European Anaerobic Digestion Educational Mission

'Tour de Manure'

Switzerland, Austria and Germany

August 27th – September 1st, 2007

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EXECUTIVE SUMMARY

European Anaerobic Digestion (AD) Educational Mission Report

Mission Destination:
The mission visited Anaerobic Digestion (AD) facilities in Switzerland, Austria and Germany from August 27th – September 1st, 2007 (Appendix A).

Specific Mission Gains:
The objective of this mission was to provide participants with hands-on learning and enable them to obtain answers to the following questions:

- What are the primary feedstocks for AD in Europe and what methods are used to secure/guarantee feedstock supplies?
- How can AD help solve manure management and odour related issues in the Fraser Valley and beyond?
- What technologies and digester designs are being used to generate biogas, what are their advantages / disadvantages and how would they work in BC?
- Who are the technology providers and which of these have proven track-records?
- Are any dedicated feedstocks being grown for use in AD?
- What government, industry and/or community ownership models are in operation with regards to biogas production (e.g. private ownership, owner co-operatives, government ownership, public/private partnerships, etc)?
- How is biogas being used in Europe? What technologies are used and in which applications (e.g. power production, district heating, industrial heat, biomethane production, etc.)?
- What policies or incentives enable economically viable biogas production in each European country and how and why did these come about?

Background to AD:
AD is a naturally occurring biological process involving the microbiological conversion of organic matter in the absence of oxygen. While the science underlying AD can be complicated, the fundamental process is simple. This involves the symbiotic actions of three distinct groups of bacteria to convert the biodegradable portion of the feedstock into biogas[1].

AD systems can digest organic inputs, such as manure, crops and crop residues, agri-food waste, the organic fraction of municipal solid waste (OFMSW), biosolids, grass clippings / yard waste and some industrial wastes[2]. The two principle outputs of AD are a flammable gas, known as 'biogas', and digestate.

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1. Conversion occurs at one of three temperature ranges. These are thermophylic (50°C - 60°C), mesophilic (30°C - 38°C), or psychrophylic (15°C - 25°C).
2. However, inputs with high lignin content are un-suitable for digestion as they require longer retention times and high concentrations of other feedstock.

Biogas is a renewable, carbon neutral fuel[3] consisting of between 55% - 75% methane (CH4) and 25% - 45% CO_2. Once cleaned, it can be fed into a generator set to generate electricity, into a combined heat and power unit (co-gen) to generate electricity and heat, or further upgraded to biomethane (natural gas quality) and used as such. Digestate, which will have a mass roughly 90% - 95% of the feedstock that is fed into the digester, is the solid and liquid residue resulting from the AD process. The fate of this digestate depends on a number of factors, the most important of which is the degree of contamination[4].

Digesters can be installed on farms, or in centralized locations receiving inputs from a number of farms and/or industries and municipalities. Due to differing physical and chemical characteristics of feedstock, digesters vary greatly with regards to design and technology. These variations include high or low volume systems, single or multi-stage digester vessels and continuous flow or batch processes.

The most obvious benefit of AD is that it produces a GHG neutral, renewable energy / fuel that can displace any oil, coal or natural gas used for energy generation and transportation. Significant co-benefits include an additional and diversified revenue streams, new and stable, predominantly rural, jobs[5], waste diversion and odour and pathogen reduction.

Attendees:
In total, twenty one attendees participated in the AD mission. These participants were drawn from a variety of sectors within BC and from companies with projects/interests in BC (Appendix B).

Budget:
The National Research Council and BC BioProducts Association provided CD$20,000 funding for this mission. While eight participants received CD$2,000 towards the cost of their flights and accommodation, all benefited from the ground transportation provided.

Mission Conception:
On July 19th, 2006, BC BioProducts Association held a one-day workshop to raise the awareness of AD in BC. This workshop, entitled 'is biogas production through anaerobic digestion a relevant alternative for the agricultural sector in BC?' brought together a variety of interested people from around BC and beyond.

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3. This is because the CO_2 in biogas was recently extracted from atmospheric CO_2 by the organic feedstock as it grew.
4. If contamination is high, digestate is often incinerated and / or disposed of in landfills. If digestate contamination is low, it can be applied directly onto land / crops, or if necessary, further processed through composting / post-treatments technologies before being used as a fertilizer.
5. In 2005, AD technologies resulted in over 37,000 FTE in the EU (www.eubia.org/217.0.html).

During this workshop, Dr. Steffen Preusser (then a trade commissioner for the Canadian Embassy in Germany) mentioned that a group from Ontario was planning to visit Southern Germany and Austria in the coming fall (2006). This group was to research the different technologies used in the production and utilization of biogas. After its completion, having heard what a success this visit was, Dr. James Wilkin and Warren Nagata (industrial technology advisors for the National Research Council) decided to search for funding to facilitate such a tour for interested parties from BC. Thus, the European Anaerobic Digestion Educational Mission was born.

With the departure of Dr. Preusser from the Canadian Embassy in January of 2007, the mission planning stalled. Mathew Dickson (Bioeconomy Policy Advisor for the BC Ministry of Agriculture and Lands) then took over the task of organizing the mission. Without his perseverance and hard work, this mission would not have taken place.

Trade commissioners and other employees from the Canadian Embassies in Bern, Vienna and Berlin played key roles in arranging the mission itinerary. These included, but were not limited to Werner Naef (Bern), Phillip Wieltschnig (Vienna) and Dr. Bruno Wiest (Berlin), all of whom are members of the Multi-Market Renewables Group of DFAIT trade commissioners in Europe. Valuable input on potential site visits was also received from Urs Heutschi and Roger Strasse of the Swiss environmental publication “Umwelt Perspektiven”.

This Biogas Mission can be viewed as a model for collaboration between Provincial and Federal agencies for international science and technology missions, and is a best practice example of a Multi-market event.

INTRODUCTION

On Monday August 27th, a group organized by the BC Ministry of Agriculture and Lands met outside the hotel Krone Unterstrass Best Westernin in Zurich, Switzerland. The following 6 days were spent travelling by bus through Switzerland, Austria and Germany to witness first hand the day-to-day operations of AD facilities. The 21 participants were drawn from a variety of sectors, including: the dairy, poultry, pork and aquaculture industry, Independent Power Producers (IPP), a provincial utility company, a Canadian embassy, a university, the National Research Council, Provincial Ministries, and a local entrepreneur (Appendix B). Although a diverse group, all had the common interest of seeing and learning as much as possible about AD.

During the week the group visited 13 AD facilities and technology providers in the three countries. Each site visit was carefully chosen in order to showcase the versatility and practical applications of AD technology, and to give each participant a broader understanding of some of the issues and complications surrounding this technology (including feedstocks availability, transportation, connectivity, utilization of heat and digestate, government policies / regulations, etc).

What follows is a report of this mission. Each country section begins with an introduction to the country in question and sets the scene with regards to AD. This is followed by a brief description of each site visit. The report concludes with a summary of the participant's thoughts and concerns about AD and some of the lessons learnt during the mission.

COUNTRY PROFILE
Switzerland

Throughout Switzerland agricultural-based subsides are decreasing and more and more farmers are finding it harder to remain in business. Because of this, the Swiss government is currently looking for new ways in which to make agriculture more profitable. One solution that is being strongly supported is AD. On-farm digesters provide additional and diversified revenue streams for the agricultural industry and can help create new and stable, predominantly rural, jobs throughout the country[6].

In 2005, Ernst Basler and Partners Ltd., an independent Swiss engineering and consulting company, was assigned the task of promoting production of biomass-based energy, such as through AD. As a result of this assignment, BiomassEnergy was launched. This national program, which has a mandate to coordinate activities to increase the use of non-woody biomass to produce energy throughout Switzerland, estimates that by 2020 biomass energy could meet 4.5% of Switzerland's power, 4.7% of its heat and 8% of its fuel needs.

In essence, BiomassEnergy is a network that connects the relevant market players, enables the exchange of experience, promotes and supports biomass-based projects and works towards the elimination of market obstacles. These objectives can be divided into four main categories. These are:

- Information (fact sheets, newsletters, info centres, etc).
- Public relations (media events, conferences, lobbying, exhibitions, etc).
- Quality and safety (courses for farmers, workshops for municipalities, feasibility studies, etc).
- Networks (connecting key payers and making use of synergies).

AD is also being supported through government programs, general changes in attitudes and increasing awareness of the financial opportunities of AD. Of these, the two that have had the greatest impact have been the removal of fuel tariffs on biogas fuels and cost-covering electricity tariffs (feed-in tariffs). Additionally, the Swiss Electricity Supply and revised Energy and CO_2 Law will come into force on 1st January 2008. These laws, aimed at promoting renewable energies, will (among others) require grid operators to purchase electricity from renewable resources and sell it at a cost-covering price and introduce a SwF0.12 / tonne (CD$0.10) tax on imported fossil fuels (to be increased in 2009 and 2010). These changes are expected to further benefit AD.

However, while government support for AD is increasing, there are still problems associated with heat utilization and heterogeneity of laws and regulations. Because the demand for heat is limited near digesters (e.g., greenhouses,

[6] Digesters can even be built in the Alps. Currently, an on-farm digester that utilises restaurant waste is operational at 1,750 meters above sea level.

industry, etc), many facilities in Switzerland (as with other European countries) utilize only a fraction of the heat they generate, while the rest is wasted. One way in which to overcome this problem is to upgrade the gas to biomethane. However, at present only 120 service stations in Switzerland sell biomethane and connectivity to the natural gas grid is not widely available[7]. Furthermore, In Switzerland, each province (kanton) has different laws and regulations related to AD. This heterogeneity creates additional costs and construction delays for technology providers.

[7] Trucking of gas (under high pressure) is only feasible when it involves very large quantities (such as those imported from the Middle East).

PLANT VISITS
Switzerland

Name: Kompogas-Infocentre
Address: Libernstrasse 16, CH-8112 Otelfingen
Contact Info: Tel. +41 44 809 7770 / E-Mail: info@kompogas.ch
Web Site: www.kompogas.ch

The mission's first site visit was to Kompogas' information centre. In addition to the information centre and indoor go-cart track (which, much to our disappointment, we didn't get to try!), the site has a digester. The digester utilises agri-food waste, OFMSW and green-waste, servicing an area of roughly 100,000 people. No slaughter house waste or sewage sludge is accepted as these contaminate the digestate and make it hard to get rid of.

The feedstock enters the horizontal plug-flow reactor at 30% solids. While high lignin feedstock causes biogas output to fall, 30% lignin material is introduced into the digester as this increases the quality and structure of the compost (in summer excess lignin is stored for use during winter months).

Once digested, the digestate is extracted and pressed to remove all liquids (dewatered). The liquid digestate is given away while the solid digestate is composted further before being given away. 90% of this digestate is used by farmers, the remaining 10% is used by landscapers and gardeners. Some of the biogas is converted to electricity and heat in a cogeneration unit (co-gen), while the rest is upgraded to biomethane. The electricity is sold to the grid, the heat is used onsite (in a demonstration greenhouse) and the biomethane is piped to a nearby service station.

While the facility is operational 24/7, it requires only two full-time staff working from 9AM – 5PM. 75% of the digester's revenue comes from tipping fees, while the remaining 25% is from biomethane sales. The facility consumes only 10 - 15% of its own energy and is operated under low pressure. This ensures that all odours are captured in a biofilter before the air from the facility is released.

Quick Stats:

- Technology Provider: Kompogas.
- Year commissioned: 1996.
- Digester volume: One 800m^3 digester (32m length / 5m diameter).
- Cost: SwF12.5 million (CD$17.8 Million).
- Daily feedstock volume / type: 35 tonnes of agri-food waste, OFMSW and green-waste.
- Outputs: Electricity (sold to the grid), heat (used on site), 100m^3 / mt of biomethane (sold to the grid) and digestate (given away).

Name: Biopower Northwestern Switzerland Ltd.
Address: Industrie Pratteln Nord, Heissgländstrasse 12, CH-4133 Pratteln.
Contact Info: Tel. +41 61 821 4388 / E-Mail: vergaerung@leureko.ch
Web Site: www.leureko.ch / www.bio-power.ch/pratteln.html

Situated between a motorway restaurant service station and a purification plant, this site, because of its central location, easy access and existing high traffic flow, was seen as ideal for AD. The digester is a large biogas production plant run by IWB (sub of Swiss Power) and Leureko AG, in Kanton Basil.

The digester utilises agri-food waste, OFMSW, green-waste and industrial organics from the surrounding areas. The feedstock is ground, mixed and pasteurise at 133°C and 3 bars for 20 minutes before being fed into the horizontal plug flow reactor at 30% solids. This treatment pasteurises the digestate and increases biogas production by breaking down cell walls.

Once digested, the digestate is extracted and dewatered. The liquid digestate is then given away for use in agriculture while the solid digestate (around 20 tonnes / day) is treated further. This treatment, which can involve the addition of sand, lignin, colourants, etc, is done to create high-quality compost that is then sold for horticulture, gardening, industrial landscaping and sports field construction.

The biogas is upgraded to biomethane and then fed directly into the natural gas grid (at present some technical difficulties are being experienced with the gas up-grading technology). The gas produced by this plant displaces the equivalent of 1,900 – 2,800 litres of fossil fuel / day (depending on feedstock volumes) and up to 850 tonnes of CO_2. As with the digester in Otelfinge, this facility requires only two full-time staff, consumes only 10% - 15% of its own energy and is operated under low pressure conditions.

Quick Stats:

- Technology Provider: Leureko AG.
- Year commissioned: 2006 (March).
- Digester volume: One 1,150m^3 digester (32m length / 6m diameter).
- Cost: SwF11.5 million (CD$16.3 million).
- Daily feedstock volume / type: 27 - 40 tonnes of agri-food waste, OFMSW, green-waste and industrial organics.
- Outputs: 1.8 million m^3 / day biomethane (sold to the natural gas grid) and digestate (liquid is given away, 20 tonnes / day solid is sold as fertilizer).

Name: Agrigas Communal
Address: Im Sunnehof 1, CH-8460 Marthalen ZH.
Contact: Tel: +41 79 387 8839 / E-Mail: shegmbh@bluewin.ch

This on-farm digester accepts cattle and horse manure (both on-farm and that piped from a dozen surrounding farms in existing and specially laid pipes), agri-food waste, OFMSW and green-waste. Before being conveyed in lots to the digester, foreign objects and non-fermentable components (such as lignin) are removed from the OFMSW and green waste. The liquid feedstock is pumped via the pre-mixing pit to the digester.

The feedstock enters the digester at 12% - 13% solids (if solid content is too high after mixing, liquid digestate from previous batches can be added) where it is digested for 40 - 50 days at 35^{o}C - 40^{o}C. Once digested, the digestate is extracted and dewatered. The liquid digestate is spread onto the fields of farmers who contributed feedstock, while lignin is added to the solid digestate before it is composted. This compost is then given away.

The biogas is condensed, cleaned and converted into electricity and heat in the co-gen unit. 100 kW/h energy (enough to power 200 – 250 houses) is fed into the grid and sold. Heat not required for the digester is used for the farm house's heating and hot water needs, or wasted (there are plans to connect the workshop and one more household to the heating system).

The digester, which cost SwF1.2 million to build, SwF600,000 (CD$520,000) for the facility and SwF600,000 (CD$520,000) for storage of feedstock and compost, is run by 1 person and is fully-automated. To ensure that nutrient overloading does not occur, every farm that contributes feedstock to the digester has a nutrient management plan.

Quick Stats:

- Technology provider: Genesys.
- Year commissioned: 2006.
- Digester Volume: One 510m^3 digester.
- Cost: SwF600,000 for digester (CD$520,000) and SwF600,000 for storage (CD$520,000).
- Daily feedstock volume / type: 19 tonnes liquid (52%) and solid (16%) cattle manure, solid horse manure (4%), mill / cereal waste (10%), OFMSW (8%) and green-waste (10%).
- Outputs: 100 kW/h of electricity (sold to the grid), heat (some used for digester and on-farm, the rest is wasted) and digestate (used on-farm and given away).

Name: Agrigas Farmer
Address: Hinterdorf 14, CH-8564 Wagerswil TG.
Contact Info: Tel: +41 79 286 2600 / E-Mail: e.fill@bluewin.ch

Because it was build by the same company (Genesys) for similar feedstock types and volumes, this digester was very similar to the previous digester visited. It accepts both chicken and cattle manure (delivered by tanker from 5 other farms, rather than piped) as well as grass cuttings from a local golf course, horse manure and slaughter house waste (despite accepting this waste, no pasteurisation takes place). Tipping fees from this waste account for 20% of the income.

The feedstock enters the digester at 12% – 13% solids daily via pre-mixing pit and direct solids feeding system, where is digested for 40 - 50 days at 35^{o}C - 40^{o}C. Once digested, the digestate is extracted and dewatered. The liquid digestate is spread onto the fields of farmers who contributed feedstock, while lignin is added to the solid digestate before it is composted. This then given away.

As before, the biogas is cleaned before entering the co-gen unit. 100 kW/h of energy is fed into the grid and sold (enough to power 200 - 250 houses). 35% of the heat is used for the farm house's heating, hot water needs and the chicken coop. The rest is used for the digester or wasted.

The digester, which cost SwF900,000 (CD$780,000) to build, is run by 1 person and is fully-fully-automated. As with the digester in Marthalen, all farms involved in the project have a nutrient management plan.

Quick Stats:

- Technology Provider: Genesys.
- Year commissioned: 2006.
- Digester volume: One 870m^3 digester.
- Cost: SwF900,000 (CD$780,000).
- Daily feedstock volume / type: 13 tonnes of liquid (50%) and solid (15%) cattle and horse manure, chicken manure (12%), stomach / gut content (12%) golf course grass cuttings (6%), mill / cereal waste (2%) and food processing waste (3%).
- Outputs: 100 kW/h of electricity (sold to the grid), heat (some used for digester and on-farm, the rest is wasted) and digestate (90% liquid and 10% solid used on-farm and given away).

Name: Jakob Bösch AG
Address: Aedelswil, CH-9100 Herisau (near St. Gallen).
Contact Info: Tel: +41 71 354 8910 / E-Mail: info@boesch-entsorgung.ch
Website: www.boesch-entsorgung.ch

Jakob Bösch is a hog farmer who used to collect agri-food waste to feed to his 1,300 pigs. However, recently a law was passed in Switzerland banning this practice. This left Jakob with a lot of waste and manure to dispose of and so he decided, along with his brother, to build a digester.

The digester utilizes pig manure, slaughter house waste, and agri-food waste. Upon delivery the feedstock is divided into two categories, green waste (for material that does not require pasteurization), and red waste (for material that requires pasteurization). Pasteurization occurs at 133°C and 3.4 bars.

The feedstock enters the digester at 12% - 13% solids, where the three digesters utilize a unique hydraulic mixing system that does not require mechanical agitators. Once digested, the digestate is extracted and treated using an ultra filtration and reverse osmosis system. From 40 tonnes of digestate, this system produces 9.5 tonnes of concentrated fertilizer (which is given away) and 28.5 tonnes of water. This water can be used for irrigation or discharged to the sewage network.

The biogas is condensed, cleaned and converted into electricity and heat. Electricity is fed into the grid and sold, and once again, only a fraction of the heat is utilized. However, when constructed, extra space was build to rent out to a company with high heat demands (currently this space is unoccupied).

The digester, which cost SwF10 million to build (CD$8.6 million), is run by 3 - 4 people. Currently, although it takes between 39 - 41 tonnes of feedstock / day, the hope is that this will reach 70 tonnes / day at year end, and will approach capacity (110 tonnes / day) in 2008. As with Kompogas, this facility is operated under low pressure, and air is passed through a biofilter before being released.

Quick Stats:

- Technology Provider: AAT GmbH
- Year commissioned: 2006.
- Digester volume: Three 1,650m^3 digesters.
- Cost: SwF10 million (CD$8.6 million).
- Daily feedstock volume / type: 39 - 41 tonnes (capacity is 110 tonnes) of pig manure (25%), slaughterhouse and agri-food waste (75%).
- Outputs: 1.1 MW/h of electricity (sold to the grid), 55 k/h heat (used as steam / hot water for the digester and on-farm, the rest is wasted) and digestate (given away).

COUNTRY PROFILE
Austria

In 2001, total AD energy production in Austria was below 2 MW. Since then AD energy production has risen steadily, reaching just under 40 MW in 2004 and 86 MW at the beginning of 2007. While production is fairly well distributed across Austria, Lower Austria has the highest percentage of energy generation, accounting for roughly 1/3 of total production. Average Austrian digester size is 295 kW/h and the majority of digesters (77%) are under 500 kW/h.

The main catalyst behind this increase in AD energy production was the adoption of new legislation by the Austrian Parliament in July 2002. This legislation, known as the 'Ökostromgesetz' or 'Green Electricity Act', amongst other initiatives, implemented a feed-in tariff for renewable energies, introduced a mandatory target of at least 4% green electricity (without small hydro) by 2008 and guaranteed grid access for renewable energy projects. Furthermore, because there are no regulations limiting the importation of off-farm waste onto farms, farmers are able to earn tipping fees of between €10 - €60 / tonne (CD$14 - CD$85). However, lower feed-in tariffs are paid for on-farm digesters utilizing high proportions of off-farm waste.

In 2006, the Ökostromgesetz was amended, and today the 'Ökostromgesetz 2006' is the current act for production and consumption of renewable energies in Austria. While similar to the 2002 act, the 2006 act has increased assistance for green energies to roughly €17 million / yr (CD$24 million). This assistance is divided as followed:

- 30% for solid biomass
- 30% for gaseous biomass
- 30% for wind, and
- 10% for liquid biomass, gas from waste water treatment plants and landfills, and photovoltaic.

Additional amendments to the Ökostromgesetz include introduction of a first come first served principle, a reduction in the size of digesters eligible for licences (down to roughly 6 MW), and a new stipulation that only digesters converting 60% of the biogas to biomethane will be eligible. Furthermore, the fixed life span of the feed-in tariff has been reduced from 13 years to 10 years (in the 11th year the tariff is reduced by 25%, while in the 12th year it is reduced by 50%). This feed-in tariff is currently:

- €0.165 (CD$0.23) for projects under 100 kW/h
- €0.149 (CD$0.21) for projects under 500 kW/h (10% less)
- €0.132 (CD$0.19) for projects below 1 MW (20% less), etc.

Because biomethane is one of the few renewable energies that can be stored without experiencing dissipation, the Austrian Federal Minister for agriculture and environment has signed an agreement with OMV (a Central European oil and

gas corporation) to promote the production and consumption of biomethane through a five point program. This programme aims to achieve these objectives by:

- Creating 200 biomethane service stations by 2010.
- Guaranteeing biomethane tax exemptions until 2020.
- Introducing more gas-powered government owned vehicles.
- Introducing better rules and legislation for feeding biomethane into the gas grid.
- Creating a mandate for all gaseous fuels to contain at least 20% biomethane.

PLANT VISITS
Austria

Name: Allgauer
Address: Leusbündtweg 49, A-6800 Feldkirch.
Contact Info: Tel: +43 5522 9000 / E-Mail: office@aat-biogas.at
Web Site: www.aat-biogas.at

The main feedstock (70%) for this on-farm digester is cattle manure from the farm's 270 cows. Additional feedstocks include agri-food waste (grease, whey, milk and red bull sludge), straw and grass cuttings from parks and gardeners, and some corn. Built in 2002, this digester (similar in design to the previous on-farm digesters and fully-automated) has a 35 day retention time and can operate in winter temperatures as low as $^{-}16^{o}$C. During this time, 90% of the heat from the co-gen unit is needed to warm the manure before it enters the digester.

Total output from the cogeneration unit is 200 kW/h. This is in the form of electricity (which is sold to the grid), and heat (when not needed for the digester, this is used for on-farm hot water and heating needs and for drying hay. Any residual heat is wasted). The digestate is dewatered and then both the liquid and the solid digestate are spread onto the fields and given away. Since spreading digestate instead of un-treated manure, the farmer has reduced his chemical fertilizer and pesticide needs, noticed a significant reduction in odour (much to the pleasure of his neighbours) and seen a 25% increase in crop growth.

Overall, the digester cost €720,000 (CD$1.02 million) and is half owned by the local utility company. 65% of the digesters' revenue comes from electricity sales, 25% from heating cost reductions and 10% from fertilizer cost reductions. The payback period is 6 - 7 years, and based on his experience thus far, the farmer would now like to build another digester. However, before he can do this he has to run it by his wife.

Quick Stats:

- Technology Provider: AAT GmbH.
- Year commissioned: 2002 (Autumn).
- Digester volume: Two 620m^3 digesters.
- Cost: €600,000 (CD$850,000).
- Daily feedstock volume / type: 12 tonnes of manure (70%), agri-food waste, corn, straw and grass cuttings (30%).
- Outputs: 100 kW/h of electricity (sold to the grid), 145 kW/h of heat (some used for digester and on-farm, the rest is wasted) and digestate (used on-farm and given away).

Name: Wastewater Treatment Plant ARA
Address: Koblacherstrasse, Meiningen.
Contact Info: Tel: +43 5522 9000 / E-Mail: office@aat-biogas.at
Web Site: www.aat-biogas.at

To enable participants to fully appreciate and understand the versatility and practical applications of AD technology, a visit to a waste water treatment plant was also incorporated into the educational mission.

The waste water treatment plant receives 22,000m³ / day of sewage, and services a population of around 380,000 people from the town of Feldkirch. Once the sewage has passed through the primary treatment stage, it is pumped into a 4,000m^3 hydraulic digester. Here it is digested before being transferred into a second 4,000m^3 Continuously Stirred Tank Reactor (CSTR) digester.

The digested is then dewatered. The solid digestate (approximately 300,000 kg / day) is soil blended and given away for use in non-agricultural applications such as road construction and landscaping, while the liquid digestate is sent for tertiary treatment (where it is disinfected in lagoons) before being discharged into a local stream.

Total biogas yield of the facility is approximately 5,000m³ / day. This biogas, which has a methane concentration of 62%, is converted via a co-gen unit to electricity and heat.

Quick Stats:

- Technology Provider: AAT GmbH.
- Year commissioned: 2000.
- Digester volume: A 4,000m^3 hydraulic and a 4,000m^3 continuously stirred tank digester.
- Cost: €Unknown.
- Daily feedstock volume / type: 22,000m³ of primary and secondary sewage.
- Outputs: 460 kW/h of electricity (used on site), heat (used for digester and on-site) and digestate (soil blended and given away for use in non-agricultural applications such as road construction and landscaping).

Name: GE Energy - Jenbacher Headquarters
Address: Achensee Str. 1-3, A-6200 Jenbach.
Contact Info: Tel: +43 5244 6000 / Web Site: www.ge-energy.com

Throughout the mission, the vast majority of AD facilities visited (over 75%) used co-gen units to turn biogas into electricity and heat. Because of this fact, it was decided that the mission should incorporate a visit to one of the world's leading manufacturers of co-gen units for power generation.

GE - Jenbacher is one of the only companies in the world that focuses exclusively on gas engine technology. These engines, which range in power from 250 kW/h - 3 MW, can run on natural gas or a variety of other gases, including biogas, landfill gas and sewage gas. The plant employs 1,300 in Jenbach and 1,500 worldwide.

Today, GE - Jenbacher produces around 1,200 gas powered engines / year (an increase of 300% from before GE's takeover 4 years ago). These engines are used for a broad range of commercial, industrial, and municipal customers for on-site generation of power, heat and cooling. Of these engines, which take around 2 days to build, 70% of the parts are outsourced while the remaining 30% (core parts) are produced in-house.

Patented combustion systems and engine controls enable these cogeneration units to offer high levels of efficiency (from biogas, these engines can produce 42% electrical and 50% heat energy with only a 8% loss). Cost varies according to engine size and design, although a 1 MW engine with all the necessary equipment (including container), costs around €400,000 (CD$570,000). Currently, GE - Jenbacher's largest markets are Russia, Germany, India and The Netherlands.

Quick Stats:

- Technology Provider: GE - Jenbacher.
- Engine volume: From 250 kW/h to 3 MW.
- Cost: Varies depending upon engine size and design.
- Outputs: Electricity (42%) and heat (50%).

Name: Landwirtschaftliche Lehranstalt Rotholz
Address: Rotholz 46, A-6200 Rotholz.
Contact Info: Tel: +43 5244 62161 / Email: Heribert.Insam@uibk.ac.at
Web Site: www.rotholz.at

Because small-scale digesters are usually considered uneconomical, currently no digesters are built (< 50 kW/h) for very small (100 - 350 cattle) remote farms. This lack of small-scale digesters is the motivation behind the new BIO4GAS technology, which is being developed in a joint venture between the University of Innsbruck and the Austrian Research Centers GmbH.

The basic concept behind the BIO4GAS design is to produce a digester that has no, or very few, moving parts, and requires very little energy for operation. The main feature of this design is that the digestate is mixed not with a mechanical pump or mixer, but with a patented 'air-lift' system and by the hydraulic pressure that builds up through gas production (thus requiring no energy).

Currently, a demonstration digester is being set-up at the Rotholz agricultural school and is expected to be operational by this October (2007). This digester, which will utilize cattle and pig manure, lawn cuttings and kitchen scraps, is a mesophilic (37°C) stable 4 chamber reactor designed to operate on feedstock volumes equivalent to manure from 100 - 350 cattle.

Aiming to be market ready by the end of 2007, the hope is that once proven, a standardized 'one size fits all' digester design that is suitable for any application can be prefabricated (or at least a high percentage of the components). This will help to reduce construction costs and increase feasibility.

Quick Stats:

- Technology Provider: BIO4GAS (University of Innsbruck).
- Year commissioned: To begin October 2007.
- Digester volume: One 300m³ digester.
- Cost: Predicted at around €180,000 (CD$255,000).
- Daily feedstock volume / type: Developed for about 100 - 350 cattle units and other additional organic wastes.
- Outputs: 40 kW/h of electricity, heat (some used on-farm with the residual ideally sold for off-farm applications) and digestate (preferably used on-farm and given away).

Name: Salzburger Abfallbeseitigung GmbH
Address: Siggerwiesen Aupoint 15, A-5101 Bergheim.
Contact Info: Tel: +43 662 46949 0 / E-Mail: helga.feil@rhvsab.at
Web Site: www.rhv-sab.at

In 1975, Salzburg Waste Management Ltd. (SAB) was founded to develop a suitable and environmentally sustainable solution to the disposal of waste generated by approximately 400,000 people and 3,000 commercial and industrial enterprises from 85 municipalities (Greater Salzburg). One solution was to build an anaerobic digester for the organic waste.

The digester, which was commissioned in 2005, utilizes 55 tonnes / day of OFMSW collected from households in designated green waste bins. Upon delivery a €120 / tonne (CD$170) tipping fee is charged. This waste is hand separated on a conveyor belt (if necessary) before being mixed and sieved. Any waste that is larger than 5cm is automatically rejected (as this is often plastics). The sieved waste is then passed under a magnate before being fed into the digester at 30% solids.

Once the digestate has passed through the digester, it is pumped back into the top to pass through a second time (this removes the need for mixing). The digestate is then extracted and dewatered in a screw press to remove all liquids. The liquid digestate is sent to a nearby sewage plant for further treatment, while the solid digestate is mixed with lignin and composted aerobically in tunnel reactors for 12 days. It is then sent to a composting facility, where it is processed further (to reach the composting ordinances sanitary and physical criteria) and sold.

The biogas is condensed, cleaned and converted into electricity and heat in a co-gen unit. All electricity and heat from this unit is used on site to meet 70% - 80% of SAB's energy requirements and heating needs.

Quick Stats:

- Technology Provider: Dranco.
- Year commissioned: 2005.
- Digester volume: Unknown.
- Cost: €Unknown.
- Daily feedstock volume / type: 55 tonnes of OFMSW.
- Outputs: Unknown electricity and heat (all used on site) and digestate (70% of which is sold for €10 - €15 / tonne (CD$14 - CD$21 / tonne)).

COUNTRY PROFILE
Germany

In 2006, approximately 3,500 digesters, producing 1,100 MW of energy, were operational around Germany, (up from 1,000 digesters and 100 MW in 2000). Today, the German biogas industry employs around 10,000 people (7,000 in construction, services, etc and 3,000 in facility operations) and has an annual turnover of roughly €1 million (CD$1.4 million). While a variety of feedstocks are used in AD, the largest percentage (57%) is from agriculture, with corn being the most popular energy crop.

This exponential growth in the biogas sector was initiated in 2000 by the Renewable Energy Law (EEG). This law, amended in July of 2004, is Germany's most important regulatory instrument used to support development of the biogas industry[8], and was a success because it guaranteed three key elements:

- A minimum price for green electricity that guarantees a rate of return for the investors for a fixed period[9].
- Guaranteed access of green electricity to the grid ensures that the infrastructure is made available to any property where green electricity is produced (the biogas association is also lobbying for access to the natural gas network).
- Guaranteed 20 year contract for energy production that decreases by 1.5% per annum (this helps foster energy and cost efficient technologies).

While similar to the 2000 law, the 2004 EEG introduced a bonus for using energy crops for biogas production as well as an incentive for cogeneration facilities that use forest wood. These bonuses are cumulative and are added to the base prices.

[8] Other support programs were tried prior to this law but were ineffective because funding was indirect. E.g., a program to subsidise construction based on digester volume resulted in large digesters being built without ensuring that it would be profitably. Quotas for renewable energies were also rejected because these only supported the "cheapest" energies with guaranteed output (driving the electrical market to one type of renewable energy source, instead of a mix of renewables).

[9] Costs associated with these guarantees are paid for by the consumer (€0.001 / kWh or €10 / year (CD$16) through higher energy prices, and are not subsidised by the state. Government regularly checks the books of electrical companies to ensure fairness.

German Renewable Energy Law Prices			
Average Power	Guaranteed feed-in tariff (€Ct / kW/h electricity)		
	Base Price (2006) (i.e., using waste materials)	Bonus for Using Agricultural Crops (includes manure and energy crops)	Bonus for Heat Use
0 - 150 kW/h	11.16	+ 6	+ 2
100 kW/h - 500 kW/h	9.6	+ 6	+ 2
500 kW/h - 5 MW	8.6	+ 6	+ 2
5 MW+	8.2	+ 6	+ 2

Currently, only 2 plants in Germany upgrade biogas to biomethane. While it makes little sense to do this if all electricity and heat is utilized, this is often not the case, and residual heat not needed for on-site applications is often wasted. Because of this, Germany is starting to follow the Swedish and Austrian examples of encouraging the upgrading of biogas to biomethane.

According to estimations, the biogas sector is expected to grow by 40% in the next 5 years, and turnover is predicted to reach €18 billion by 2020 (CD$ 25 billion). At this time, installed biogas power is predicted to be around 76 million MW. This increase is expected to come mainly from an increase in energy crops, especially corn.

However, while the German biogas sector seems healthy, it is currently facing construction capacity problems, as demand is much higher than the engineering capacity of the companies. Additional costs and construction delays are also being experienced because of an increasing number of government testing bodies that certify the various safety aspects of the plants. Furthermore, the rising price of corn is also becoming an issue, as it is beginning to impact the economic viability of many digesters. Therefore, great caution is needed when entering into long term contracts for power pricing if similar contracts for input pricing are not available.

PLANT VISITS
Germany

Name: Finsterwalder
Address: Mailinger Weg 5, D-83233 Bernau.
Contact Info: Tel: +49 8051 6539 0 / E-Mail: info@fitec.com
Web Site: www.fitec.com

The feedstocks for this on-farm digester are manure (on-farm) and fish and agri-food waste (collected from over 350 locations up to 120 km away). While most feedstock suppliers are under contract to supply their waste, these contacts generally last just 1 year, and thus have to be re-negotiated annually. Tipping fees are around €45 / tonne (CD$63) and account for 65% of the digesters revenue (the remaining 35% comes from electricity sales).

Built in 2000, this digester (similar in design to the previous on-farm digesters and fully-automated) is designed to remove all plastics, sand, bones and other foreign objects that are not removed during pre-treatment. A specially designed truck is also used to collect the waste, empty the waste containers (large, green wheelie bins / mobile garbage bins) and clean them before they are returned to the client.

Once digested, the digestate is dewatered and the liquid and solid fractions are taken off-farm for a fee. The solid digestate is incinerated, while the liquid digestate is aerobically treated before being sent to the local waste water treatment plant. Biogas from the digester is fed into a co-gen unit and 75% of the generated electricity is fed into the grid at €0.10 kW/h (CD$0.14). This fee is guaranteed for 20 years under the German Renewable Energy Law (as it is with all German digesters). Heat that is not used for the digester or on-farm is wasted.

Since building the digester, and because of falling food prices, higher revenues and lower risks than with farming, the Finsterwalder family no longer farm their land. Instead it is leased out the land to others.

Quick Stats:

- Technology Provider: Finsterwalder.
- Year commissioned: 2000.
- Digester volume: Unknown.
- Cost: €2 million (CD$2.8 million).
- Daily feedstock volume / type: 10 tonnes of manure (30%) and fish and agri-food waste (70%).
- Outputs: 190 kW/h of electricity (sold to the grid), heat (some used for digester and on-farm, the rest is wasted) and digestate (incinerated or sent to waste water treatment plant).

Name: Geisenhofer
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Web Site: www.lfl.bayern.de/ilt

Built in 2004, this on-farm digester was designed and constructed by Mr. Geisenhofer and his parents. Necessary, standard, technical apparatus were purchased from various suppliers. The digester is monitored by the Institute for Agricultural Engineering, Farm Buildings and Environment Technology to evaluate its technical and economical performance and environmental impact.

This digester accepts corn, corn-cob-mix and kernels, grass, whole crop silage and small amounts of cattle manure (used to be more, but has been reduced since 2006). It consists of two parallel vertical stir tank primary digesters, a vertical stir tank digester, two vertical stir storage tanks and an underground solid ceiling collection tank for input of liquids or withdrawal of digest.

Once digested, the digestate is dewatered and used for on-farm purposes. The biogas is converted into electricity and heat in two identical co-gen units. Some (around 20%) of the electricity is used to meet the energy demands of the digester, while the rest is fed into the grid. The heat is used to meet on-farm needs, to supply a nearby senior citizens home and to dry wood (the proportions vary depending upon the time of year). Any residual heat (more prevalent during the summer) is wasted. There are plans to supply heat to several more nearby houses.

As with the Finsterwalder family, and for the same reasons, Mr Geisenhofer has ceased farming since building this digester. Instead he leases out his land to others.

Quick Stats:

- Technology Provider: Eckart Maschinenbau (solids feeding technology), Franz Eisele u. Söhne GmbH u. Co.KG (agitators), Elektro Hagl (co-gen units).
- Year commissioned: 2004.
- Digester volume: Two 880m³ vertical primary digesters, one 1500m³ vertical secondary digester and a 1,500m³ and 4,200m³ storage tank.
- Cost: €1.2 million (CD$1.7 million).
- Daily feedstock volume / type: 18 tonnes of corn silage (72%), grass silage (11%), whole crop silage (8%), corn-cob-mix (6%), corn kernels (3%) and limited cattle manure (not on a regular basis).
- Outputs: 310 kW/h of electricity (sold to the grid), heat (used on-farm, at an old persons home, for drying wood and, especially during the summer, wasted) and digestate (used on-farm and given away).

Name: Biomethananlage Pliening
Address: Tratmoosstraße 11, D-85652 Pliening.
Contact Info: Tel: 49 94 31751 346 / E-mail: oliver.vigano@schmack-biogas.com

Built by Schmack Biogas AG in 2006, this facility was a join venture between Schmack Biogas AG and Renewable Energy Systems. Financed by the Aufwind Schmack Gruppe, E.ON Bayern (a German energy company) is contracted to buy all of the biomethane produced.

Unlike most of the facilities visited on this mission, this facility uses nothing but energy crops as its feedstock and upgrades the biogas to biomethane. By far the dominant feedstock used is corn silage, although, when necessary (to boost biogas output) grains are also added. These feedstocks are purchased for €25 – €26 / tonne for corn (CD$37), and €105 / tonne for grains (CD$148). A one year supply is stored on site.

The feedstock enters the digesters where it is digested for 50 – 60 days at 42^{o}C. During this time the feedstock is stirred with a horizontal heated rod (to ensure constant mixing and temperature control). Once digested, the digestate is dewatered and taken off-site by a local farmer. The biogas is then collected and upgraded to biomethane (methane content of 96%) using a proprietary Pressure Swing Absorption (PSA) system.

The motivation to upgrade the biogas to biomethane came in early 2006 when the Russian[10] government severely restricted the flow of natural gas into Germany. Additionally, there is a growing realisation in Europe that biomethane is a great way in which to store energy, as it does not experience dissipation. At present this facility is losing money.

Quick Stats:

- Technology Provider: Schmack Biogas AG / Carbotech.
- Year commissioned: December 2006.
- Digester volume: Three 1,000m^3 flow fermenters and three 2,700m^3 pit storage fermenters.
- Cost: €9.8 million (CD$13.8 million).
- Daily feedstock volume / type: 104 tonnes of corn silage (over 90%), plant silage and some grains.
- Outputs: 445 m³/h of biomethane (enough to supply 1,300 four person households) and digestate (given away to a local farmer who is contracted to collect and distribute to nearby farms).

[10] Russia is Germany's largest natural gas supplier, supplying 34% of the countries needs. Estimates are that Russian gas customers will face supply shortages and encounter supply bottlenecks next winter.

Name: Gut Karlshof
Address: Freisingstr. 64, D-85737 Ismaning.
Contact Info: Tel: 49 89 965251

The feedstock for this municipally owned and operated on-farm digester is cattle manure (from the farm's 400 steers) and corn (grown on-site). Commissioned in 2000, the digester was originally designed to run on 'pure' manure only. However, since 2002, and because the steers are now allowed outside, the manure is 'unclean' (mixed with other materials, such as bedding). Initially, this caused some problems with the stirring system, as no-one had dealt with 'unclean' manure before. Today the digester has overcome these problems.

The feedstock is pumped daily into the digester at 4% - 6% solids, where it is digested at 50^{o}C (this digester runs 365 days a year, even when temperatures drop as low as -15^{o}C). Once digested, the digestate is dewatered and used for on-farm purposes and given away. The biogas is converted into electricity and heat in a cogeneration unit. This is fed into the grid at €0.162 kW/h (CD$0.228), while the heat is used for the digester, on-farm purposes and to heat nearby houses (600m^2 living area). Any residual heat is wasted

The plan is to add an additional 540 kW/h capacity to the facility. 40 kW/h of this will be fed into the grid, while the other 500 kW/h will be upgraded to biomethane and used at city hall. This style of expansion is being encouraged in Germany as it overcomes issues of residual heat (i.e., if there is residual heat, the economics favour upgrading the gas to pipeline quality).

The farm also operates 2 tractors that run exclusively on 100% biodiesel. This is purchased from a farming co-op for 30% - 40% cheaper than regular diesel. These tractors, one of which has plug-in element to warm the tank while the other has a diesel engine that is run at the beginning and end of every use, have run for over 4 years and 4,500 hours without any difficulties.

Quick Stats:

- Technology Provider: Agricomp GmbH.
- Year commissioned: 2000.
- Digester volume: One 800m^3 fermenter and one 800m^3 digester.
- Cost: €550,000 (CD$780,000) because city owned. If purchased by a farmer the plant would have cost €450,000 (CD$650,000).
- Daily feedstock volume / type: 26 tonnes liquid (15%) and solid cattle manure (47%), corn and grass silage (23%) and brewery waste (15%).
- Outputs: 140 kW/h of electricity (sold to the grid), heat (used on-farm and heating for 600m^2 residential space, 40% - 45% is wasted) and digestate (used on-farm and given away).

SUMMARY

At the end of the mission a brief wrap up session was held. This enabled all participants to voice their thoughts and opinions. What follows is a 10 point summary of these thoughts:

1. **Political will:** Political support for AD was high in Switzerland and Germany. The group felt that similar political support from the Ministries of Agriculture and Lands, Energy, Mines and Petroleum Resources, Environment and Economic Development is needed in BC before AD will be widely adopted. This support includes incentives to support technology adoption (i.e., feed-in tariffs) and to change current waste management practices (i.e., banning of land filling organics). The hope was that this support would come soon.

2. **Benefits of AD:** The benefits of adopting this technology are much more than just a distributed form of electricity that increases generation capacity. It also results in improved air quality, as well as reductions in GHG emission, odours, and contamination resulting from pathogens and nutrients. Therefore, the group felt that this technology should be viewed more as a tool for environmental management than energy production. However, despite this, disappointment was evident at the lack of mention of carbon credits during the mission. While this may have been a result of high monitoring costs (making this modus operandi uneconomical), the group felt that this deficiency should be addressed in BC.

3. **Biomethane:** Before the mission began, several of the group had thought that electricity and heat were the only forms of energy produced through AD. However, after speaking to experts and technology providers, particularly in Switzerland and Germany, the group realized that biogas can also be (and perhaps should be) converted to biomethane.

4. **Utilization of waste streams and byproducts:** Because of BC's low energy prices, the group felt that AD will only be economically feasible if all available waste streams (including manure, crop residues, agri-food waste, green waste and OFMSW) and byproducts (including heat, digestate, and the CO_2 which could be used on-farm, as well as in greenhouses and industrial applications) are utilized.

5. **Technology variance:** Some in the group voiced their surprise with the huge variation in current AD designs and technology. Although an off-the-shelf product with over 3,500 built in Germany alone, no one specific design or technology has emerged as a clear winner. This has resulted in different technology providers having different designs and set-ups, including high or low volume systems, single or multi-stage digester vessels and continuous flow or batch processes.

6. **One size doesn't fit all:** One message that the group took from the mission is that there is no one-size fits all digester design. Each site is very different with regards to feedstock types, volumes, infrastructure, demand for byproducts, etc. Therefore, each potential AD site will require a site specific evaluation and technological adaptations.

7. **Future research:** The group expressed surprise at the lack of research into microbes and their potential use in AD. Currently, very little is known about the vast majority of microbes on this plant and it was felt that more research, such as that being done for cellulosic ethanol, should be conducted. These microbes may have the potential to produce 2, 5 or even 10 times the amount of biogas that current microbes.

8. **Concerns:** Although impressed with Germany's aims to replace 17% of its energy needs through AD by 2020, there was concern within the group that this would be achieved primarily through the consumption of energy crops (as a result of the additional €0.06 kW/h (CD$0.08) offered in the German Renewable Energy Law). This caused concern for two reasons. First, it raises the ethical debate of food versus fuel currently being discussed with respect to ethanol and biodiesel. Second, increased demand for crops will inevitably push up prices. Since 2002, the price of corn in Austria has doubled from €20 to €40 / tonne (CD$28 to CD$56 / tonne). This has clearly impacted the viability of AD in Austria. Further concerns were also voiced about the recent trend for farmers to stop farming once their digester has been built. However, some argued that this will change if AD continues to push up crop prices.

9. **Nutrient management:** A further concern, with respect to adoption of AD in the Fraser Valley, was that most of the digesters visited showed no evidence of design for optimizing the manure nutrient management process. Therefore, several in the group felt that before AD is adopted in the Fraser Valley, add-on nutrient extraction and concentration technologies must be developed. These technologies will convert low-value digestate into a high-value saleable product that people will pay for, or at the very least, transport out of the Fraser Valley free of charge (such as the extraction and concentration of nutrients).

10. **Current BC climate:** In reality, economics and regulations will dictate the success of AD in BC. Therefore, AD is probably a few years away from becoming feasible. However, during this time, the group felt that missions such as this should be encouraged as they enable participants to learn from others experiences and mistakes. Furthermore, the group also felt that it was important for them to take what they have learnt from this mission to educate others about the potential benefits of AD.

Appendices

Appendix A

Sunday, August 26th	Switzerland
6 PM	Meet in the hotel restaurant for introductions.
Monday, August 27th	**Switzerland**
7.45 AM	Depart from hotel.
8.45 AM - 9:45 AM	**Presentation**: 'Introduction to the European Biogas Sector; Current Trends, Technologies and Policies' by Dr. Arthur Wellinger (Novaenergie). **Presentation**: 'Biogas Sector in Switzerland' by Mrs. Katharina Serafimova (Biomass-Energy Program 'Swissenergy').
9:45 AM - 11:45 AM	Introduction to the 'Kompogas' Technology by Mr. Huwiler, Managing Director
2 PM - 3:30 PM	**Plant Visit:** Biopower Plant Pratteln. Feedstock: Biogas production, uses of biogas, conditioning of biogas for use (including fuel-station for biogas).
4:00 PM - 6:00 PM	**Presentations:** 'Anaerobic Digestion of Biomass for Energy-Generation in the Canton of Baselland' by Tobias Andrist (EBL Liestal). **Presentations:** 'Introduction to Project 'Swiss Farm Power' by Dr. Reto von Schulthess (Holinger, Lucerne). **Presentations:** 'Digestion of Wastes from Abattoirs 'Project Hunziker' by Dr. Uwe Sollfrank (Holinger AG, Liestal). **Presentations:** 'Digestion of Renewable Agricultural Raw Materials' by Dr. Rainer Gottschalk. **Presentations:** 'Digestion of Residues from Production of Bio-Ethanol; Cooperation with Econcept, Canada' by

	Dr. Uwe Sollfrank (Holinger AG, Liestal).
Tuesday, August 28th	**Switzerland / Austria**
8:00 AM	Depart from hotel.
10:00 AM - 12.15 PM	**Plant Visit:** Agrigas Communal Biogas Plant. Feedstock: Cattle and pig manure, grape residues from winery mixed and communal green waste. **Presentation:** 'Genesys Biogas Technology and Biogas Production from Commercial Fish Farming' by Mr. Florian Ruesch (Genesys Biogas AG).
2:00 PM - 2:30 PM	**Plant Visit:** Agrigas Basic Biogas-Plant. Feedstock: Cattle and chicken manure.
3:00 PM - 5:00 PM	**Plant Visit:** Jakob Bösch AG. Feedstock: Waste treatment plant.
Wednesday, August 29th	**Austria**
8:30 AM	Departure from Hotel.
9:00 AM - 10:00 AM	**Presentation:** 'Austrian Biogas Sector' by Mr. Egon Arnold (AAT).
11:00 AM - 12:00 PM	**Plant Visit:** Stadtwerke Feldkirch. Feedstock: Manure, waste oil and garden residues.
2:15 PM - 3:30 PM	**Plant Visit:** ARA Meiningen. Feedstock: Municipal sludge digestion.

Thursday, August 30th	Austria / Germany
7:30 AM	Depart from Hotel.
8:00 AM - 10:00 AM	**Plant Visit:** GE Energy - Jenbacher Headquarters (gas-powered electrical generators).
10:00 AM - 11:00 AM	**Plant Visit:** Landwirtschaftliche Lehranstalt Rotholz (LLA Rotholz). Demonstration-plant of a new plant-type (BIO4GAS).
2:00 PM - 4:00 PM	**Plant Visit:** Salzburger Abfallbeseitigung GmbH (operates with Dranco technology). Feedstock: Organic waste systems.
5:00 PM - 6:00 PM	**Plant Visit:** Biogas Plant Finsterwalder. Feedstock: Bio-waste, fish waste and manure.
Friday, August 31st	**Germany**
8:30 AM	Depart from Hotel.
9:00 AM - 10:30 AM	**Presentations:** 'Biogas in Germany' by Mr. Matthias Effenberger **(**Institute for Agricultural Engineering, Farm Buildings and Environment Technology). **Presentations:** 'Biogas in Germany - Legislative Framework and Situation Report, by Mr. Claudius da Costa Gomez (CEO, German Biogas Association).
11:15 AM - 12:30 PM	**Plant Visit:** Biogas plant Geisenhofer. Feedstock: Used to be mainly manure, now mainly maize silage, grass silage, whole crop silage and kernels.
2:30 PM - 4:00 PM	**Plant Visit:** Biomethananlage Pliening Feedstock: Maize silage, whole plant silage and grain.

Saturday, September 1st	Germany
8:30 AM	Depart from Hotel.
9:00 AM - 11:00 AM	**Plant Visit:** Gut Karlshof Biogas Plant. Feedstock: Silage, maize and manure.
2:30 PM - 4:00 PM	De-briefing session at Gut Karlshof.
END OF STUDY TOUR	

Appendix B

List of Tour Attendees:

- **BC Milk Producers Association**:**
  - Dick Klein Geltink (Director and Dairy Framer).
  - Paris Thomas (Director, Communications and Planning).
  - Thomas Wynker (Board Member and Dairy Operator).
- **BC Sustainable Poultry Group**:**
  - Kevin Chipperfield (Manager).
  - Dave Siemens (Fraser Valley Egg Producer).
- **Marine Harvest*:**
  - Sharon DeDominics (Environmental Sustainability Manager).
- **Ritchie-Smith Feeds Inc:**
  - Frank Curtis (Fieldman)
- **Independent Power Producers:**
  - Doug Hazelton* (Manager, Thermal Division, Canadian Hydro).
  - Richard Lemaire (West Canadian Development manager, Boralex).
  - Pierre Boulay (Director, Cascades Canada Energy Action Group).
  - Claes Fredrikson* (Principal, Freethem Energy Inc).
  - Alexander Kopp* (President & CEO, Econcept Bio-Energy Corp).
- **Ministry of Energy Mines and Petroleum Resources:**
  - Janice Larson (Director, Bioenergy & Renewables Branch).
- **BC Hydro:**
  - Ralph Zucker (Director, Asset Investment & Reliability).
- **Ministry of Agriculture and Lands:**
  - Ted Van der Gulik (Senior Engineer, Resource Management Branch).
  - Mathew Dickson (Bioeconomy Policy Advisor).
- **Ministry of Economic Development:**
  - Rolf Fyne (Director, Business Development - European Region).
- **National Research Council:**
  - Warren Nagata (Industrial Technology Advisor, Industrial Research Assistance Program).
- **Canadian Embassy in Mexico:**
  - Rosalba Cruz (Trade Commissioner; Clean Energy).
- **University of Mexico:**
  - Dr. Gerardo Hiriart (Researcher, Institute of Engineering).
- **Additional:**
  - Jim Sandwith (Entrepreneur).

** = CD$2,000 funding*