alberta's 2008 Climate Change Strategy Actions & Targets

As Alberta looks to meet the 2020 emission reduction targets, there are multiple opportunities that can be drawn upon:

1. Alberta is the highest generator of waste per capita in Canada[14]
2. Alberta has access to prominent agricultural feedstock[15]
3. Alberta elected a new government into power on May 5, 2015

Points one and two above are opportunities as these are primary sources of feedstock for anaerobic digestion (AD), which is an alternative energy to fossil fuels and is an option for reducing GHG emissions.

[12] Sutter, John D. *2 degrees: The most important number you've never heard of.* CNN website. April 22, 2015. Data accessed on April 22, 2015 (URL: http://www.cnn.com/2015/04/21/opinions/sutter-climate-two-degrees/index.html)
[13] *Human and Natural Drivers of Climate Change.* Intergovernmental Panel on Climate Change. 2007. Data accessed on May 4, 2015 (URL: https://www.ipcc.ch/publications_and_data/ar4/wg1/en/spmsspm-human-and.html)
[14] *Waste Management Industry Survey: Business and Government Sectors.* Statistics Canada. 2010. Catalogue no. 16F0023X. Data accessed on April 23, 2015 (URL: http://www.statcan.gc.ca/pub/16f0023x/16f0023x2013001-eng.pdf)
[15] *Biogas Energy Potential in Alberta.* Government of Alberta. Revised May 2011. Agri-Facts Agdex 768-3. Data accessed on April 22, 2015 (URL: http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex11397/$file/768-3.pdf?OpenElement)

Point three indicates that there is a change in governmental power. Since the election, the new government has implemented work on *The Alternative and Renewable Energy Framework,* which "will set the direction for how government will help grow alternative and renewable energy production and use in the province[16]." Alberta has been taking strides towards reducing their GHG emissions by increasing their biomass energy production, and now this accounts for 2.86% of electricity generation in the province[17].

3.1. ANAEROBIC DIGESTION

Anaerobic digestion (AD) is a "*biological process that uses microbes to breakdown organic materials in the absence of oxygen. Digestion takes place in a special reactor, or enclosed chamber, where critical environmental conditions, such as moisture content, temperature and pH levels, can be controlled to maximize microbe generation, gas generation, and waste decomposition rates*"[18]. "*AD is a net energy-producing process.*"[19]

AD principles are fairly well understood, however in Canada the economics behind an AD project is the biggest disadvantage[20]. There are alternatives available for waste disposal in Canada (i.e. landfill, compost), and since Canada has an abundance of land space, finding and/or using new technologies, which cost more than existing options (i.e. landfilling), has significantly slowed down the adoption rate of AD as an alternative method of energy and waste disposal.

However, based on Alberta's mandate to meet the 2020 emission reduction targets, identifying alternatives to current energy and disposal methods is necessary. With AD having the applicability to three different provincial government ministries (Alberta Agriculture and Forestry, Alberta Environment and Parks, and Alberta Energy) this renewable, alternative energy source is an option that should be seriously considered.

In the past, AD has had two main focuses in Canada:

- **Agricultural:** Used on farms with agricultural livestock by-products (i.e. manure) and agricultural residues as feedstock to generate energy for the farm
- **Municipal**: Mainly used at wastewater treatment plants

However, a global trend has started to emerge with the municipal uses of AD increasing and using source separated organics (SSOs) and municipal solid waste (MSW) as feedstock in generating heat and/or cooking fuel for home use[21]. One of the main benefits of AD is the fact that it is considered a 'green' or 'renewable' energy source. By using AD processes municipalities can show that they support renewable energy[22]. Figure 2 shows a basic AD flow diagram for SSO and MSW into the AD process. It can be seen from this figure that AD is a net energy producing process that produces energy that can be transferred to the grid, and used for operating the AD system itself. It also creates by-product called digestate that can be used in compost or on agricultural land as fertilizer.

[16] *Alternative and Renewable Energy.* Government of Alberta Energy website. Data accessed on October 9, 2015 (URL: http://www.energy.alberta.ca/ourbusiness/bioenergy.asp)
[17] *Electricity Statistics.* Alberta Energy. Data accessed on April 28, 2015 (URL: http://www.energy.alberta.ca/Electricity/682.asp)
[18] *Solid Waste as a Resource. Review of Waste Technologies*. Federation of Canadian Municipalities. Data accessed on April 24, 2015 (URL: https://www.fcm.ca/Documents/tools/GMF/Solid_Waste_as_a_Resource_Review_of_Waste_Technologies_EN.pdf)
[19] *Solid Waste as a Resource. Review of Waste Technologies.* Federation of Canadian Municipalities. Data accessed on April 24, 2015 (URL: https://www.fcm.ca/Documents/tools/GMF/Solid_Waste_as_a_Resource_Review_of_Waste_Technologies_EN.pdf)
[20] *Solid Waste as a Resource. Review of Waste Technologies*. Federation of Canadian Municipalities. Data accessed on April 24, 2015 (URL: https://www.fcm.ca/Documents/tools/GMF/Solid_Waste_as_a_Resource_Review_of_Waste_Technologies_EN.pdf)
[21] *Solid Waste as a Resource. Review of Waste Technologies*. Federation of Canadian Municipalities. Data accessed on April 24, 2015 (URL: https://www.fcm.ca/Documents/tools/GMF/Solid_Waste_as_a_Resource_Review_of_Waste_Technologies_EN.pdf)
[22] *Municipal Solid Waste (MSW) Options: Integrating Organics Management and Residual Treatment/Disposal.* Municipal Waste Integration Network & Recycling Council of Alberta. April 2006. Data accessed on April 21, 2015 (URL: https://recycle.ab.ca/uploads/File/pdf/MSWworkshop/MSW_Options_Report.pdf)

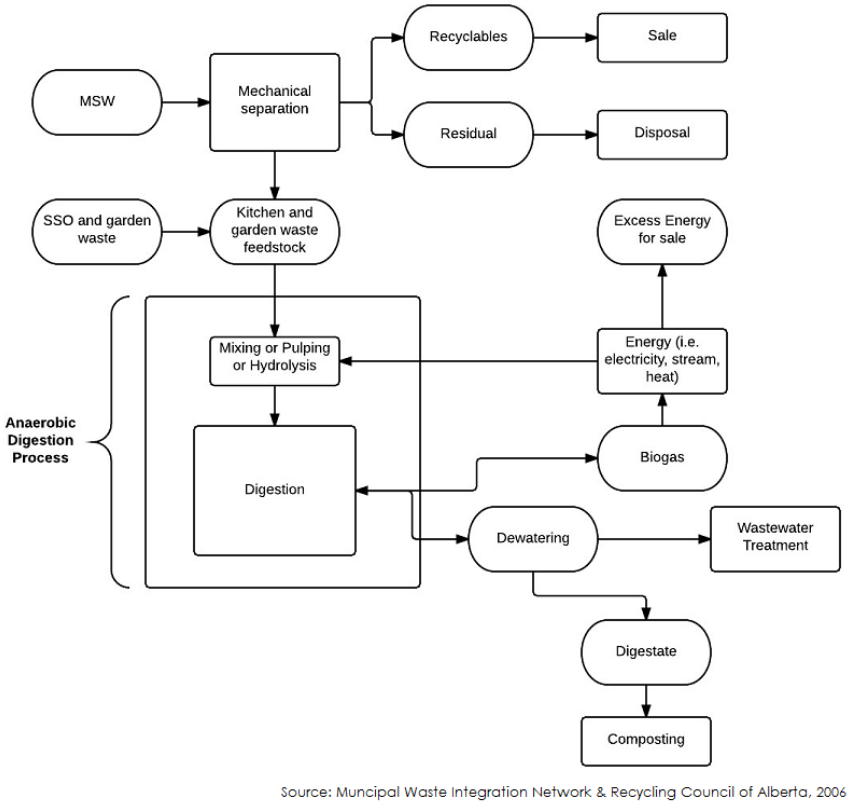


Figure 2: Anaerobic Digestion Flow Diagram[23]

Through conversations with AD and biogas industry participants in Alberta[24] it was highlighted that the AD process works best as a combination process with SSO, MSW, and agricultural inputs (i.e. manure). The agricultural input acts as a stabilizing feedstock with bacteria that allows for the AD process to run at optimal levels. This is due to the fact that:

- The agricultural input is very low in energy
- SSO and MSW are difficult to digest in the AD process without additional feedstock
- The agricultural input combined with SSO and MSW allows the SSO and MSW to more easily be digested, while increasing the energy output of the AD process

When looking at AD options, there are three different plant designs that the industry can choose from[25]:

- Single stage versus two stage systems
- Wet versus dry systems
- Thermophilic versus mesophilic systems

The below table highlights the advantages and disadvantages of the three designs:

[23] *Municipal Solid Waste (MSW) Options: Integrating Organics Management and Residual Treatment/Disposal.* Municipal Waste Integration Network & Recycling Council of Alberta. April 2006. Data accessed on April 21, 2015 (URL: https://recycle.ab.ca/uploads/File/pdf/MSWworkshop/MSW_Options_Report.pdf)

[24] Industry participants include Lethbridge Biogas, GrowTec, Renew Bioenergy, BioRefinex, Growing Power Hairy Hill, Permolex, and Blue Source Canada

[25] *Municipal Solid Waste (MSW) Options: Integrating Organics Management and Residual Treatment/Disposal.* Municipal Waste Integration Network & Recycling Council of Alberta. April 2006. Data accessed on April 21, 2015 (URL: https://recycle.ab.ca/uploads/File/pdf/MSWworkshop/MSW_Options_Report.pdf)

Table 3: Advantages and Disadvantages of AD System Designs

System	Advantages	Disadvantages
Single Stage	• Lower capital cost • Easier to operate • Less technical failures	• Conditions for two stages are not optimized • May lead to somewhat lower biogas yields
Two Stage	• Potentially higher gas yields • More breakdown of biodegradable material under optimal conditions	• Higher cost • More technical complexity • More technical failures
Wet	• Can remove plastic from incoming waste streams • More suited for co-digestion with animal manures or biosolids	• Higher water requirements • Higher energy needs to heat and pump water • Higher energy needs to dewater digester contents • Loss of volatile solids and potentially lower gas yields
Dry	• Less energy requirements • More energy available for export	• Cannot handle high plastic content in incoming waste
Thermophilic	• Higher temperatures can potentially yield superior biogas production in a shorter time frame	• Higher odour potential
Mesophilic	• Lower operation temperature • Bacteria are more robust and adaptable to environmental conditions • Lower odour potential	• Lower biogas yields

Source: Municipal Waste Integration Network & Recycling Council of Alberta, 2006

3.1.1. MAIN PLAYERS IN ALBERTA

3.1.1.1. Industry Organizations

Although AD is prevalent in the rest of the world[26], Alberta is still developing this market. Through the CCEMC, TEC has been able to identify that there are active companies (four that are CCEMC funded) in Alberta that have developed technologies and/or have opened AD and/or biogas facilities in excess of 1MW[27]. These companies have navigated through the complexity of provincial regulations for on-farm and off-farm AD facilities – as policies and regulations in these areas do not exist yet as AD is still in the early adoption phase of development in Alberta (more details on regulations can be found in Section 3.3).

Main players in Alberta include:

- Lethbridge Biogas (http://www.lethbridgebiogas.ca) – CCEMC proponent
- GrowTec (http://growtheenergycircle.com) – CCEMC proponent
- Renew Bioenergy (http://www.renewbioenergy.ca)
- BioRefinex (http://www.biorefinex.com) – former CCEMC proponent
- Growing Power Hairy Hill (http://www.growingpower.com) – CCEMC proponent
- Permolex (http://www.permolex.com)
- City of Edmonton – CCEMC proponent
- Wastewater treatment plants

[26] *Solid Waste as a Resource. Review of Waste Technologies.* Federation of Canadian Municipalities. Data accessed on April 24, 2015 (URL: https://www.fcm.ca/Documents/tools/GMF/Solid_Waste_as_a_Resource_Review_of_Waste_Technologies_EN.pdf)
[27] This does not include AD facilities / technologies that are active within water treatment facilities in the province

3.1.1.2. Stakeholders

When looking at AD as an alternative energy and disposal method source, there are multiple stakeholders that need to be consulted and engaged to create a successful project. The main stakeholders in AD in Alberta are outlined in Table 4.

Table 4: Main Alberta Stakeholders in the AD Industry

Stakeholder	Description
Government	This includes participation by ministries and departments at all levels of government (i.e. municipal, provincial, and federal) in divisions of agriculture, environment, energy, and policy. The government is the ultimate policy and regulation setting body.
Industry Organizations	Organizations and/or individuals who are active in the AD market in Alberta and are either operating an AD facility, or are in the process constructing and establishing an AD facility.
Waste Management Agencies	These are agencies that would potential be impacted due to the diversion of waste (i.e. landfill operators, landfill transportation companies, etc.).
Feedstock Providers	Feedstock providers are individuals and/or organizations that have feedstock excess that is viable in AD (i.e. manure, agricultural residue, SSO, MSW)
Equipment Providers	Equipment providers are corporations that provide the necessary technology and equipment to the biogas industry (i.e. PlanET Biogas)
End Users	This includes any individual or corporation that could potential use by-products of AD and/or service the biogas industry (i.e. farmers, service providers, etc.)
Communities	Individuals, businesses, and organizations who live and work in geographic proximity to each other. They are producers of waste and users of by-products

One method for classifying stakeholders is the RACI model (Table 5). In this model, stakeholders are classified into four categories (*Source: Project Smart*)[28]:

- **Responsible:** "The person who does the work to achieve the task. They have responsibility for getting the work done or decision made. As a rule this is one person"
- **Accountable**: "The person who is accountable for the correct and thorough completion of the task. This must be one person and is often the project executive or project sponsor. This is the role that responsible is accountable to and approves their work"
- **Consulted**: "The people who provide information for the project and with whom there is two-way communication. This is usually several people, often subject matter experts"
- **Informed:** "The people who are kept informed about progress and with whom there is one-way communication. These are people that are affected by the outcome of the tasks so need to be kept up-to-date"

[28] Haughey, Duncan. *RACI Matrix.* Projectsmart.co.uk. Data accessed on May 5, 2015 (URL: http://www.projectsmart.co.uk/raci-matrix.php)

Table 5: Stakeholder Classification – RACI Matrix

	Responsible	Accountable	Consulted	Informed
Government	✓	✓		
Industry Organizations	✓	✓		
Waste Management Agencies		✓	✓	✓
Feedstock Providers			✓	✓
Equipment Providers			✓	✓
Communities			✓	✓
End Users			✓	✓
General Public / Media				✓

Another method of classifying stakeholders is from the perspective of governments' (i.e. municipal, provincial, and / or federal). The figure below is based on Freeman's principal of stakeholder analysis[29] which designates stakeholders into four categories:

- **Manage Closely:** stakeholders "have both great interest in the effort and the power to help make it successful (or to derail it)"
- **Keep Informed:** stakeholders that "have a vested interest and can voice their support in the community, but have little actual power to influence the effort in any way"
- **Keep Satisfied:** stakeholders that "have no particular interest or involvement in the effort, but have the power to influence it greatly if they become interested"
- **Monitor:** stakeholders / individuals who "have little interest and little power, and may not even know the effort exists[30]"

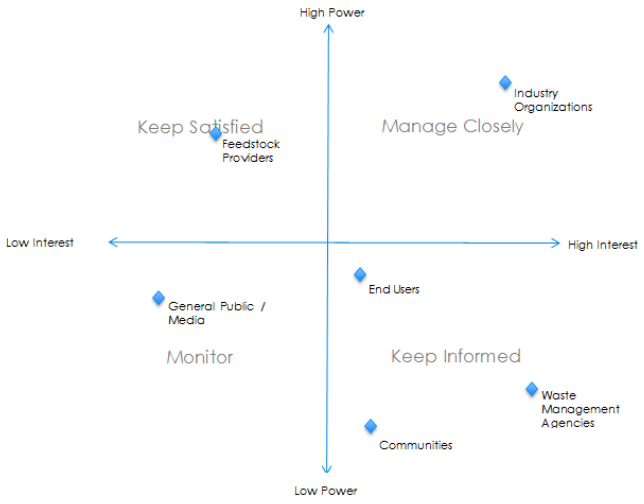


Figure 3: Stakeholder Overview – Government Perspective

[29] Grushka-Cockayne, Yael. *Fundamentals of Project Planning and Management.* University of Virginia Darden School MOOC. Delivered on Coursera. Data accessed on April 29, 2015.
[30] *Section 8: Identifying and Analyzing Stakeholders and Their Interests.* Community Tool Box. Data accessed on May 4, 2015 (URL: http://ctb.ku.edu/en/table-of-contents/participation/encouraging-involvement/identify-stakeholders/main)

3.1.2. ANAEROBIC DIGESTION ACCEPTANCE IN ALBERTA

Anaerobic digestion (AD) is not a new phenomenon, however it is a relatively new consideration (last 10-20 years) for municipalities and their source separated organics (SSO) and municipal solid waste (MSW)[31]. Alberta has multiple policies and regulations[32] that are focused on Alberta's environmental industry. These policies and regulations range from *Oil Sands Rules & Regulations*, *Carbon Capture & Storage* to *recycling and compost waste management*.

3.1.2.1. Challenges

Although AD is a beneficial and alternative energy source and GHG emission reducing alternative, there are still challenges to acceptance of AD in Alberta. Below are six challenges that new AD producers need to be aware of and cognizant of when considering constructing a new AD facility.

- **Feedstock availability**

  Normally on-farm AD facilities will have sufficient feedstock within the confines of the farm and through agreements with neighbours. An on-farm facility will normally have a capacity less than 1 MW, usually around the 500kW size. This size of facility is very common in other countries including Germany.

  However, off-farm AD facilities not only use agricultural feedstock, but also a combination of wet and dry SSO and MSW feedstock, which are critical to ensuring full capacity and economies of scale for the facility. One of the main considerations that off-farm AD facilities need to be aware of is that there are other waste-to-biofuel facilities that are in existence that use dry system SSO and/or MSW (i.e. post-sorted MSW after recycling and composting) as their main feedstock; this could cause a supply shortage of feedstock for large mixed feedstock AD facilities. For example, in Edmonton, Enerkem recently built a waste-to-biofuels and chemicals facility that uses MSW as the main feedstock. The facility is expected to convert 100,000 tons of Edmonton's MSW into 38 million litres of biofuel and chemicals. The CCEMC and Alberta Innovates – Energy and Environment Solutions are supporters of this City of Edmonton facility and it is expected that this facility will allow the City of Edmonton to divert up to 30% more residential waste from landfills (60% is already diverted through recycling and composting)[33]. Consequently additional facilities within a similar geography may not receive sufficient feedstock to become economically viable.

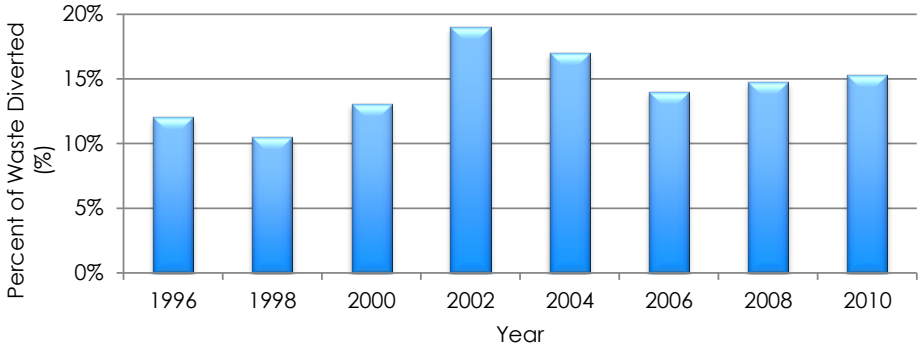
  Further details on feedstock availability in Alberta can be found in Section 3.2.2.

- **Consumer waste diversion attitude**

  One of the challenges of AD adoption is changing consumers' mentality on waste diversion. Even with the influx of new recycling and composting regulations and alternative energies, Alberta consumers have held steady with the amount of waste they divert from households over the last 15 years (Figure 4).

  - Alberta diversion rates for residential MSW have been steady around 25.5% between 1996 and 2010[34]
  - While non-residential MSW diversion is approximately 11.4%

[31] *Municipal Solid Waste (MSW) Options: Integrating Organics Management and Residual Treatment/Disposal.* Municipal Waste Integration Network & Recycling Council of Alberta. April 2006. Data accessed on April 21, 2015 (URL: https://recycle.ab.ca/uploads/File/pdf/MSWworkshop/MSW_Options_Report.pdf)
[32] *Policies and regulations.* Alberta Government. Data accessed on April 29, 2015 (URL: http://www.albertacanada.com/business/industries/eps-policies-and-regulations.aspx)
[33] *Waste-to-Biofuels and Chemicals Facility. Turning Garbage into Fuel.* The City of Edmonton website. Data accessed on April 29, 2015 (URL: http://www.edmonton.ca/programs_services/garbage_waste/biofuels-facility.aspx)
[34] *Solid Waste Diversion.* Alberta Environment and Sustainable Resource Development website. Data accessed on April 29, 2015 (URL: http://esrd.alberta.ca/focus/state-of-the-environment/land/response-indicators/solid-waste-diversion.aspx)



Source: Alberta Environment and Systainable Resource Development

Figure 4: Alberta Waste Diversion (1996-2010)[35]

- **Political environment**

  Biogas is a long term commitment and a political environment tends to focus on the shorter term. It takes a biogas facility approximately five to eight years to go from concept to production[36] in Alberta due to the infancy of the industry[37]. The normal election cycle in Alberta is four years. Many politicians are expected to show short term wins during their mandate, and as such, longer term projects, such as biogas, may not be at the forefront of the public dialogue; even though in the long run AD could provide significant emission reductions and an alternative energy source to fossil fuel.

- **Regulatory environment**

  With a biogas facility development cycle being five to eight years, most of this is contributed to navigating the regulatory environment in Alberta (see further details in Section 3.3). There are four different departments that the facility has to get approval from (Municipal / County, Alberta Agriculture and Forestry, Alberta Environment and Parks, and Alberta Energy) outside of the additional construction permits and scheduling.

- **Less understood energy alternative**

  In Alberta, coal, oil & gas are the main sources of energy. Fossil fuels have gained traction over the years due to the abundance of supply in Alberta, relative low cost and the global demand for the products. These energy sources are well understood and relied upon by domestic and international consumers.

  AD is an alternative energy that is not well understood, is more capital intensive at the beginning of a project, and economies of scale have not been realized due to a lack of adoption. Having Alberta and other energy users break the mold of only using non-renewable energy sources is a milestone that biogas industry participants around the world will have to overcome to speed up adoption of AD as an energy source. With government support and understanding of AD, this could revolutionize the progression of this source of alternative energy in Alberta.

[35] *Solid Waste Diversion.* Alberta Environment and Sustainable Resource Development website. Data accessed on April 29, 2015 (URL: http://esrd.alberta.ca/focus/state-of-the-environment/land/response-indicators/solid-waste-diversion.aspx)

[36] This includes tasks such as: regulatory navigation, identification of funding and partners (financial and feedstock providers), design and construction of the facility, to production commencement.

[37] Through conversations with industry participants, a typical design build cycle for an AD facility in a mature market is one to two years.

- **Community acceptance**

  It will be important for biogas facilities and industry participants to include and educate the general public about the benefits and impacts that AD can have on the overall environment. Holding community forums and consultations will go a long way in the development of the industry in Alberta, and the eventual acceptance.

With these above challenges, the biogas industry in Alberta has hurdles to conquer, however, the biogas industry is in a very favorable position to start expanding.

3.2. WHY ANAEROBIC DIGESTION?

3.2.1. WASTE STATISTICS IN ALBERTA

Based on 2010 data, Alberta is the highest generator of waste per capita in Canada at 1,052 kg per person[38], an equivalent of 3,917,492 tonnes of MSW being added to Alberta landfills every year[39].

Alberta has approximately 75 landfills that are either privately or publically owned[40]. These landfills receive waste from multiple sources including: MSW, IC&I, C&D, leaf and yard, household organics, recyclable material, and hazardous[41]. In addition, Alberta is the only province in Canada that "regulates [all] landfills based on the quantity of greenhouse gases emitted." [42]

MSW can be classified into two categories: residential and non-residential. Residential waste is approximately 37% of the total waste generated and can be broken down further as: organic material, bulky goods, recyclable materials, and other (Figure 5)[43]

Based on 2010 data, Albertans divert 713,153 tonnes (192 kg per person) of waste material from landfills. Compared to the four other largest provinces, Alberta diverts the least amount of waste on a per capita basis, as seen in Table 6 below[44].

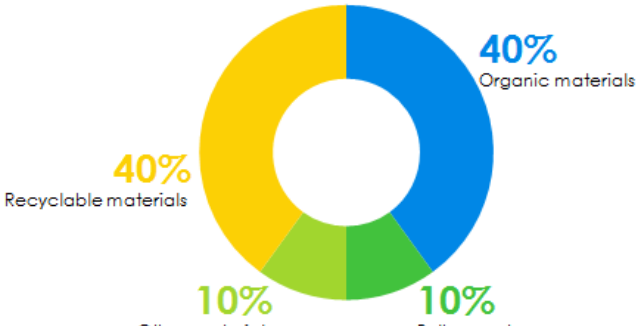


Figure 5: Content of Residential Waste in Canada

Table 6: Materials Diverted from Landfills

Province	Total Materials Diverted (tonnes)	Per Capita Diversion (kg)	Total Organics Diverted (tonnes)
Alberta	**713,153**	**192**	**210,657**
Ontario	2,749,047	208	1,058,272
Quebec	2,336,400	296	253,000
British Columbia	1,457,062	322	378,139
Nova Scotia	265,467	281	148,750

Source: Waste Management Industry Survey: Business and Government Sectors, 2010

Most organic waste that is sent to landfills does not decompose properly and emits damaging GHGs (CO_2 and methane) into the atmosphere.

[38] *Waste Management Industry Survey: Business and Government Sectors.* Statistics Canada. 2010. Catalogue no. 16F0023X. Data accessed on April 23, 2015 (URL: http://www.statcan.gc.ca/pub/16f0023x/16f0023x2013001-eng.pdf)
[39] Behrens, Annaliese, Arifa Sultana. *Zero Organic Waste in Alberta. Policy Recommendations.* Alberta Innovates – Energy and Environment Solutions. December 2014. Data accessed on April 20, 2015 (URL: http://www.ai-ees.ca/media/14377/zero_organic_waste_alberta-_jan_2015.pdf)
[40] *Regional Waste Management Authority Contact List – 2013.* Alberta Environment and Sustainable Resource Development. Data accessed on April 7, 2015 (URL: http://environment.gov.ab.ca/info/library/8286.pdf)
[41] *Getting to 50% and Beyond: Waste Diversion Success Stories from Canadian Municipalities.* Federation of Canadian Municipalities (FCM). Data accessed on April 20, 2015 (URL: http://www.fcm.ca/Documents/tools/GMF/Getting_to_50_percent_en.pdf)
[42] *Landfills.* Alberta Environment and Sustainable Resource Development. Data accessed on April 23, 2015 (URL: http://esrd.alberta.ca/waste/waste-management-facilities/landfills/default.aspx)
[43] *Getting to 50% and Beyond: Waste Diversion Success Stories from Canadian Municipalities.* Federation of Canadian Municipalities (FCM). Data accessed on April 20, 2015 (URL: http://www.fcm.ca/Documents/tools/GMF/Getting_to_50_percent_en.pdf)
[44] *Waste Management Industry Survey: Business and Government Sectors.* Statistics Canada. 2010. Catalogue no. 16F0023X. Data accessed on April 23, 2015 (URL: http://www.statcan.gc.ca/pub/16f0023x/16f0023x2013001-eng.pdf)

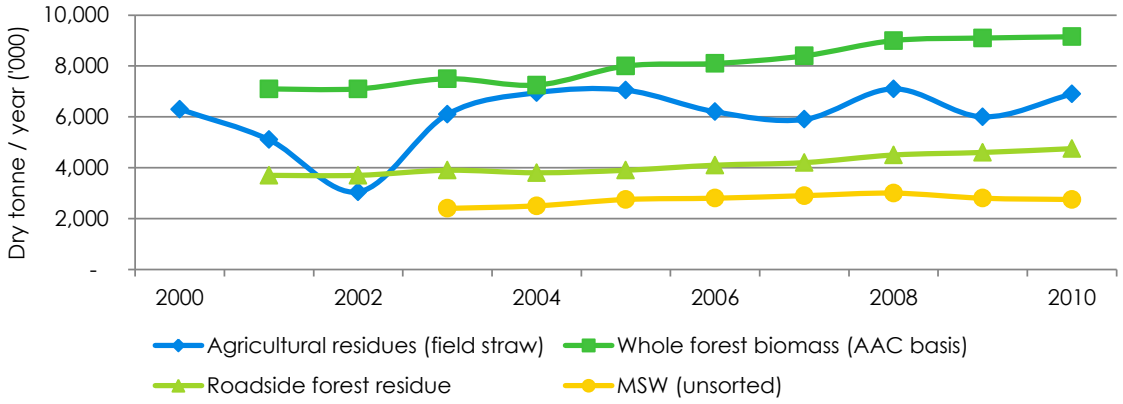
3.2.2. FEEDSTOCK AVAILABILITY IN ALBERTA

There are multiple different sources of feedstock that can be used in the AD process and the main sources are highlighted in the table and figure below. Agricultural livestock (including manure and animal by-products) is the most prominent feedstock in Alberta, mainly in the form of manure[45] (Table 7); while Figure 6 shows that agricultural residues are variable, and forest and MSW are steadily increasing.

Table 7: Agricultural Feedstock Availability in Alberta[46, 47, 48]

Feedstock	Description
Agricultural Livestock*	
Cattle	There are approximately 20,000 cattle farms in Alberta, with an inventory of approximately 4.99 million head 94% of cattle facilities have solid manure storage facilities
Hog	There are approximately 550 hog farms in Alberta, with an inventory of 1.51 million head 88% of swine production facilities have liquid manure storage
Other	Sheep/Lamb • There are over 2,100 producers with approximately 80,000 head Bison • There are over 850 farms with approximately 97,000 head Deer • There are 81 deer producers with over 5,500 head Elk • There are over 350 farms

** Note that only about 60% of the farms in Alberta have facilities that have manure storage[49]*



Source: Identification of Opportunities for the Production of Bio-Products from Waste Bio-Mass in Alberta, Jacobs Consultancy (March 2013)

Figure 6: Feedstock Availability in Alberta[50]

[45] *Biogas Energy Potential in Alberta.* Government of Alberta. Revised May 2011. Agri-Facts Agdex 768-3. Data accessed on April 22, 2015 (URL: http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex11397/$file/768-3.pdf?OpenElement)

[46] *Alberta Livestock & Meat Strategy: 2008 – 2013 Implementation Plan.* Government of Alberta. Data accessed on April 21, 2015 (URL: file:///C:/Users/k.gibson/Downloads/Alberta%20Livestock%20and%20Meat%20Strategy%20(1).pdf)

[47] *Agri-Food Statistics Update.* Government of Alberta. February 24, 2012. Issue No: LS12-01. Data accessed on April 21, 2015 (URL: http://www1.agric.gov.ab.ca/$Department/deptdocs.nsf/all/sdd13897/$FILE/agrifoodupdatels12-01.pdf)

[48] *Biogas Energy Potential in Alberta.* Government of Alberta. Revised May 2011. Agri-Facts Agdex 768-3. Data accessed on April 22, 2015 (URL: http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex11397/$file/768-3.pdf?OpenElement

[49] *Biogas Energy Potential in Alberta.* Government of Alberta. Revised May 2011. Agri-Facts Agdex 768-3. Data accessed on April 22, 2015 (URL: http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex11397/$file/768-3.pdf?OpenElement)

Other feedstock that AD facilities can use include: organic food resources (i.e. fats, oils, greases (FOG), food processing residues, and kitchen & market residues)[51].

Of all the feedstock available in Alberta, agricultural livestock (manure and by-products) and SSO are the most suitable for AD.

3.2.2.1. Challenges with Feedstock

There are four main challenges specific to feedstock (Table 8).

Table 8: Feedstock Challenges

LEGEND: Low: ○ Medium: ◑ High: ●

	Level of Energy	Ease of Digestion	Contamination	Transportation
Agricultural Manure	○	●	Prone to contamination from sand and feed spills (i.e. hay, straw)[52]	Heavy and wet Requires specialized trucks Cost to the provider and/or AD facility
Agricultural Residue	○	◑	Unknown	Heavy Cost to the provider and/or AD facility
MSW	●	○ *Requires additional processing step prior to AD*	Higher contamination levels versus SSO Main contaminant: Non-biodegradable materials[53]	Municipal collection
SSO	●	○	Minimal contamination in comparison to MSW (10% versus 30%)[54] Main containment: Plastic bags	Municipal collection
Forest Residue	◑	◑ *Requires additional processing step prior to AD*	Unknown	Heavy and wet Cost to the provider and/or AD facility

[50] *Identification of Opportunities for the Production of Bio-Products from Waste Bio-Mass in Alberta*. Jacobs Consultancy and University of Alberta. March 2013. Data accessed on May 1, 2015 (URL: http://www.ai-ees.ca/media/13681/ab_biomass_to_products_study_report.pdf)

[51] *Organic Feedstock for Lethbridge Biogas Cogeneration Plant.* Data accessed on August 31, 2015 (URL: file:///C:/Users/k.gibson/Downloads/Feedstock%20List.pdf)

[52] *Biogas Energy Potential in Alberta.* Government of Alberta. Revised May 2011. Agri-Facts Agdex 768-3. Data accessed on April 22, 2015 (URL: http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex11397/$file/768-3.pdf?OpenElement)

[53] *Solid Waste as a Resource. Review of Waste Technologies.* Federation of Canadian Municipalities. Data accessed on April 24, 2015 (URL: https://www.fcm.ca/Documents/tools/GMF/Solid_Waste_as_a_Resource_Review_of_Waste_Technologies_EN.pdf)

[54] *Solid Waste as a Resource. Review of Waste Technologies.* Federation of Canadian Municipalities. Data accessed on April 24, 2015 (URL: https://www.fcm.ca/Documents/tools/GMF/Solid_Waste_as_a_Resource_Review_of_Waste_Technologies_EN.pdf)

3.2.3. BY-PRODUCTS OF ANAEROBIC DIGESTION

There are two main by-products of AD: biogas and digestate.

Biogas is a combination of methane and CO_2 that is produced when organic material decomposes. Biogas normally consists of 50-60% methane and 40-50% CO_2[55]. Biogas is a naturally occurring by-product of decomposition and occurs in landfills. However, AD allows for the natural occurrence of organic matter decomposition, within a confined space, to capture the biogas and harness these emissions for use as energy. The energy that is created from AD is used to not only fuel plant operations (8-30%[56]), but also can be sold to the electricity grid to add capacity (70-92%).

Digestate is a "nutrient-rich slurry"[57] that is mainly used as a fertilizer for agricultural land. Digestate is "usually separated to create a liquid and a solids product[58]." Liquid digestate is normally directly applied to agricultural land and results in a fertilizer that is less odorous than the original manure feedstock and less environmental harmful, as all of the GHGs have been removed during the AD process. The solid digestate can be used as livestock bedding or further processed[59] into a pelletized fertilizer that can then be applied to the land.

Currently CCEMC proponents have indicated that digestate fertilizer is not being commercially sold due to Canadian Food Inspection Agency (CFIA) regulations of agricultural products[60].

3.2.4. ANAEROIC DIGESTION EMISSION REDUCTION POTENTIAL [61]

An AD facility can be configured in many different ways and the protocol for calculating emission reductions can apply in multiple different fashions. As such, ranges of emission reduction can be calculated.

With an AD facility producing emission reductions through:

- Diversion of waste from a landfill where the waste would have been left to decompose into methane
- Creation of organic-based electricity, substituting for the mostly fossil fuel-based electricity generation in Alberta
- Generation of thermal heat, substituting for the natural gas furnaces and boilers most Albertans use to heat buildings

For a typical **100,000 tonne waste processing AD facility**

- 240 – 480 kWh / t of waste can be generated
- 14 – 28 kt CO_2e emission reduction from displacing fossil fuel-based grid electricity can be generated
    - **40 – 50 kt CO_2e emission reductions** if waste diversion from landfills is included

A 100,000 tonne AD facility could replace a 4 MW coal or natural gas electricity generation facility. Based on the amount of waste produced by Alberta (approximately 35 Mt waste / year), there could be a

[55] *Technical Guidance for the Quantification of Specified Gas Emissions from Landfills.* Specified Gas Emitters Regulation. Version 1.2. November 2008. Government of Alberta . Data accessed on May 13, 2015 (URL: http://esrd.alberta.ca/focus/alberta-and-climate-change/regulating-greenhouse-gas-emissions/greenhouse-gas-reduction-program/compliance-information-for-industry/documents/TechnicalGuidanceDocument-Landfill.pdf)

[56] Based on conversations with industry participants

[57] Kelleher Environmental. *Canadian Biogas Study Benefits to the Economy, Environment and Energy. Summary Document*. Biogas Association. November 2013. Data accessed April 1, 2015 (URL: http://www.biogasassociation.ca/bioExp/images/uploads/documents/2013/resources/Canadian_Biogas_Study_Summary.pdf)

[58] Alexander, Ron. *Digestate Utilization In The U.S.* BioCycle. January 2012, Vol. 53, No1, p.56. Data accessed on May 13, 2015 (URL: http://www.biocycle.net/2012/01/12/digestate-utilization-in-the-u-s/)

[59] An example of a company in Canada that provides technology to pelletize biomass is Vecoplan (http://www.vecoplanllc.com/markets/biomass-pelletizing)

[60] Additional details on the CFIA regulations for fertilizers can be found on the Government of Canada Canadian Food Inspection Agency website (http://www.inspection.gc.ca/plants/fertilizers/eng/1299165827648/1299165914316)

[61] Information in this section was gathered from i) Christine Schuh, associate partner at PricewaterhouseCoopers LLP, on August 7, 2015 and ii) industry partners

maximum of 350 similarly sized AD facilities producing 1,400 MW of electricity (9% of the electricity currently on Alberta's grid). However, it is unlikely that all waste will be used in electricity generation – assuming 10% of Alberta's waste is used as feedstock for electricity generation, emission reductions could be at least 0.7 Mt CO2e and generation of up to 140 MW of organic-based electricity.

3.2.5. BENEFITS OF ANAEROBIC DIGESTION

The main benefit of AD is the production of a renewable energy that stabilizes waste organics through the AD process[62]. Below is a highlight of the main benefits, including energy generation.

3.2.5.1. Footprint

In comparison to landfills, AD facilities are estimated to need only between three to five hectares of land[63], but will vary from vendor to vendor based on the specific size and needs of the facility being designed.

If an anaerobic digester is incorporated into an existing facility (i.e. landfill or wastewater treatment plant) the footprint becomes even smaller.

3.2.5.2. Additional Employment for Alberta

It is estimated that approximately 12-13 staff would be required for an AD facility that is located in conjunction with either an existing landfill or wastewater treatment plant[64].

If the AD facility was to be a 366,032 tonnes / year greenfield operation, additional employment would result due to the inability to share staff, and the construction workers needed to build the facility. In this scenario, it is estimated that 200 full-time construction jobs would be created during the span of construction, and approximately 30-40 permanent operational facility positions[65].

3.2.5.3. Emission Reduction

Full details on the emission reduction potential of AD in Alberta can be found in Section 3.2.4. above.

The emission reduction calculation for AD facilities is based on inputs, technology, and process. In Alberta, the government has set emission reduction calculation parameters that are complex calculations outlined in the *Quantification Protocol for the Anaerobic Decomposition of Agricultural Materials* under the Specified Gas Emitters Regulation[66]. Under the current protocols, the agricultural sector (i.e. dairy and hog operation open storage lagoons) is not included as a large emitter of GHGs. There is a potential opportunity here to review the Quantification Protocols to further potential GHG reductions.

Currently, Alberta is the largest energy and GHG emission producer in Canada (Figure 7).

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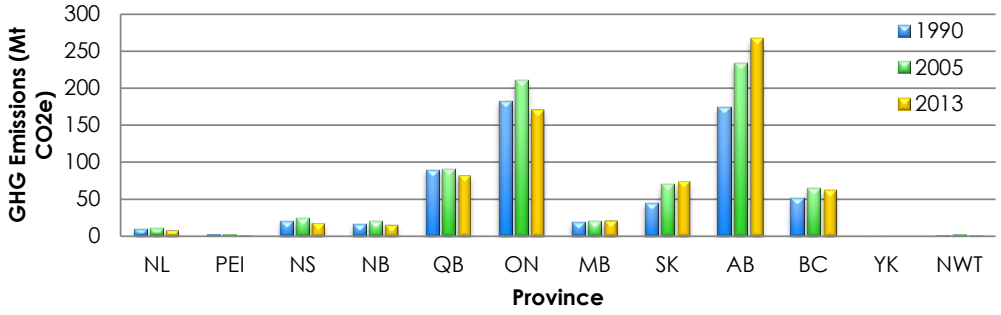
[62] *Biogas Energy Potential in Alberta.* Government of Alberta. Revised May 2011. Agri-Facts Agdex 768-3. Data accessed on April 22, 2015 (URL: http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex11397/$file/768-3.pdf?OpenElement)

[63] *Municipal Solid Waste (MSW) Options: Integrating Organics Management and Residual Treatment/Disposal.* Municipal Waste Integration Network & Recycling Council of Alberta. April 2006. Data accessed on April 21, 2015 (URL: https://recycle.ab.ca/uploads/File/pdf/MSWworkshop/MSW_Options_Report.pdf)

[64] *Municipal Solid Waste (MSW) Options: Integrating Organics Management and Residual Treatment/Disposal.* Municipal Waste Integration Network & Recycling Council of Alberta. April 2006. Data accessed on April 21, 2015 (URL: https://recycle.ab.ca/uploads/File/pdf/MSWworkshop/MSW_Options_Report.pdf)

[65] *Phase 3, Task 7: Capital and Operating Costs. An assessment of life-cycle costs and benefits associated with potential development of an energy from waste facility.* Prepared by HDR. Approved by SAEWA. January 27, 2012. Project#147454. Data accessed on April 23, 2015 (URL: http://www.saewa.ca/pdf/engineering_study/Task7.pdf)

[66] *Specified Gas Emitters Regulation. Quantification Protocol for the Anaerobic Decomposition of Agricultural Materials.* Alberta Environment. September 2007. Version 1. Data accessed on May 7, 2015 (URL: http://environment.gov.ab.ca/info/library/7917.pdf)



Source: Environment Canada (2015) National Inventory Report 1990–2013: Greenhouse Gas Sources and Sinks in Canada[67]

Figure 7: GHG Emissions, by Province and Territory (1990 – 2013)

For Alberta to reach the province's 2020 emission reduction targets there will need to be a shift in the trend of using petroleum resource production as the main source of energy and fuel in the province. AD is an alternative method that can reduce GHG emissions.

With the new Alberta government's commitment to renewable energy this is an important time for the biogas industry to engage with their elected officials and senior bureaucrats[68].

3.2.5.4. Additional Environmental Benefits

Outside of reducing emissions, there are additional environmental benefits that AD facilities can provide[69]:

- Reduced water contamination risks due to stabilized nutrients (i.e. reduced pathogen levels versus undigested manure)
- Increased nutrient recovery and recycling opportunities
- Reduction of odours during storage and decomposition that alternative strategies produce (i.e. compost, landfill)
- A natural, efficient, and biological waste treatment process that is confined

3.2.5.5. Energy Generation

Alberta electricity supply has increased capacity over the last 15 years, with biomass now accounting for 2.86% of the provincial capacity (Table 9)[70]

Table 9: Alberta Electricity Capacity

Generating Capacity	Megawatt (MW)	Percent of Total Capacity
Coal	6,258	42.87%
Gas	5,812	39.81%
Wind	1,113	7.62%

[67] *Greenhouse Gas Emissions by Province and Territory*. Environment Canada. Data accessed on May 7, 2015 (URL: https://www.ec.gc.ca/indicateurs-indicators/default.asp?lang=en&n=18F3BB9C-1)
[68] *NDP Platform 2015. Diversified Economy*. Alberta's NDP Party. Data accessed on May 7, 2015 (URL: https://web.archive.org/web/20150423162547/http://www.albertandp.ca/platform)
[69] *Biogas Opportunities Roadmap. Voluntary Actions to Reduce Methane Emissions and Increase Energy Independence*. US Department of Agriculture, US Environmental Protection Agency, US Department of Energy. August 2014
[70] *Electricity Statistics*. Alberta Energy. Data accessed on April 28, 2015 (URL: http://www.energy.alberta.ca/Electricity/682.asp)

Generating Capacity	Megawatt (MW)	Percent of Total Capacity
Hydro	900	6.17%
Biomass	**417**	**2.86%**
Waste Heat	86	0.59%
Fuel Oil	12	0.08%
TOTAL	**14,598**	**100%**

Source: Alberta Energy, September 2014

The below table highlights the biogas energy potential for various feedstock in Alberta[71].

Table 10: Livestock and Municipal Feedstock Material and Biogas Energy Potential – Alberta

Feed Material	Total solids (%)	Volatile solids (%) of total solids	Biogas yield (m^3/tonne)	Annual biomass production (tonnes)	Annual energy potential (PJ)	Methane content (%)
Beef cattle manure	8 – 12	80 – 85	19 – 46	22,955,019	8.7 – 21.1	53
Hog manure: grower to finisher	9 – 11	80 – 85	28 – 46	1,848,415	1.0 – 1.7	58
Dairy manure	12	80 – 85	25 – 32	3,217,714	1.6 – 2.1	54
Poultry manure	25 – 27	70 – 80	69 – 96	284,342	0.4 – 0.5	60
Animal fat	89 – 90	90 – 93	801 – 837	87,000	1.4 – 1.5	n/a
Animal carcass (homogenized-bovine)	34 – 39	90 – 93	348 – 416	264,023	1.8 – 2.2	n/a
Municipal wastewater sludge	30 – 20	90	17 – 140	539,835	0.2 – 1.5	65
Household waste	n/a	n/a	143 – 214	n/a	n/a	n/a
Total straw and other roughages	70	90	105 – 158	2,654,585	5.6 – 8.4	60 – 70
This stillage (ethanol by-product)	7	-	58	105,000	-	50 – 60
Total manure (including municipal sludge) and straw and other roughages	-	-	-	31,850,933	21 – 39	50 – 70

Source: Source: Biogas Energy Potential in Alberta. Government of Alberta. Revised May 2011. Agri-Facts Agdex 768-3

3.2.5.6. Social Perception

With Alberta being one of the main locales for fossil fuel extraction, there is an opportunity for government to proactively support alternative energy sources that could offset some of the negative environmental impacts that fossil fuel extraction produces. With a new public dialogue the AD and biogas industry has an opportunity to increase conversations with regulators and policy makers.

[71] *Biogas Energy Potential in Alberta.* Government of Alberta. Revised May 2011. Agri-Facts Agdex 768-3. Data accessed on April 22, 2015 (URL: http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex11397/$file/768-3.pdf?OpenElement)

3.3. REGULATORY / POLICY

With the review of the province's climate change strategy[72] this is an opportune time for the AD and biogas industry to engage with policy makers. With biogas as an alternative energy that provides application in agriculture, environment, and energy, this is an alternative that is very relevant to Alberta. Below is an outline of the existing policies and regulations, which were approved by the Alberta government prior to 2015.

The regulatory process for the establishment of a biogas facility in Alberta encompasses four different departments of government in Alberta:

- Municipal/County
- Alberta Agriculture and Forestry
- Alberta Environment and Parks
- Alberta Energy

Each of these departments have different regulations and policies in place that biogas facilities have to meet in order to receive permits to execute on construction. Based on conversations with industry participants, both small and large generators[73], the regulatory process from start to issuance of the required permits (four in total) will take at minimum three years, up to seven or eight years. The length of the timeline for permit issuance is due to many reasons, such as[74]:

- Infancy of the industry in Alberta
- Delays in distribution or transmission agencies conducting connection audits
- Need for noise assessments
- Necessity for biogas fuel source upstream process review, potentially by both Alberta Energy and Alberta Environment and Parks
- Minimal coordination among the three provincial divisions involved in the process
- Differing rules between Alberta Agriculture and Forestry and Alberta Environment and Parks regarding land application rules
- Requirements for identifying, securing, and proving financial security in the event of bankruptcy and land decontamination under Alberta Environment and Parks regulations
- Length of acceptance terms in the Interconnection Proposal
- Reliance on the divisions' timelines and not necessarily solely the project timelines (time management between project and regulatory divisions)

The below two tables outline the regulatory considerations for either an

- **On-farm (manure only) Facility (Table 11)**
  - Digestate – governed by AOPA and NRCB's land application rules
  - Biogas – governed by Rule 007 and AUC's discretion
- **On-farm (manure plus waste) Facility or Off-farm (manure plus waste) Facility (Table 12)**
  - Digestate – governed mainly by the Environmental Protection and Enhancement Act (EPEA), with a memorandum of understanding between Alberta Environment and Parks and Alberta Agriculture and Forestry that places NRBC's land application rules into effect
  - Biogas - governed by Rule 007 and AUC's discretion

For the on-farm (manure-only) Facility, three of the four departments of government are involved (Municipal, Alberta Agriculture and Forestry, and Alberta Energy)[75], while in the second option, all four departments of government are involved. In each of these scenarios however there are multiple paths that can be taken depending on the size of the biogas facility.

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[72] A five member expert panel has been assembled that will be guiding the discussions with the public and aiming to create an architecture of the policy for review by December 2015.
Krugel, Lauren. *Alberta public to have say in climate change policy review.* August 14, 2015. The Globe and Mail website. Data accessed on October 9, 2015 (URL: http://www.theglobeandmail.com/news/alberta/alberta-public-to-have-say-in-climate-change-policy-review/article25969636/)

[73] Small generators are less than 1 MW, while large generators are greater than 1 MW

[74] Based on conversations with industry participants

[75] It is important to note that if an On-Farm (manure-only) Facility chooses to store and/or flare the excess biogas instead of selling it into the grid, then only two divisions are involved: municipal and Alberta Agriculture and Forestry. It is rare for this to occur though.

Table 11: On-Farm (manure-only) Facility Regulatory Considerations

Municipal	Alberta Agriculture and Forestry	Alberta Environment and Parks	Alberta Energy
Development permits necessary for zoning approvals and construction Construction permits	Governing Act: **Agricultural Operation Practices Act (AOPA)** AOPA is **enforced by the Natural Resources Conservation Board (NRCB)** Land application rules for the digestate by-product fall to Alberta Agriculture and under the NRCB's jurisdiction	n/a	Governing Regulation: **Rule 007** Regulations are **enforced by the Alberta Utilities Commission (AUC)** Three separate policies are eligible under this regulation 1. Micro-Generation Policy (see Section 3.1. below for additional details with respect to this policy) a) Renewable resource only b) Only for off-setting own consumption c) Allowance of net-metering 2. Small Power Plant Regulation (Directive 28, Schedule 2) a) Renewable resource only b) Surplus of electricity (i.e. more than the facility needs) → commercial electricity generator i) Simplified process if under 1 MW 3. Full Power Plant Regulation Under this regulation, producers need to provide the following, while the AUC also performs an upstream process review due to the alternative fuel source (i.e. biogas) a) Municipal development permits b) Letter stating access to the grid is available (provided by a distributor[76]) c) Noise assessment An Interconnection Proposal (coordinated with the local distribution and/or transmission company) is then issued and valid for 60 days – this proposal provides an outline on the cost to actual execute connection to the grid a) Acceptance – requires 100% of funds to be paid upfront b) Decline – re-application and fees have to be incurred again[77] Once the producer accepts the Interconnection Proposal, the distributor will then (once payment is received) plan out the construction and provide a timeline AUC then issues a power plant approval and connection order At this point the producer can begin construction (tying timelines into the distributor construction timeline)

[76] There are nine main distribution companies in Alberta that distribute electricity and monitor connection to the grid, including: AltaGas Utilities, ATCO Electric, City of Lethbridge, EPCOR Distribution Inc., ENMAX Power Corp., FortisAlberta Inc., City of Medicine Hat Electric, City of Medicine Hat Natural Gas, and City of Red Deer Electric Light & Power
[77] Based on conversations with industry participants, normally producers will have to go through the regulations process, which results in the Interconnection Proposal at least twice due to costs and ability to raise necessary funds within 60 days of receiving pricing

Table 12: On-Farm (manure+waste) Facility or Off-Farm (manure+waste) Facility Regulatory Considerations

Municipal	Alberta Agriculture and Forestry	Alberta Environment and Parks	Alberta Energy

Development permits necessary for zoning approvals and construction
 	
Construction permits
	Governing Act: **Agricultural Operation Practices Act (AOPA)**
	
	AOPA is **enforced by the Natural Resources Conservation Board (NRCB)**
	
	Since the waste stream into the facility is now considered more than just agricultural inputs (i.e. waste stream + manure) the AOPA and NRCB is no longer the governing act that covers this type of facility. The governing act and enforcement switches over to Alberta Environment.
		Governing Acts:
		
		• **Environmental Protection Enhancement Act (EPEA)**
		  • **Activities Designation Regulation (ADR)** – Schedule 2 – facility classification – is a subset of the EPEA registration process
		
		Under these two acts, the biogas facility is now considered a waste management facility, and as such need to not only apply under the AUC for power generation permits, but must also under Alberta Environment provide sufficient financial security in the event that the facility goes bankrupt and land decontamination needs to be performed.
		
		Alberta Environment hence performs an upstream process review of the biogas fuel source‡
		
		In addition to the financial security and upstream process review, Alberta Environment also does not have guidelines specific for biogas facilities, as they are still new to Alberta, and as such, storage guidelines for digestate and biogas are built to existing petroleum standards, which add addition costs to the overall construction of the project,
		
		Since the biogas facility falls under Alberta Environment' and Parks jurisdiction, and not Alberta Agriculture and Forestry, the odour control system requirements also change and feedstock needs to be stored in a building with filtration systems
		
		After all of the above is completed, in parallel with AUC and municipal permit applications, the land application rules from Alberta Environment and Parks, which differ from Alberta Agriculture and Forestry land applications
			Governing Regulation: **Rule 007**
			
			Regulations are **enforced by the Alberta Utilities Commission (AUC)**
			
			Three separate policies are eligible under this regulation
			
			1. Micro-Generation Policy (see Section 3.1. below for additional details with respect to this policy)
			  a) Renewable resource only
			  b) Only for off-setting own consumption
			  c) Allowance of net-metering
			2. Small Power Plant Regulation (Directive 28, Schedule 2)
			  a) Renewable resource only
			  b) Surplus of electricity (i.e. more than the facility needs) → commercial electricity generator
			  i) Simplified process if under 1 MW
			3. Full Power Plant Regulation
			
			Under this regulation, producers need to provide the following, while the AUC also performs an upstream process review due to the alternative fuel source (i.e. biogas)
			
			a) Municipal development permits
			b) Letter stating access to the grid is available (provided by a distributor[78])
			c) Noise assessment
			
			An Interconnection Proposal (coordinated with the local distribution and/or transmission company) is then issued and valid for 60 days – this proposal provides an outline on the cost to actual execute connection to the grid
			
			a) Acceptance – requires 100% of funds to be paid upfront

[78] There are nine main distribution companies in Alberta that distribute electricity and monitor connection to the grid, including: AltaGas Utilities, ATCO Electric, City of Lethbridge, EPCOR Distribution Inc., ENMAX Power Corp., Fortis Alberta Inc., City of Medicine Hat Electric, City of Medicine Hat Natural Gas, and City of Red Deer Electric Light & Power

Municipal	Alberta Agriculture and Forestry	Alberta Environment and Parks	Alberta Energy
	Land application rules for the digestate by-product, under the MOU between Alberta Agriculture and Forestry and Alberta Environment and Parks, fall to Alberta Agriculture and Forestry and under the NRCB's jurisdiction	(governed by NRCB) technically come into play for the biogas facility. However Alberta Environment and Parks and Alberta Agriculture and Forestry have established a memorandum of understand (MOU) that • If the manure feedstock is 50% or more of the input, then land application rules will fall back to NRCB See Section 3.2. below for additional regulations related to GHG quantification protocols that Alberta Environment has established.	b) Decline – re-application and fees have to be incurred again[79] Once the producer accepts the Interconnection Proposal, the distributor will then (once payment is received) plan out the construction and provide a timeline AUC then issues a power plant approval and connection order At this point the producer can begin construction (tying timelines into the distributor construction timeline)

‡ This is the same type of review done by the AUC, however there is no harmonization or coordination between the two divisions. So in essence, the same work is being performed twice.

[79] Based on conversations with industry participants, normally producers will have to go through the regulations process, which results in the Interconnection Proposal at least twice due to costs and ability to raise necessary funds within 60 days of receiving pricing

3.1. MICRO-GENERATION POLICY

Micro-generation Regulation

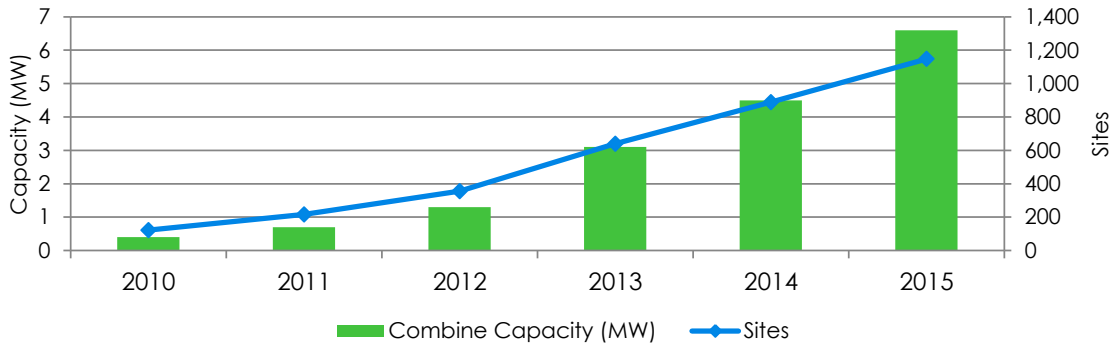
This regulation allows for Albertans to generate electricity from renewable resources or alternative energy (such as anaerobic digestion) and receive credit for the excess sent to the electricity grid.

There are two categories that an Alberta micro-generator could fall into:

- Small: <150kW generated capacity
- Large: >150 kW, but <1MW of generated capacity

Additional details on the full micro-generation regulation can be found at http://www.auc.ab.ca/involving-albertans/micro-generation/Pages/default.aspx

In Alberta there are currently 1,147 sites that are classified as micro-generators, which account for a combined 6.6MW of capacity on the grid (Figure 8)[80].



Source: Alberta Energy, 2015

Figure 8: Micro-Generators in Alberta

Through discussions with industry participants, many indicated that the micro-generation regulations were put in place to help micro-generators navigate the regulatory framework with ease and quicker. Unfortunately, many of the CCEMC proponents do not qualify for the micro-generation requirements as their facilities are greater than 1MW and generate excess energy that they wish to sell back into the grid. As such, many CCEMC proponents have to compete with significantly larger competitors (i.e. ATCO Power, TransAlta, Capital Power and Enmax - distributors).

In addition to the micro-generation regulations set out by the Alberta Utilities Commission (AUC), the Alberta Electric System Operator (AESO) is responsible for the operation of the Alberta Interconnected Electric System (AIES), which consists of all energy transmission facilities and distribution systems in Alberta[81]. There are nine main distribution companies in Alberta that distribute electricity and monitor connection to the grid, including: AltaGas Utilities, ATCO Electric, City of Lethbridge, EPCOR Distribution Inc., ENMAX Power Corp., Fortis Alberta Inc., City of Medicine Hat Electric, City of Medicine Hat Natural Gas, and City of Red Deer Electric Light & Power[82]. The AESO has a seven stage process for getting connected to the AIES (Figure 9) that takes approximately 96 weeks (1

[80] *What is Micro-generation?* Alberta Energy. Data accessed on April 28, 2015 (URL: http://www.energy.alberta.ca/electricity/microgen.asp)
[81] *AIES – Alberta Interconnected Electrical System.* Alberta Federation of Rural Electrification Associations. Data accessed on April 28, 2015 (URL: http://www.afrea.ab.ca/aies-alberta-interconnected-electrical-system)
[82] *Distribution Companies.* Alberta Government. Data accessed on April 28, 2015 (URL: http://www.ucahelps.alberta.ca/distribution-companies.aspx)

year 10 months) to navigate through.

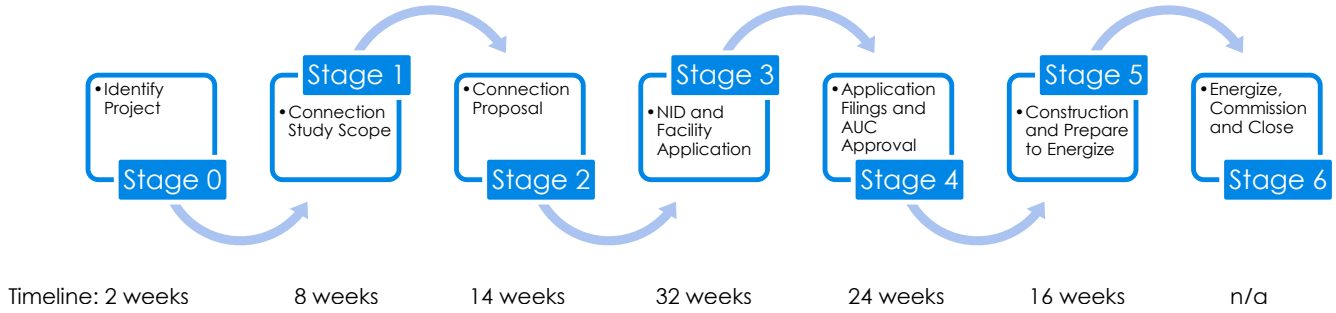


Figure 9: AESO Connection Process[83]

3.2. ENVIRONMENTAL REGULATIONS

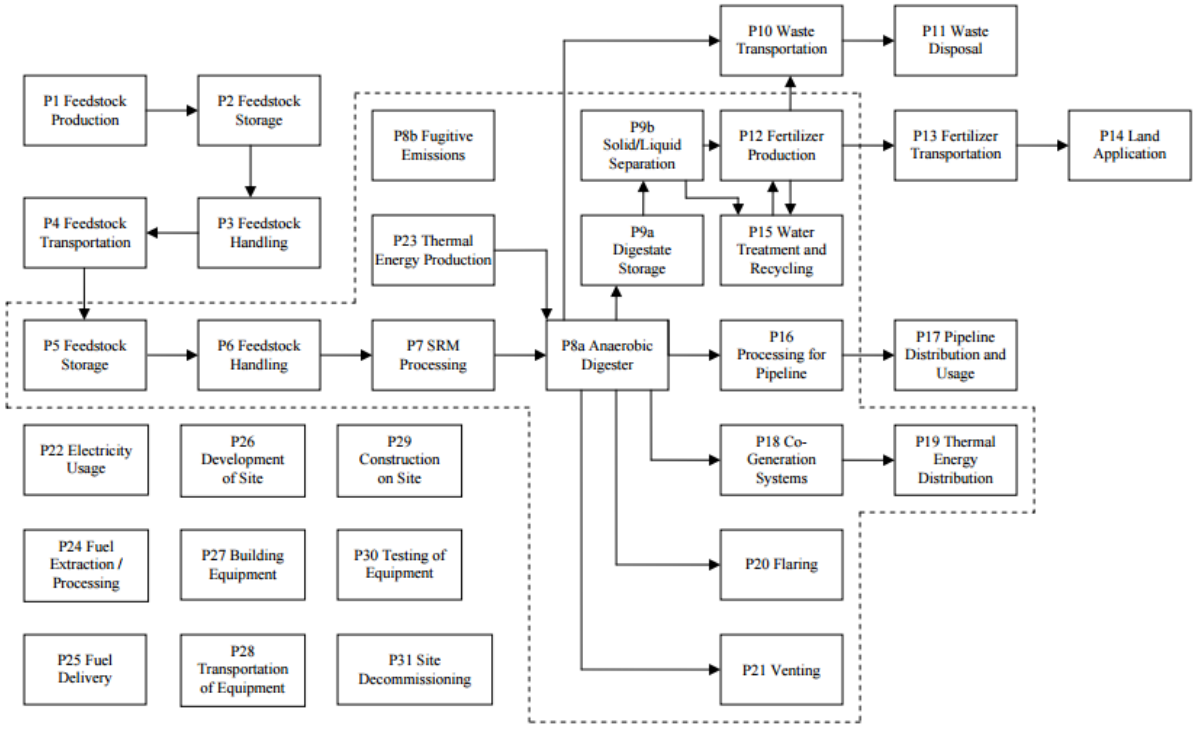
Alberta Environment and Parks has developed and published a *Quantification Protocol for the Anaerobic Decomposition of Agricultural Materials* under the Specified Gas Emitters Regulation[84]. This protocol is specifically designed for facilities that choose to claim and / or sell their offset credits. If a facility does not choose to claim and / or sell their carbon offset credits, then this regulation will not come into play during the approval process.

Under this protocol, project developers must:

- *Demonstrate that the agricultural material would have been managed differently (collected, processed, and either land spread, sent to landfill or incinerated as per the current agricultural practices – as confirmed by an affirmation from the biomass supplier*
- *For projects where methane production processes are enhanced (e.g. mesophilic, thermophilic, etc.) the anaerobic digestion facility manages the risk of fugitive emissions in keeping with the guidance provided in APPENDIX A as evidenced by an affirmation from the project developer and applicable records*
- *The digestate does not undergo active windrow composting as indicated by an affirmation from the project proponent*
- *The quantification of reductions achieved by the project is based on actual measurement and monitoring (except where indicated in this protocol) as indicated by the proper application of this protocol*
- *The project must meet the requirements for offset eligibility as specified in the applicable regulation and guidance documents for the Alberta Offset System*

Figure 10 below shows what a typical project process flow would be under this protocol.

[83] *Get Connected.* AESO Alberta Electric System Operator. Data accessed on April 28, 2015 (URL: http://www.aeso.ca/connect/#overview)
[84] *Specified Gas Emitters Regulation. Quantification Protocol for the Anaerobic Decomposition of Agricultural Materials.* Alberta Environment. September 2007. Version 1. Data accessed on May 7, 2015 (URL: http://environment.gov.ab.ca/info/library/7917.pdf)



Source: Quantification Protocol for the Anaerobic Decomposition of Agricultural Materials under the Specified Gas Emitters Regulation, 2007

Figure 10: Quantification Protocol Process Flow Diagram

During conversations with industry participants, it was brought to light that the existing protocol outlined above does not include avoided methane emissions from open liquid manure lagoons. With agricultural livestock (manure and by-products) being one of the main feedstock for AD, adjustments to the *Quantification Protocol for the Anaerobic Decomposition of Agricultural Materials* under the *Specified Gas Emitters Regulation* may be required.

Detailed information about the quantification protocol can be found on the Alberta Environment and Parks website (http://esrd.alberta.ca/).

3.3. OTHER CONSIDERATIONS

In addition to the four departments above that biogas facilities need to go through to be able to construct and operation the facility, each facility also needs to manage the delivery of feedstock to the facility (i.e. tipping fees).

The average landfill tipping fee in Alberta is $71.30 per tonne[85]. Based on conversations with industry participants, landfill tipping fees range between $30 and $65 depending on the local municipality[86]. These tipping fees are a reflection of landfill operating cost, but do not reflect the environmental cost of tipping materials into a landfill.

With biogas facilities aiming to reduce GHG emissions, it is difficult to compete with landfill tipping fees when these fees do not reflect the true, long-term cost of tipping into a landfill.

[85] *Waste Management Strategy. Background Report 2012 – 2022. Sustainable, Cost Effective Solid Waste Management.* City of Medicine Hate Environmental Utilities Department. July 13, 2011. Data accessed on May 11, 2015 (URL: http://www.city.medicine-hat.ab.ca/modules/showdocument.aspx?documentid=295)

[86] Based on conversations with industry participants at the April 17, 2015 Round Table Discussion held in Calgary, AB

If the Alberta government reviewed tipping fees and could reflect the long-term value of tipping waste into a landfill, this could assist with the diversion of waste to alternative energy facilities and reflect the value biogas facilities add to the Alberta environment and their economic viability.

3.4. FINANCIALS

The financial feasibility of AD has always been the major challenge for participants in the industry to succeed as a sustainable industry. Incentives are required to make biogas and AD facilities economically viable in Alberta[87].

Traditional methods of disposal for waste in Alberta have been through landfill sites.

- **Capital Investment**

The capital cost for the development of an AD facility can range between $26,750,000 and $34,000,000, depending on the feedstock input and technology implemented at a facility[88, 89]. Additional details can be found in Appendix 5.2. Financials – Operating Costs.

- **Operating Costs**

The annual operating cost of a landfill site is $6,222,126 for a 100,000 tonne site[90]. This is in comparison to an AD facility processing MSW which would be between $6,134,000 and $6,790,000, depending on the type of feedstock[91] (see Table 13). With AD facilities mainly using agricultural livestock (manure and by-products) and SSO as their main feedstock, it is expected that **operating costs for an AD facility in Alberta would be approximately $3,067,000 to $3,395,000** (50% less than the operation cost of a MSW feedstock facility)[92]. Full details on the breakdown of the costing for each alternative can be found in Appendix 5.2. Financials – Operating Costs.

Table 13: Operating Cost Comparison – Landfill versus Anaerobic Digestion Facility

	Landfill Cost (100,000 tonne facility)	AD facility (SSO) (100,000 tonnes)	AD facility (MSW) (100,000 tonnes)
Annual Operating Cost	6,222,126	6,134,000	6,790,000

Even though Canada has been slow at adopting AD due to high initial capital costs[93], there are economies of scale that can be realized by implementing AD facilities. Based on the March 2006 BIOCAP Canada report by Emad Ghafoori and Peter Flynn "small farm based manure digesters are less cost effective than centralized units that receive manure from many producers[94]."

[87] *NDP Platform 2015. Health Care.* Alberta's NDP Party. Data accessed on May 7, 2015 (URL: https://web.archive.org/web/20150423162547/http://www.albertandp.ca/platform)
[88] *Municipal Solid Waste (MSW) Options: Integrating Organics Management and Residual Treatment/Disposal.* Municipal Waste Integration Network & Recycling Council of Alberta. April 2006. Data accessed on April 21, 2015 (URL: https://recycle.ab.ca/uploads/File/pdf/MSWworkshop/MSW_Options_Report.pdf)
[89] *Report Card on the Alberta Bioenergy Producer Credit Program. Impacts on Biofuel Capacity, Environmental Improvements and Economic Multipliers.* Prepared by Viresco Solutions Inc. September 2015. Data accessed on September 2, 2015.
[90] *Phase 3, Task 7: Capital and Operating Costs. An assessment of life-cycle costs and benefits associated with potential development of an energy from waste facility.* Prepared by HDR. Approved by SAEWA. January 27, 2012. Project#147454. Data accessed on April 23, 2015 (URL: http://www.saewa.ca/pdf/engineering_study/Task7.pdf)
[91] *Municipal Solid Waste (MSW) Options: Integrating Organics Management and Residual Treatment/Disposal.* Municipal Waste Integration Network & Recycling Council of Alberta. April 2006. Data accessed on April 21, 2015 (URL: https://recycle.ab.ca/uploads/File/pdf/MSWworkshop/MSW_Options_Report.pdf)
[92] Based on conversations and consultation with industry participants.
[93] *Municipal Solid Waste (MSW) Options: Integrating Organics Management and Residual Treatment/Disposal.* Municipal Waste Integration Network & Recycling Council of Alberta. April 2006. Data accessed on April 21, 2015 (URL: https://recycle.ab.ca/uploads/File/pdf/MSWworkshop/MSW_Options_Report.pdf)
[94] Ghafoori, Emad, Peter Flynn. *Optimum Sizing for Anaerobic Digestion.* BIOCAP Canada. March 2006. Data accessed on April 24, 2015 (URL: http://www.cesarnet.ca/biocap-archive/rif/report/Flynn_P.pdf)

The CCEMC has an opportunity to create case studies that reflect each of the following options that could be used to support discussions between industry participants and the Alberta regulatory and policy makers.

For AD facilities in Alberta **to be economically viable, there are many different options that have been discovered through conversations with industry participants that could be reviewed and evaluated**.

- **Continuation of the Bioenergy Producer Credit Program**

  The Bioenergy Producer Credit Program was developed "*to encourage investment in bioenergy production capacity in Alberta in order to reduce reliance on fossil fuels*[95]." The program was discontinued in March 2013 and will cease assistance as of March 2016.

  By continuing this program, AD facilities could be supported through the development and acceptance of AD in Alberta.

- **Modification to the Micro-Generation Policy to reflect average electricity prices ($0.06-$0.07)**

  By modifying the micro-generation policy to higher thresholds (i.e. 3 MW or 5MW), this could allow for generators to take advantage of net meter readings, which allows for sustainability of the AD facilities as they grow and become accepted in Alberta as an alternative energy source.

- **Review of landfill tipping fees to reflect the environmental impact of tipping, and not just operational cost coverage**

- **Introduction of a feed in tariff (FIT) program to support the renewable energy sector in Alberta**

  The introduction of a FIT program could be viewed as a program to promote and support the development of alternative energies in the province.

- **Modification on how CCEMC funds are distributed to projects**

  Currently the CCEMC provides upfront payments and milestone payments to projects. Based on a suggestion received during discussions with industry proponents, providing continued support payments throughout the project instead of milestone payments would be a way for the CCEMC to show commitment and support to the industry.

3.5. RISKS

As with any new technology or alternative energy source, there are risks that need to be considered and mitigated. With respect to AD facilities, Section 3.1.2.1. Challenges outlined the challenges with AD and its eventual acceptance. Having the general public and government understand these challenges will be the largest mitigation strategy to allow the overall risk management of the facilities to succeed and eventually be accepted as an energy source in Alberta. Risks that AD facilities face include:

- **Running below full capacity**

  Many AD facilities economies are based on scale and full deployment of the facility and the technology. Without these economies of scale, the financial viable of facilities is challenging. By securing partnerships with municipalities and government to support the use of alternative energies is necessary to ensure success of this industry.

- **Transportation cost of feedstock**

  Being able to secure support from municipalities, neighboring farms, and the provincial government will help to keep transportation costs low for each facility.

- **Loss of feedstock**

  Ensuring partnerships are managed appropriately and that facilities are keeping current on other technologies in the industry that use the same feedstock is important. This can be done by an annual market review by either an industry association or third party consultant.

[95] *Bioenergy Producer Credit Program Guidelines.* Alberta Energy. March 2013. Data accessed on May 19, 2015 (URL: http://www.energy.alberta.ca/BioEnergy/pdfs/Guideline_March_2013_Including_3_Yr_Budgets.pdf)

- **Lack of support: Acceptance of AD as an alternative energy source**

  Without support from the Alberta and municipal governments to divert waste from landfills it is not clear how AD will be viable. Using every opportunity to meet with the public and the stakeholders to show how AD can impact the environment is important to the acceptance and support of AD. The introduction of a biogas association in Alberta to manage these meetings and discussions could be a first step.

- **Regulatory hurdles**

  Currently with the existing regulations and policies, it is prohibitive and time consuming for an AD facility to be constructed and operated in Alberta. Review of the existing policies, along with the potential extension of the Bioenergy Producer Credit Program[96] and introduction of a feed in tariff (FIT) program could help move sustainability of the AD industry in Alberta forward. The introduction of a biogas association to promote on behalf of industry participants will assist industry participants to navigate and provide input to the future regulatory framework.

- **Low energy prices (price of electricity, price of natural gas)**

  This is a difficult risk to mitigate, as energy prices are a commodity and as such are governed by market perceptions. Having the Alberta government continue to support the Bioenergy Producer Credit Program along with promotion of alternative energy sources is a start that could help mitigate this risk.

- **Cheap alternative energy sources (i.e. coal power)**

  AD facilities will always have competition, which is important and what makes a market healthy and encourages innovation.

  Until less costly fossil fuel sources are treated differently in Alberta though, this will be a very challenging risk to mitigate. Conversations with the provincial government are important to bring the benefits of AD to light and, in time, may encourage policy makers to review existing policies and work with the alternative energy sectors to make them more viable in the Alberta economy. The introduction of a biogas association to promote on behalf of industry participants to facilitate the conversations between the industry and government is a practical step.

[96] Details on the Producer Credit program can be found on the Alberta Energy website (http://www.energy.alberta.ca/bioenergy/1400.asp). This program has been discontinued and will cease support in 2016.

4.0. KEY INITIATIVESS

TEC Edmonton's suggested initiatives afford an opportunity for the CCEMC to provide information and assistance to industry participants who could take steps to form an industry association and engage with government to help support the industry through the barriers and hurdles that are perceived to exist today.

There are three overarching activities that underlie each initiative: i) partnership and collaboration, ii) policy and legislation, and iii) education and promotion. Keeping each of these in mind, TEC has three major initiatives for consideration:

1. Creation of a Biogas Association
2. Providing information to industry participants who can engage policy makers
3. Engaging with Individuals and organizations who are promoters of alternative energy

Each of these initiatives have supporting ideas that break out specific details identified for industry participants.

The table below is a summary of initiatives, which are focused on increasing the awareness of biogas AD in Alberta. TEC has ranked each initiative based on three criteria: i) time to implement, ii) cost to implement, and iii) the complexity of implementation. Each of these rankings are subjective rankings, and are based on TEC's perception and understanding of the environment in Alberta in May 2015.

Table 14: Summary of Key Considerations

	Key Considerations	Time to Implement	Cost to Implement	Complexity to Implement
1	CREATE A BIOGAS ASSOCIATION			
	1.1. Facilitate the co-operation of global biogas associations	◑	○	◑
2	ENGAGE POLICY MAKERS			
	2.1. Consider the review of landfill tipping fees	◑	◑	●
	2.2. Consider the review of the Micro-Generation Policy	◑	◑	●
	2.3. Consider the review of the carbon credit program	◑	◑	●
3	ENGAGE SUPPORTERS OF ALTERNATIVE ENERGY			
	3.1. Leverage pilot project sites for public education	◑	●	◑
	3.2. Continue partnership creation with feedstock providers	◑	○	◑
	3.3 Identify municipalities who are interested in diverting waste from landfills	○	○	●

The key to successful execution of the above opportunities is for the CCEMC and the Province of Alberta to engage with industry participants. Industry representatives can form an association and ensure that each recommendation has:[97]

- Clear long term plan with timelines, milestones, financials, and quantified goals
- Approach the biogas industry like a utility that is based on volume, free unlimited diversion options, difficult and expensive waste disposal options
- Convenience for all stakeholders involved
- Municipal support and is based on a supply of feedstock

[97] Rathbone, Geoff. *Getting to 50% and Beyond: Waste Diversion Success Stories from Canadian Municipalities. Target 70.* City of Toronto. February 10, 2010. Data accessed on April 24, 2015 (URL: http://www.fcm.ca/Documents/presentations/2010/SCC2010/Getting_to_50perc_beyond_Target70_EN.pdf)

Below are more detailed descriptions of each of the key initiatives.

4.1. CREATE A BIOGAS ASSOCIATION

With a growing interest in alternative energy provincially, nationally and globally, and with work underway to craft a new provincial climate change strategy there is an opportunity for the biogas industry in Alberta to take clear action.

It is a time for promoters of the biogas industry to meet with policy makers and support the development of future strategies. As such, **the CCEMC may choose to support participants in the biogas industry to create a biogas association that will promote and educate the community on their behalf**.

Based on conversations with the Biogas Association headquartered in Ontario[98], TEC found that there is interest from the association to increase their presence across Canada, and they are considering opening regional offices in the West. With this interest and consideration from the Biogas Association this could be an opportunity for the CCEMC to facilitate conversations between the Biogas Association and industry participants in Alberta. Working with an existing Canadian association may allow for reduced upfront set-up costs, and the regional office will benefit from the experience and knowledge available from head office.

TEC believes that this association could be **comprised of individuals who will be supporters and promoters for the biogas industry, and all aspects of the value chain.** TEC suggests that the **representation could include: government, technology providers, CCEMC, industry organization representation, and service providers**.

The below table offers a suggestion of supporters, not an exhaustive list, that TEC believes would be a good representation on the biogas association.

Table 15: Suggested Alberta Biogas Association Representation

Organization	Role / Position
Government	
Alberta Energy	Assistant Deputy Minister (ADM) Policy and technical representatives in • Electricity • Heat • Power
Alberta Environment & Parks	Assistant Deputy Minister (ADM) Policy and technical representatives in emission reduction
Alberta Agriculture & Forestry	Assistant Deputy Minister (ADM) Policy and technical representatives
Municipal Government	Policy and development representatives
CCEMC[99]	CEO
Technical	
	AITF
	AI Bio
	AI-EES
Technology Providers	
	Enerkem
	Veconplan?
	PlanET Biogas
Biogas Industry	
	Enerkem
	Lethbridge Biogas

[98] Primary research conversation with Jennifer Green from the Biogas Association on April 30, 2015
[99] Information provider only

Organization	Role / Position
	GrowTec
	Renew Bioenergy
	BioRefinex
	Permolex
	Growing Power Hairy Hill
Other (Service Providers and Supporters)	

4.1.1. FACILITATE THE CO-OPERATION OF GLOBAL BIOGAS ASSOCIATIONS

In conjunction with initiative 1, the CCEMC and industry association could support the engagement and connection of industry participants with other biogas associations globally to learn from their experiences and create the most effective biogas association in Alberta. Each biogas association will have strengths and approaches to challenges that could be observed and adapted to the Alberta marketplace. By doing this the CCEMC will be able to gather information that can be used to educate the greater community of the benefits of biogas and AD to the Alberta economy.

Biogas association industry participants could consider cooperation and collaboration with include:

- European Biogas Association (Germany) (http://european-biogas.eu/)
- American Biogas Council (United States, Washington, DC) (https://www.americanbiogascouncil.org/)
- Biogas Association (Canada, Ontario) (http://www.biogasassociation.ca/bioExp/)
- Global Alliance for Productive Biogas (Netherlands) (http://www.productivebiogas.org/)
- World Bioenergy Association (Sweden) (http://www.worldbioenergy.org/node/13)
- Anaerobic Digestion and Bioresources Association (United Kingdom) (http://adbioresources.org/)

4.2. ENGAGE POLICY MAKERS

The CCEMC could support the work of the Alberta biogas association to engage industry participants with government ministries and departments in all four areas of applicability for AD (Municipal Affairs, Alberta Agriculture and Forestry, Alberta Energy, and Alberta Environment and Parks). **The main focus of the engagement could be to collaborate, remove barriers to adoption and identify synergies across ministries and departments**.

The Biogas Association could demonstrate the benefits of AD (Section 3.2.4.) including how increasing adoption of AD will assist in reaching the 2020 GHG emission reduction targets.

The engagement between industry participants and policy makers could occur on a regular basis with all policy makers from each department and ministry. TEC expects that the CCEMC will play a supporting role where industry participants will:

- Outline new developments in the AD and biogas industry
- Update stakeholders on the status of AD projects in the province
- Highlight barriers to adoption that AD and biogas participants encounter

With AD still being a relatively new industry in Alberta, early adopters will have challenges to address. However TEC identified that even though AD is still new and navigating through regulations, there is hope that policies will change. Solar power, another renewable alternative energy, over the last ten years has made inroads as the province adapted and shifted policies to be applicable and relevant to the energy source itself[100, 101].

[100] Conversation with Chris Lerohl, TEC Edmonton on May 21, 2015
[101] Howell, Gordon. *Connecting to the Grid – Alberta's New Micro-Generation Regulations.* April 9, 2009. Howell-Mayhew Engineering, Inc. Data accessed on May 21, 2015 (URL: http://www.hme.ca/presentations/SESCI-NAC_-_Connecting_Micro-Generators_to_the_Grid_2009_04_21.pdf)

4.2.1. CONSIDER THE REVIEW OF LANDFILL TIPPING FEES

DISCUSS WITH POLICY MAKERS THE IMPORTANCE TO REVIEW LANDFILL TIPPING FEES TO REFLECT THE TRUE COST OF LANDFILLS ON THE ENVIRONMENT

Currently, the average landfill tipping fee in Alberta is $71.30[102], and based on conversations with industry participants landfill tipping fees range between $30 and $65 depending on the municipality[103]. These tipping fees are a reflection of landfill operating cost, but do not reflect the environmental cost of tipping materials into a landfill.

With tipping fees at this level, there is no diversion factor in place, as these costs are quite low. Until there is a financial impact on tippers, there are limited reasons to adopt diversion tactics.

The CCEMC may choose to support industry participants' (and/or the newly created Biogas Association's) engagement with policy makers in the province by providing research that can support the justification **of the environmental impact landfills have which will allow for open dialogue to potentially adjust the tipping fees to reflect the true cost**. Through conversations with industry organizations who participated in this research, one suggestion for amendment to tipping fees was:

> **Consider an additional fee**, similar to the carbon emissions fund, which would impose an additional carbon levy (suggested to be the same rate as the carbon emission fund), **on those who tip into landfills.**

4.2.2. CONSIDER THE REVIEW OF THE MICRO-GENERATION POLICY

DISCUSS WITH POLICY MAKERS TO REVIEW THE MICRO-GENERATION POLICY

Currently in Alberta there is a regulation, the Micro-Generation Policy, which has been introduced to make attaching to the electricity grid easier for micro-generators (less than 1 MW). This is an important step that the government needed to take. With the review of the provincial climate change strategy the provincial government may be interested in reviewing this policy and consider adjusting the eligibility requirements of the policy. As outlined in the BIOCAP Canada report by Ghafoori and Flynn[104], larger centralized units are more effective that small farm-based manure digesters. By having industry participants' work with the Alberta government to review and potentially amend the Micro-Generation policy, this may create a short-term win for the province to show progress towards achieving the 2020 targets and the acceptance of alternative energy sources.

Based on the conversations that TEC had with industry participants, **TEC identified that the CCEMC could support the Biogas Association's conversations between industry participants and policy makers to enable discussion around adjusting the micro-generator requirements from 1 MW to something higher such as 3MW and eventually 5MW**. This change in policy would allow for AD facilities to become economic faster and become more prevalent in the province. The CCEMC could support research with existing proponents to support industry participants' conversations with policy makers with the aim to ensure that supportive policies and regulations for the biogas industry are achieved, without negatively impacting any other stakeholder or industry involved in energy generation.

An alternative approach that the industry could explore with municipal and / or provincial government would be the introduction of a feed-in-tariff program (FIT). In Ontario, the FIT program was introduced to "*encourage and promote greater use of renewable energy sources including on-shore wind, waterpower, renewable biomass, biogas, landfill gas and solar photovoltaic (PV) for electricity generating projects in Ontario[105].*" With the Bioenergy Producer Credit Program rounding down, a FIT program in Alberta, whether municipal or provincially based would help the industry promote and showcase the benefits and viability of biogas.

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[102] *Waste Management Strategy. Background Report 2012 – 2022. Sustainable, Cost Effective Solid Waste Management.* City of Medicine Hate Environmental Utilities Department. July 13, 2011. Data accessed on May 11, 2015 (URL: http://www.city.medicine-hat.ab.ca/modules/showdocument.aspx?documentid=295)

[103] Based on conversations with industry participants at the April 17, 2015 Round Table Discussion held in Calgary, AB

[104] Ghafoori, Emad, Peter Flynn. *Optimum Sizing for Anaerobic Digestion.* BIOCAP Canada. March 2006. Data accessed on April 24, 2015 (URL: http://www.cesarnet.ca/biocap-archive/rif/report/Flynn_P.pdf

[105] *FIT Program*. Independent Electricity System Operator (IESO). Data accessed on May 19, 2015 (URL: http://fit.powerauthority.on.ca/fit-program)

4.2.3. CONSIDER THE REVIEW OF THE CARBON CREDIT PROGRAM AND PRODUCTION BASED CREDIT SYSTEM

DISCUSS WITH POLICY MAKERS TO REVIEW THE CARBON CREDIT PROGRAM AND PRODUCTION BASED CREDIT SYSTEM TO BENEFIT ALTERNATIVE ENERGY PRODUCERS

The existing carbon credit program in place in Alberta requires facilities that emit more than 100,000 tonnes CO_2e/ year to reduce their emissions to a specified target. For those unable to meet their target, one compliance option is to pay $15 / tonne into the Climate Change and Emissions Management Fund (CCEMF)[106].

Under the existing quantification protocols for AD facilities, due to the early stage of the industry, only approximately 30% of emissions are actually eligible for credit[107].

The CCEMC could support industry participants by providing information regarding quantification that they can use in discussions with policy makers to review and potentially amend the existing quantification protocols to allow AD facilities to either

- Be eligible to claim more of their actual CO_2e
- Increase the dollar amount per tonne of CO_2e that needs to be paid into the CCEMF by large emitters, which in turn will result in great revenue generation for AD facilities through their credit offset claims
- Combination of the above two options

During the preparation of this report, policy changes were introduced on June 30, 2015 to the carbon credit program and compliance options:

- 2015: $15 / tonne into the CCEMF
- 2016: increase to $20 / tonne into the CCEMF
- 2017: increase to $30 / tonne into the CCEMF

The Bioenergy Producer Credit Program was developed "to encourage investment in bioenergy production capacity in Alberta in order to reduce reliance on fossil fuels." The program was discontinued in March 2013 and will cease assistance as of March 2016.

The CCEMC may choose to support industry participants by providing information regarding quantification that they can use in discussions with policy makers to review and potentially re-introduce the Bioenergy Producer Credit System.

GERMAN BIOGAS INDUSTRY

Germany is a leader in the biogas industry in the world. In Germany there are close to 8,000 biogas plants and there are favourable regulations and policies in place to make biogas plant construction viable.

Policies and regulations in German include:

- Energiewende – Renewable Energies Sources Act (EEG)
  - Special regulation related to biodegradable waste where "post-rotting is a prerequisite for compost production"
- Local authorities are regulated and obligated to have separate waste collection for organic waste (2015)
- European Waste Framework Directive
- German Closed Cycle Management Act (2015)

However, it is interesting to note that in the last 12 months there have been additional restrictions added to the EEG that have made construction and economic viability very challenging for biogas plants. This new restrictive policy shows that over-regulation and restrictive policies is one of the main barriers to the economic viability and construction of biogas plants.

Additional details on the German Biogas Industry can be found in the *Biogas all-rounder. New Opportunities for Farming, Industry and the Environment (http://www.german-biogas-industry.com/)*

[106] *Welcome to the Alberta Carbon Registries.* Data accessed on May 12, 2015 (URL: http://www.csaregistries.ca/albertacarbonregistries/home.cfm)
[107] Based on TEC's conversations with industry participants

4.3. ENGAGE SUPPORTERS OF ALTERNATIVE ENERGY

4.3.1. LEVERAGE PILOT PROJECT SITES FOR PUBLIC EDUCATION

WORK WITH AN EXISTING CCEMC PROPONENT AND INTERESTED MUNICIPALITIES TO UTILIZE A PROJECT AS AN EDUCATIONAL SITE THAT IS ACCESSIBLE TO THE PUBLIC AND POLITICIANS TO CREATE ACCESS AND UNDERSTANDING TO THE BIOGAS INDUSTRY

The CCEMC has supported Lethbridge Biogas' design, construction, and implementation. This could be an ideal facility for an Alberta Biogas Association to leverage into an education site, as it is already constructed and community members would be able to tour and see the benefits of the facility immediately.

By providing access to education sites across the province a biogas association can showcase the benefits of AD and allow for the public to see how alternative energies can impact their everyday life.

4.3.2. CONTINUE PARTNERSHIP CREATION WITH FEEDSTOCK PROVIDERS

Having a provincial biogas association engage with individuals, organizations, and associations, will not only raise awareness for biogas uses, but also increase the AD and biogas participants understanding of the needs of the community.

Organizations that the provincial biogas association could facilitate regular engagements with include:

- Alberta Association of Municipal Districts and Counties (AAMDC)
- Alberta Urban Municipalities Association (AUMA)
- Alberta Dairy Council
- Alberta Dairy Farmers - members of the Alberta Holstein Association[108]
- Alberta Pork
- Alberta feedlots

As AD facilities are considering construction, it is critical that preliminary feedstock is secured prior to construction. It has been observed in Alberta that biomass projects normally always need to identify additional feedstock even after construction due to the demand for a free resource (i.e. manure, forestry waste, MSW, SSO, etc.)[109]. Due to this demand, and other biomass facilities that require the same feedstock (i.e. Enerkem facility in Edmonton), AD facility owners should consider, not only feedstock partnerships with neighbouring farms for the biological technical feedstock (i.e. manure), but also look at identifying organic wastes from hotels, hospitals, universities, and production plants[110] within reasonable transportation distance of the facility.

The CCEMC has a significant network of individuals and organizations in the biomass, biogas, and anaerobic digestion industries, and thus, supporting an association that would act as **a connector and network supporter** for existing and new participants is important.

4.3.3. IDENTIFY MUNICIPALITIES WHO ARE INTERESTED IN DIVERTING WASTE FROM LANDFILLS

Most municipalities in Alberta have set targets for managing and reducing waste[111]. Each municipality is different, but many are open to solutions that will help divert waste from landfills, and in turn reduce GHGs. The techniques for diversion and reduction are by either incorporating technologies into existing infrastructure projects (such as at landfills or water treatment plants, or into fleet vehicles[112]), or building new facilities.

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[108] Locations of dairy farmer members in Alberta can be found at http://www.albertaholstein.ca//Uploaded/members%20map.pdf

[109] Primary conversation on May 8, 2015 with an Alberta forester and CEO of an energy consulting firm with operations in Canada and the United States

[110] *Biogas Opportunities Roadmap. Voluntary Actions to Reduce Methane Emissions and Increase Energy Independence.* US Department of Agriculture, US Environmental Protection Agency, US Department of Energy. August 2014.

[111] Based on municipal waste management, diversion strategy, and targets review of major cities in Alberta (i.e. Edmonton, Calgary, Red Deer, Lethbridge, Medicine Hat, Fort McMurray, and Grande Prairie)

[112] *Innovation Forum: New Markets for Biogas. Final Report.* Biogas Association. June 2012. Data accessed on May 8, 2015 (URL: http://biogasassociation.ca/bioExp/images/uploads/documents/2012/singlePosts/IF_New_Markets_for_Biogas_Final_Report_June_28_FINAL_2.pdf)

Municipalities have an abundance of feedstock that is appropriate for AD use from both residential and non-residential waste. Identifying the municipalities that are interested in improving their waste management strategy and do not yet have AD facilities within a reasonable distance are the most promising locations for new AD facilities. With Edmonton already committing a large amount of their MSW and SSO to the City's new Enerkem facility, it would be **advantageous for AD facilities to proactively start discussions with other municipalities in the province that are close to the AD facility feedstock** (to reduce transportation costs). Research into each region to identify if feedstock is available, capital resources and municipal acceptance are necessary for each of the following **suggested regions for new plants** (Table 16).

Table 16: Potential Municipalities for a Future AD Facility

	Waste Diversion Targets	Additional Details
Calgary	Divert 80% of waste from landfills by 2020[113]	Has a biosolids to land program (Calgro) that looks "to examine environmentally-friendly alternatives to incinerating or depositing biosolids in the landfill[114]."
Fort McMurray	100% waste diversion from landfills by 2016[115]	Locate an AD facility in the region that will be specifically dedicated to the municipality. However agreements with aboriginal communities and major corporations with work camps in the region that have significant amounts of waste and organics will need to be negotiated to ensure sufficient feedstock The municipality has be considering and developing a Zero-Waste Facility in the region
Grande Prairie[116]	Increase recycling and composting to 33% by 2030 Reduce annual per capita municipal waste production to 1.15t by 2030	n/a
Medicine Hat[117]	No specific quantifiable targets defined, but a detailed document on steps the City will take to encourage waste diversion	n/a

Currently there are already AD facilities that are accessible for the below cities that have identified waste diversion targets

- Edmonton[118] (Enerkem)
- Vegreville, (Growing Power Hairy Hill)
- Red Deer[119] (Renew Bioenergy)

[113] *Waste and waste diversion.* The City of Calgary website. Data accessed on May 11, 2015 (URL: http://www.calgary.ca/UEP/ESM/Pages/State-of-the-Environment/Land/Waste-and-waste-diversion.aspx)
[114] *Calgro program overview.* The City of Calgary website. Data accessed on May 11, 2015 (URL: http://www.calgary.ca/UEP/Water/Pages/Water-and-wastewater-systems/Wastewater-system/Calgro-biosolids/Calgro.aspx)
[115] *Environmental Responsibility Plan. City Centre Redevelopment Entity.* City Centre McMurray. January 2013. Data accessed on May 11, 2015 (URL: http://www.citycentremcmurray.com/uploads/files/PDFs/RMWB_EnvironRespPlan.pdf)
[116] *New Regional Solid Waste and Recycling Plan a Roadmap for the Future.* Joint Media Release December 12, 2011. Country of Grande Prairie. Data accessed on May 11, 2015 (URL: http://www.countygp.ab.ca/assets/News/2011/news-111212.pdf)
[117] *Waste Management Strategy. Background Report 2012 – 2022. Sustainable, Cost Effective Solid Waste Management.* City of Medicine Hate Environmental Utilities Department. July 13, 2011. Data accessed on May 11, 2015 (URL: http://www.city.medicine-hat.ab.ca/modules/showdocument.aspx?documentid=295)
[118] *The Way We Green. The City of Edmonton's Environmental Strategic Plan.* The City of Edmonton. July 2011. Data accessed on May 20, 2015 (URL: http://www.edmonton.ca/city_government/documents/TheWayWeGreen-approved.pdf)

- Lethbridge[120] (Lethbridge Biogas and GrowTec)

However, additional facilities in the larger municipalities (i.e. Edmonton and Calgary) may be possible due to large amounts of MSW and SSO available.

[119] *The City of Red Deer Waste Management Master Plan.* City of Red Deer website. April 2013. Data accessed on May 11, 2015 (URL: http://www.reddeer.ca/media/reddeerca/city-services/garbage-and-recycling/Waste-Management-Master-Plan---Final-April-2013.pdf)

[120] *Waste & Recycling. Business Plan 2012-2014.* City of Lethbridge website. Data accessed on May 11, 2015 (URL: http://www.lethbridge.ca/City-Government/city-administration/Documents/2012-2014-WasteRecycling%20Bus%20Plan.pdf)

5.0. APPENDICES

5.1. FINANCIALS – OPERATING COSTS

5.1.1. LANDFILL

Detailed landfill site operating costs can be found in Table 17 below.

Table 17: Estimated Annual Landfill Site Operating Costs[121]

	Landfill Site Costs ($): 366,666 tonne facility	Landfill Site Costs ($): 52,233 tonne facility[122]
Wages, salaries, and benefits	4,400,004	628,572
Management administration and support	3,300,003	471,429
Supplies	366,667	52,381
Power and Fuel	366,667	52,381
Equipment ownership/rentals	1,833,335	261,905
Equipment maintenance	476,667	68,095
General site maintenance	2,933,336	419,048
Leachate treatment	366,667	52,381
Leachate hauling	750,000	107,143
Contract services	623,334	89,048
Waste transfer and hauling	7,333,340	1,047,620
TOTAL Annual Cost	**22,750,020**	**3,250,003**

Source: Phase 3, Task 7: Capital and Operating Costs, HDR report (2012)

5.1.2. ANAEROBIC DIGESTION FACILITIES

In a report produced by the Municipal Waste Integration Network & Recycling Council of Alberta (2006)[123], cost estimates for an AD processing facility were calculated for both SSO and MSW plants (see Tables 18 & 19 below). Based on a municipal population of 800,000:

- Capital Costs would range between $32,000,000 and $34,000,000
- Gross Annual Costs would range between $7,300,000 and $7,445,000
- Net Annual Facility Costs would range between $6,134,000 and $6,790,000 (this assumes electricity revenues at $0.06 / kwh and zero heat revenues)
- Cost per Input Tonne (SSO or MSW) would be $68

Table 18: Estimated AD Facility Cost (SSO)

	Population 20,000	Population 80,000	Population 200,000	Population 800,000
Annual Input Quantity to Facilities (tonnes)	2,000	7,500	18,500	100,000
Capital Cost ($)	3,00,000	7,000,000	12,000,000	32,000,000
Capital Financing ($/yr)				
Annual Capital Change ($/yr)	291,000	643,000	1,100,000	3,020,000
Operation and Maintenance (O&M) Costs ($/yr)				

[121] *Phase 3, Task 7: Capital and Operating Costs. An assessment of life-cycle costs and benefits associated with potential development of an energy from waste facility.* Prepared by HDR. Approved by SAEWA. January 27, 2012. Project#147454. Data accessed on April 23, 2015 (URL: http://www.saewa.ca/pdf/engineering_study/Task7.pdf)

[122] Average size of an Alberta landfill site based on the amount of waste produced and the number of landfills in Alberta, as outlined in Section 3.2.1. Waste Statistics in Alberta of this report.

[123] *Municipal Solid Waste (MSW) Options: Integrating Organics Management and Residual Treatment/Disposal.* Municipal Waste Integration Network & Recycling Council of Alberta. April 2006. Data accessed on April 21, 2015 (URL: https://recycle.ab.ca/uploads/File/pdf/MSWworkshop/MSW_Options_Report.pdf)

	Population 20,000	Population 80,000	Population 200,000	Population 800,000
O&M Costs ($/yr)	205,000	450,000	770,000	2,115,000
Off Site Curing and Residue Disposal ($30/tonne)	34,000	128,000	315,000	1,700,000
Total O&M Cost ($/yr)	239,000	578,000	1,085,000	3,815,000
Gross Annual Cost ($/yr)	530,000	1,200,000	2,200,000	7,300,000
Electricity Revenues ($0.06 / kwh)	14,000	53,000	130,000	700,000
Heat Revenues (assuming zero)	0	0	0	0
Net Facility Costs ($/yr)	515,000	1,170,000	2,060,000	6,134,000
Cost per Input Tonne ($/yr)	257	156	111	68

Source: Municipal Waste Integration Network & Recycling Council of Alberta, 2006

Table 19: Estimated AD Facility Cost (MSW)

	Population 20,000	Population 80,000	Population 200,000	Population 800,000
Annual Input Quantity to Facilities (tonnes)	2,470	10,000	24,700	100,000
Capital Cost ($)	3,300,000	7,300,000	12,600,000	34,000,000
Capital Financing ($/yr)				
Annual Capital Change ($/yr)	310,000	690,000	1,180,000	3,210,000
Operation and Maintenance (O&M) Costs ($/yr)				
O&M Costs ($/yr)	231,000	511,000	880,000	2,380,000
Off Site Curing and Residue Disposal ($30/tonne)	37,000	140,000	345,000	1,855,000
Total O&M Cost ($/yr)	270,000	650,000	1,220,000	4,235,000
Gross Annual Cost ($/yr)	580,000	1,340,000	2,400,000	7,445,000
Electricity Revenues ($0.06 / kwh)	13,000	49,000	121,000	656,000
Heat Revenues (assuming zero)	0	0	0	0
Net Facility Costs ($/yr)	565,000	1,291,000	2,280,000	6,790,000
Cost per Input Tonne ($/yr)	282	172	123	68

Source: Municipal Waste Integration Network & Recycling Council of Alberta, 2006

In addition to the Municipal Waste Integration Network & Recycling Council of Alberta (2006) report, Viresco Solutions produced a report in August 2015 that showed that $107,000,000 has been invested into the development of four biogas facilities in Alberta (approximately $26,750,000 per facility)[124].

[124] *Report Card on the Alberta Bioenergy Producer Credit Program. Impacts on Biofuel Capacity, Environmental Improvements and Economic Multipliers.* Prepared by Viresco Solutions Inc. September 2015. Data accessed on September 2, 2015.