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In This Issue

Biogas Production – Lessons Learned from Europe
… seeing and learning as much as they could in seven short days
…cover story

Thinking About Construction ?
…constructing a farm building in Ontario takes a great deal of planning. Make sure you understand Nutrient Managemet Regs
…pg. 5

Take the Winter Feeding Challenge
… ten cost saving feeding strategies for cow/calf producers
… pg. 8

Bossy, It's Cold Outside!
… how we can help cows deal with winter
... pg. 10

Biogas Production – Lessons Learned from Europe

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On Monday August 21st a group organized by the Ontario Large Herd Operators left from Toronto Airport bound for Amsterdam. The next seven days would be spent traveling by bus through the Netherlands, Germany, and Denmark to study anaerobic digestion technology. The 32 participants were quite a diverse group, made up of dairy, beef, swine, vegetable and cash crop producers, research and extension people, waste haulers, industry people, plus a banker, a representative from Hydro One, and the Ontario Power Authority. Although a diverse group, they all had a common goal of seeing and learning as much as they could in seven short days. Or perhaps the group would say seven long days, as the tour started early every morning, and ended late every night.

Figure 1. horizontal digester

……continued on next page

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Virtual Beef is compiled by the OMAFRA Beef Team and edited by Tom Hamilton, Beef Program Lead, Production Systems

Many hours where spent riding the bus, but each stop managed to give the group something new to talk about in between. The route went from Amsterdam, in the Netherlands to Ribe, Denmark in the North and then back again. We visited 16 anaerobic digester installations, or biogas plants, as they are more commonly referred to in Europe. Each stop had been carefully chosen because it was unique in some way - either by the technology at the facility, or because of the goals that the owners were trying to achieve.

There are other things in Europe to see besides biogas plants … the first day started with a stop at the Aalsmeer Flower Auction. Aalsmeer is a co-operative where 3000 grower members market their floriculture products through a central marketplace using the Dutch Clock auction system. The group saw a lot more colour than the usual black and white many were used to. But after that, the rest of the European scenery and history was mostly enjoyed from the bus window, or from visiting the interesting towns the group stayed in each night.

The first biogas plant was located in the Netherlands at the Eissen Dairy. Here the group was introduced to the basics of how biogas is produced from manure. Manure from the dairy was pumped into an insulated above ground concrete manure tank. Hot water heating tubes wrapped around the tank kept the contents at about 40^{o}C. At this temperature anaerobic bacteria in the manure are quite active, converting the organic matter in the manure into methane gas (CH_4), more commonly referred to as biogas. The biogas was collected off the top of the digester and used to fuel two Jenbacher diesel engines running a pair of 625 kW electrical generators. Heat from the engines was collected and used to heat the hot water to keep the digester warm (Figure 2).

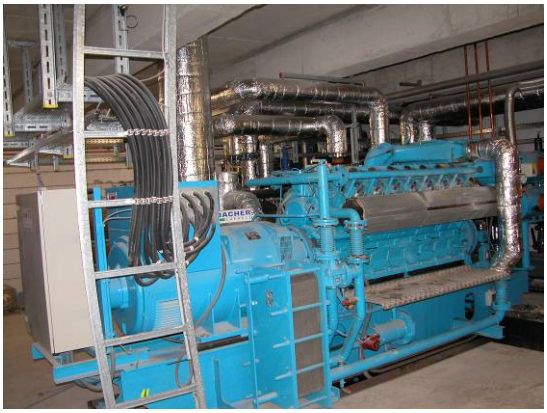

Figure 2: Jenbacher diesel engine

Before the biogas could be used in the engines, the hydrogen sulphide and moisture had to be removed. A small amount of oxygen was added in the head space of the digester to combine with the hydrogen sulphide to produce a precipitate, thus removing most of the hydrogen sulphide. The biogas was then transferred to the engines underground, so most of the moisture would condense out of the gas.

The majority of gas was removed in the anaerobic digester, and the remaining effluent was then transferred to a long term storage where the bacteria continued to work as the manure cooled off. This tank was also covered so the biogas could be collected and pumped to the engine.

The effluent in the long term storage was eventually applied on adjacent fields. Anaerobic digestion preserves the nutrient content of the manure, so that it can continue to be land applied as a fertilizer. Anaerobic digestion also greatly reduces both the pathogen content of the manure and the odour. This was most evident when the group visited the Futterkamp Research Station. While the group stood and viewed the digester, the long term storage tank 50 ft away was being agitated and manure was being hauled to the fields. There was no smell, other than what was coming from the cows in the barn!

The group quickly learned that a variety of other ingredients were added to the digesters to increase the output of biogas. The most notable ingredient was corn silage (Figure 3). Many digesters used a modified TMR mixer to meter corn silage into the mix to increase the

gas production. At one stop, a German engineer remarked that you had to "Love her like a cow", when referring to the digester. This helped the group to understand that you have to "feed" the digester very similar to how you would feed a cow. You need to concentrate on providing lots of energy feedstocks, and to make changes gradually when you introduce new feeds. The group also saw installations that were further processing the energy crops added to the digester to make the energy more available to the bacteria, in order to increase gas production. One company was also adding grain to the long term storage to try to keep the digestion process going after the effluent had left the main digester.

Figure 3: Corn silage being added to a digester

The biogas reactors which the group saw were basically of two types. The most common was the vertical totally mixed digester (Figure 4), while we also saw several horizontal digesters (Figure 1).


Figure 4: vertical totally mixed digester

The horizontal digesters were usually used for feedstocks with higher dry matter content, like poultry litter. There did not seem to be a clear right or wrong, in terms of digester designs. The biogas companies would design the digester to meet the individual needs of the producer. The design would be based on feedstocks available, intended use for the biogas, alternate uses for heat, etc.

We saw several creative uses for the additional heat captured from the engine-generator sets or gen-sets. Most biogas plants were using excess heat to heat hot water for the barn or house, but three of the biogas plants were actually selling the heat for use by others. One plant in particular was using the excess heat to provide hot water heating to a nearby airport, and two others were supplying a portion of home heating requirements in adjacent villages, such as Jühnde.

Jühnde is a small German village where all the energy to the village is supplied by the adjacent biogas plant (Figure 5). The plant supplies the electricity from the diesel engines operating on biogas running generators, and then excess heat from the engines is used to heat hot water with is supplied to the villagers for water and heating needs. In the winter when excess heat from the gen-sets is not enough to provide the homes with heat, extra boilers are fired with wood chips. Plans are currently under way to dry the wood chips with extra heat that is available in the warm summer months.


Figure 5: biogas plant

Another unique stop was to a "gas" station that offered its customers the option of filling up with biogas (Figure 6). The biogas supplied to the gas station was produced at a nearby plant similar to the others, but it had been through an

extensive refining process to concentrate the gas to a level that could be used in natural gas powered vehicles.

Figure 6: gas station offering option of biogas fuel

Most of the biogas plants visited with the tour had multiple partners. This allowed different feedstocks to be brought together for processing. For instance, there were several plants where the manure from cattle and hogs was mixed into the same digester. As well, at several sites, different food by-products were also added. Co-operatives ranged in size from two to three farmers up to one large plant that managed the manure from 300 farms in a 50 km radius from the plant. Here 20 tanker trucks were used to pick up the manure at the farms and transport it for processing at the centralized biogas plant. After processing, the treated manure would be stored in tanks in the area for land application, or spread directly onto fields depending on availability.

Not all biogas plants are large scale. If the group could have traveled south to Switzerland, Austria, and southern Germany more individual biogas plants would have been evident.

The group also had several opportunities to visit with technology suppliers, and leaders in the biogas industry. One leader from the German Biogas Association noted that, in Germany, direct benefits from the biogas sector include: 650 MW of installed electrical capacity, a reduction of 4 million tonnes/yr of CO_2 emissions, $960 million spent in construction in 2005, and revenues of $500 million to farmers from electricity sales each year. He also noted that the anaerobic digestion/biogas sector in NW Europe is a mature industrial sector with over 200 businesses (8000 employees) offering services to farm-based, cooperative, and industrial biogas facilities. The vast majority of biogas facilities are farm-based systems.

The vast majority of the European farms visited were similar in many ways to what the producers had at home. So why don't we have a proliferation of biogas plants here in Ontario? There are two main factors that have made biogas generation in Europe wide-spread:

1. The government there has made a commitment to have electricity prices that reflect the cost of producing renewable power from different technology systems (biogas, wind, etc), and specifically for biogas systems using different inputs (manure, energy crops, food-based inputs), and with different scales (higher prices for smaller systems).
2. Guaranteed access to the electricity grid with few restrictions or fees.

At present, the electrical prices in Ontario offered to farmers producing electricity from biogas are not sufficient in most cases to make it economically feasible. The Standard Offer Contract (SOC) program announced last March is one step in the right direction to having a biogas industry in Ontario. Hopefully this can be improved in the future to provide incentives to increase production of biogas by using energy crops in the mix, and to use excess heat recovered from the generator engines. And let's not forget that anaerobic digestion also greatly reduces the pathogen content of the manure, and greatly reduces the odour, both of which are societal benefits. Anaerobic

digestion also gives an opportunity to use food by-products that are presently going to landfill sites.

The technology used by the biogas plants that the group visited in Europe would apply in Ontario as well. Many companies there are looking to partner with companies here, so if the electricity price paid for biogas improves, the technology is ready to go.

Biogas production in the future could provide farmers with an additional source of income, while providing society with an alternative use for food by-products, reduced pathogens, and reduced odours from manure. The potential exists for a "win-win" situation.

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If You Are Thinking About Construction…Think About Nutrient Management

Andrew Barrie
OMAFRA Nutrient Management Specialist

Over the last few months I have had the privilege of seeing dozens of farm construction projects aimed at improving water quality both on and off of the farm. Many of these farms have been beef operations where the biggest challenge in the past has been dealing with manure runoff from cattle yards, open manure storages or temporary field piles. One common element I observed about every successful construction project was a well researched plan.

Constructing a farm building in Ontario takes a great deal of planning and there are a number of different regulations that you may have to comply with. You can find this information at http://www.omafra.gov.on.ca/english/engineer/facts/06-039.htm

Most farmers are aware of the Provincial *Nutrient Management Act (2002)* but are less aware of the impacts of amendments to the regulations that were filed last September which can be found on the OMAFRA website at http://www.omafra.gov.on.ca/english/nm/regs/update.html

Before obtaining a building permit, you may be required to develop or obtain a Nutrient Management Strategy (NMS) and a Nutrient Management Plan (NMP).

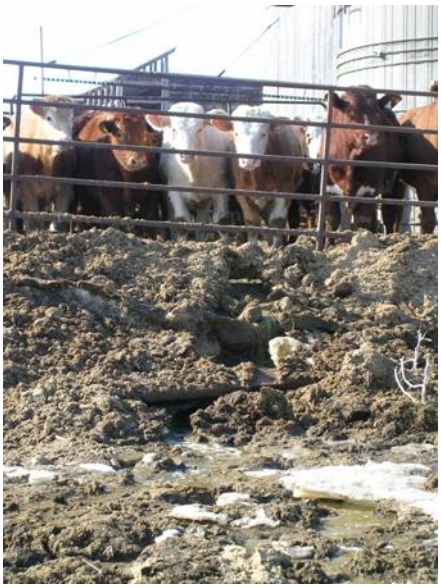

Figure 1: Open livestock yard with no containment of precipitation and runoff.*

Nutrient Management Strategies and Nutrient Management Plans

The Nutrient Management Strategy sets out the environmentally acceptable methods for managing all prescribed materials generated at an agricultural or non-agricultural operation. It is a document that describes generation, storage and destination of manure and other prescribed materials. It provides information such as: number of animals, barns, manure

storages, livestock yards and runoff management. The total capacity of the farm unit may be considered when applying for a building permit.

The Nutrient Management Plan details how manure, fertilizer and other nutrients are applied to a given land base. It is a five year plan that details the characteristics of the land, crop rotation, as well as the cropping and nutrient application practices. It optimizes the utilization of the nutrients by crops in the field and minimizes environmental impacts.

What projects require an approved NMS?

On any farm, where the number of farm animals is greater than 5 nutrient units (NU) or will be greater than 5 NU upon completion of construction, the following projects require an approved NMS:

1. Expansion or construction of any building or structures used to house farm animals that requires a building permit under the Building Code Act*.

2. Construction of any manure storage facility that requires a building permit under the Building Code Act*.

3. Construction or excavation of any earthen manure storage (eg. a lagoon), including expansions of existing earthen storages,

* An approved NMS is also required in these situations in unorganized townships.

Nutrient Units

Nutrient units are calculated based on the number of livestock housed on a farm unit. A nutrient unit is defined as the number of animals that will give the fertilizer replacement value of the lower of; 43 kilograms of nitrogen or 55 kilograms of phosphate per year as nutrients**.**

The table below describes the number of beef animals of various types per nutrient unit:

Animal Type	Animals/Nutrient Unit
Beef Backgrounders (7-12.5 months)	3
Beef Cows (including unweaned calf)	1
Beef Feeders (7-16 months)	3

For farms with other livestock species and or mixed livestock operations, call the toll free Nutrient Management Information Line at 1 866-242-4460 or consult on-line at: http://www.omafra.gov.on.ca/english/livestock/nutrient/nutrient.html

Figure 2: Roofed livestock yard with a poured cement pad and containment walls to eliminate manure runoff and divert precipitation (rain, snow) away from the yard.*

Does this mean I must document the 5 year crop plan for my farm?

Not necessarily. The five year crop plan would be part of a nutrient management plan. Although a Nutrient Management Plan (NMP) is recommended to all farm operations that apply manure and fertilizer, only some of the farms that have a Nutrient Management Strategy will need to have a Nutrient Management Plan. If any of the following conditions apply, the farm must also have a NMP:

1. Livestock numbers ≥ 300 NU in the farm unit (the NMP is kept on file on the farm)
2. Any part of the land in the farm unit is within 100 meters of a municipal well (NMS

approved by OMAFRA and NMP is kept on file on farm)

3. Apply non-agricultural source material (NASM) such as biosolids on land in the farm unit. (NMP approved by OMAFRA)

How do I get my NMS approved?

First of all, NM strategies and NM plans must be prepared by someone certified under the *Nutrient Management Act* (2002). There are two options for certification: a farmer can take the necessary courses to be certified or you can hire a certified consultant to prepare your NMS. Once your NM strategy has been prepared, it is sent to OMAFRA in Guelph for approval.

For more information on consultants, nutrient management courses, or who to contact in your area for more information on nutrient management, call the toll free Nutrient Management Information Line 1 866-242-4460 or visit the OMAFRA website on-line at: http://www.omafra.gov.on.ca/english/agops/index.html.

Funding

Funding for projects may be available under the federal Environmental Farm Plan and Cost Share program, through your local Conservation Authority, or through the Oak Ridges Moraine Environmental Enhancement Program. Costs associated with hiring consultants for completing the NMS and NMP may be eligible.

For more information on the Environmental Farm Plan Program and related cost share program, call the Ontario Soil and Crop Improvement Association toll free at 1-800-265-9751, (519) 826-4214, or visit the website at www.ontariosoilcrop.org

Figure 3: Open manure storage and livestock yard with some containment of precipitation and runoff.*

Figure 4: Covered manure storage and livestock yard (separated by concrete walls with swing gates) to eliminate contaminated runoff.*

All photos courtesy of Anne Loeffler, Grand River Conservation Authority

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Take the Winter Feeding Challenge

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It seems that most articles on the winter feeding of beef cows are quite similar, with minor variations on themes. I hope you will find this article different! I am going to give you ten feeding strategies or ideas which I believe cow/calf producers should consider (and feedlot folks could take note of a few too). Some of the strategies work well together, while some are very effective on their own. They are all intended to help reduce that winter maintenance cost which, in the end, seems to be the real make or break part of the cow/calf production equation.

My challenge to you is to try at least one new strategy from the list this coming winter!

1. **Days at Grazing** – Still the number one way to reduce feed costs. Stockpiled perennial pasture is low cost, providing feed at half the cost of using hay. Grazing a season extending annual crop is an intermediate cost strategy. There is a large amount of information available to provide ideas for your location in the province. One good link is www.omafra.gov.on.ca/english/crops/field/forages.html . Previous issues of *Virtual Beef* also have excellent articles.

Figure 1. Moderate frame size cows on fall pasture

2. **Afternoon and Evening Feeding** – No one seems to fully understand it, but the timing of cow feeding can influence the time of calving. Many producers have successfully used feeding in late afternoon and evening to push calving from nighttime to daytime. Using this strategy can reduce overnight (human) labour needs on the farm. To make this work you should start p.m. feeding about 4-6 weeks before calving to get the cows adjusted to the new routine.

3. **Reduced-Hay Rations (RHRs)** – Hay was plentiful in most parts of the province this year, but read on! Commodities are also relatively inexpensive at this point. Might some purchased barley or corn help reduce your hay use and let you build a little forage reserve? For the folks where there were regional hay shortages, this should be a top notch hay stretching method. For more details on this topic see Virtual Beef volume #4, issue #2 in October 2005 - www.omafra.gov.on.ca/english/livestock/beef/news/vbn1005a4.htm
"Hay in Cow Wintering Rations"

4. **Ethanol By-products** – Hand in hand with RHRs based on corn or barley, how about ethanol by-products? And in cases where a little extra protein is needed, such as with really bad hay, these by-product commodities deserve special consideration. For that matter, consider them in any ration where you'd use grain plus a protein source. As ethanol becomes more available at the gas pumps, the by-products from its production will become more available. Cow rations formulated with distillers' grains were covered in the Virtual Beef reference for RHRs as well. This topic promises to be popular at this winter's meetings!

5. **Bulk Silage** – Using corn and forage crops for bulk chopped silage stored in bunker silos is worth a look. There are two advantages: in larger beef cow herds labour associated with harvesting forages in bales is a bottleneck. This limitation was also encountered in large dairies, many of which have moved to bulk silage to eliminate the bottleneck. The other advantage is the

ease of mixing various feeds such as straw, grain and commodities with the chopped forage. Of interest in southern Ontario is that in many instances corn silage seems to be less expensive than hay, especially if purchased as a standing crop.

6. **Alternate Day Feeding** – There has been a reasonable amount of research and enough farm experience to recommend alternate day feeding as a means to use feeds of differing qualities or characteristics without using TMR mixers and their associated costs. For example, if the theoretical ration required ½ poor quality hay and ½ better quality haylage, it would be best to combine them in a TMR. However, a close second in effectiveness would be to feed just one type of feed on a given day, with the other the next day. As an alternative, you could offer the same feed type for two days in a row (but not for more than two days.) The poorest strategy would be to put some bales of each type out each day! This is because of the dominance order in the herd … bossy cows will get all of the best feed and grow fat, while submissive cows will get only poor feed and suffer because of it. Similarly. corn silage or grain could be fed every second day as well. Get more details at www.omafra.gov.on.ca/english/livestock/beef/facts/info_wintering.htm
"Wintering Livestock Using Alternate Day Feeding"

Figure 2. TMR mixers are a good tool for blending corn silage and commodity feeds with forages in reduced hay rations

7. **Microclimate Management** – Especially in the dead of winter, poor coat condition (caked with mud and or manure), wet wintering sites and wind can almost double energy requirements (or weight loss) for cows. In that mid-January to mid-February period in particular, consider the benefits of wind breaks and clean, dry resting areas. Get cows to that stressful period with enough body condition and clean hides to ensure good insulation. Windbreaks and shelterbelts are a science unto themselves, but a couple of key points are:

    a. slotted or porous walls are better than solid walls, (so the old bunker silo wall won't cut it unless you want to dig cows out of the snow drift).
    b. wind break fence or treed shelterbelts set at least 15 m (50 ft) from the site are the best way to go
    c. the Environmental Farm Plan promotes shelterbelts.

Figure 3. Clean coated cows in good condition at a sheltered wintering site

8. **Calving Season** – There has been a significant amount of research and discussion on how the season of calving affects winter feed needs. This is a major topic unto itself but it interrelates with the other nine techniques listed here. The OMAFRA site covers research on this topic at:

    www.omafra.gov.on.ca/english/livestock/beef/cowcalf.html

9. **Reduce Cow Frame Size** – The number one predictor of intake across cattle types is size and weight. The point is, the bigger the cow, the bigger her feed bill. Consider better use of terminal sires on smaller (not small) cows to keep calf yields up while keeping winter cow feeding costs down.

10. **Information Management** – None of these strategies can be properly evaluated without basic information on your operation, such as forage inventories, cow weights and recording days at pasture. This is especially important if a big ticket technology, such as bulk silage, is being considered. All this information and much more will be needed to evaluate the potential and allow you to make sound decisions.

So try one of these strategies … and let me know how it works out!

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Bossy, It's Cold Outside! When The Thermometer Doesn't Tell The Tale

Tom Hamilton
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Winter = snow, wind, cold, hockey and booster cables.

Dealing with winter is an unpleasant fact of life in the temperate region of North America. For most beef cattle, winter brings a very significant change to their environment. And unlike farmers, they can't jump in the truck to warm up on nasty days, nor enjoy a Thermos of hot coffee in the tractor cab, with the heater running full blast and Shania on the cd player!

However, similar to farmers who don insulated coveralls and thick gloves, cattle also prepare for colder weather. As temperatures decline during fall, cattle grow a longer hair coat, which provides a much higher level of insulation by trapping more pockets of air within the hair. Still (non-moving) air is a poor conductor of heat, so a thick layer of micro air bubbles within the coat provide the animal with a heat retaining blanket. In contrast,, cattle which are housed in a warm barn are not stimulated to grow a thick winter coat. If these cattle are suddenly moved out into cold temperatures, they will quickly get chilled and show signs of discomfort by bawling and roaming restlessly instead of bedding down. If left in the cold environment, these cattle will respond by growing a winter coat in a few weeks. But letting cattle adapt naturally to cooling temperatures is a good strategy which reduces overall stress on the animals.

Figure 1: Bush lots can provide excellent wind protection

Animals have a certain environmental temperature range in which they can function without expending extra energy to maintain their core body temperature. This range is call the thermo neutral zone. The temperature at the lower end of this zone is called the lower critical temperature. Below this temperature, the animal has to expend extra energy to keep warm, by shivering (initial stage) or producing heat in muscle tissue without shivering (later stages). The lower critical temperature is

affected by hair coat depth and whether the hair is wet or dry, along with other factors. Table 1 gives values of lower critical temperatures for various scenarios.

Table 1. Estimated lower critical temperatures for beef cattle*

Coat Description	Lower Critical Temperature
Wet or summer coat	16°C
Dry fall coat	7°C
Dry winter coat	0°C
Dry heavy winter coat	-7°C

*ref. Oklahoma State University Mesonet Weather Model, 2003

As environmental temperature drops below their thermoneutral zone, cattle respond by increasing their resting metabolic rate. This produces more internal body heat, just like cranking up the furnace in your house. Of course, producing heat requires fuel. For cattle, the fuel required is supplied by feed energy or from burning stored body fat. For each 1 degree Celsius decline in temperature below their lower critical temperature, cattle require an additional 2% energy in the diet. This can be accomplished by an increase in feed intake, but if they are already at maximum intake, then the energy density of the diet must be increased.

So far, we have just considered air temperature as measured by a regular thermometer. But as you will agree after a winter stroll across the yard on a windy January day, there is more to feeling cold than just the temperature of the air. The amount of heat lost to the environment on a cold day is also affected by wind speed. This effect is known as wind chill. Wind chill occurs when there is relative movement between a warm surface (like a cow) and the surrounding air. Although individual air molecules are relatively poor conductors of heat, when they move in a steady stream over a surface, millions of molecules each pulling away a small amount of heat add to significant heat loss. In addition to this, the air movement disrupts the cow's boundary layer, a thin layer of still air which surrounds objects and acts as a insulative layer. When the boundary layer is pulled away, its insulative value is lost and heat loss increases rapidly. In fact, the first 10 kilometers per hours (kph) of wind speed (from 0 to 10 kph) has a greater effect than going from, say, 30 to 40 kph, due to the initial loss of the boundary layer. The effect of wind chill is shown in Table 2 This gives the heat loss equivalent of still air compared with moving air at the same temperature but at various wind speeds. For example, if the thermometer read -20 C', and wind speed was 15 kph, it would feel like it was actually almost 30 C'.

Table 2. Wind Chill Effect - Still Air Temperature Equivalents For Moving Air *

Wind Speed, kilometers per hour	Still Air Temperature in Degrees Celsius												
	10	**5**	**0**	**-5**	**-10**	**-15**	**-20**	**-25**	**-30**	**-35**	**-40**	**-45**	**-50**
10	8.6	2.7	-3.3	-9.3	-15.3	-21.1	-27.2	-33.2	-39.2	-45.1	-51.1	-57.1	-63.0
15	7.9	1.7	-4.4	-10.6	-16.7	-22.9	-29.1	-35.2	-41.4	-47.6	-53.7	-59.9	-66.1
20	7.4	1.1	-5.2	-11.6	-17.9	-24.2	-30.5	-36.8	-43.1	-49.4	-55.7	-62.0	-68.3
25	6.9	0.5	-5.9	-12.3	-18.8	-25.2	-31.6	-38.0	-44.5	-50.9	-57.3	-63.7	-70.2
30	6.6	0.1	-6.5	-13.0	-19.5	-26.0	-32.6	-39.1	-45.6	-52.1	-58.7	-65.2	-71.7
35	6.3	-0.4	-7.0	-13.6	-20.2	-26.8	-33.4	-40.0	-46.6	-53.2	-59.8	-66.4	-73.1
40	6.0	-0.7	-7.4	-14.1	-20.8	-27.4	-34.1	-40.8	-47.5	-54.2	-60.9	-67.6	-74.2
45	5.7	-1.0	-7.8	-14.5	-21.3	-28.0	-34.8	-41.5	-48.3	-55.1	-61.8	-68.6	-75.3
50	5.5	-1.3	-8.1	-15.0	-21.8	-28.6	-35.4	-42.2	-49.0	-55.8	-62.7	-69.5	-76.3
55	5.3	-1.6	-8.5	-15.3	-22.2	-29.1	-36.0	-42.8	-49.7	-56.6	-63.4	-70.3	-77.2
60	5.1	-1.8	-8.8	-15.7	-22.6	-29.5	-36.5	-43.4	-50.3	-57.2	-64.2	-71.1	-78.0

*Reference: Colorado State University, 2004

How can we help cattle deal with wind chill? Give them access to natural or artificial windbreaks. Natural windbreaks include conifer shelter belts, bush lots, hills or ravines. Artificial windbreaks can be constructed out of wood, sheet metal, bales, or plastic wind barrier fencing. They can be protected from cattle damage with a hot wire or two. Making them in

an L, T or triangle shape will allow cattle to choose the best side for protection as wind direction varies. Since cattle spend a great deal of time at feeders, placing them in areas sheltered from the wind is important. If the feeders are in a comfortable zone, the cattle will spend the maximum amount of time there and consume more feed, which is beneficial for both growing cattle on high energy diets and wintering cows on base quality roughages. Interestingly, not all open front barns make good windbreaks. Unless the influence of wind swirling and tunneling are taken into account, an open front barn can feel colder on a moderately windy day than being outside in the yard ! If you see cattle crowding into the corners of the barn on a windy day, or staying totally outside, they are telling you that the main barn areas are not comfortable. You need to consider some additional wind control structures.

Figure 2: Plastic wind barrier screening makes an excellent wind break in open areas

Moisture also plays a role in heat loss. In contrast to air, water is a very good conductor of heat, and if the air spaces in the hair coat are filled with moisture, heat loss increases dramatically. So if an animal's hair coat is wetted by rain outdoors, or condensation drip in the barn, its insulative value plummets, and heat loss is rapid. Similarly, mud or manure glued onto the hair coat compresses it, squeezing out most air pockets and filling the rest with conductive material. With wet cattle, the need for extra feed energy to compensate for cold stress increases to 4% for each degree Celsius temperature drop below their lower critical temperature.

The key is to keep cattle clean prior to freeze up. Fresh paddocks, concrete yards and bedded packs go a long way to maintaining clean hides. After freeze up, mud becomes much less of a problem, and rain turns to snow, which has much less wetting power. As air temperatures drop, snow becomes drier and a better insulator. If cattle have a relatively large area with good snow cover, they can lay down comfortably without bedding. If the weather goes through freeze and thaw cycles, some bedding may still be required.

Understanding the principles of heat loss helps us help Bossy to manage winter conditions. The effects of air temperature, wind speed and moisture all work together in negative synergy to increase heat loss. Making sure cattle are acclimatized to winter, providing protection from wind, and minimizing the impact of wet conditions will dramatically improve cattle comfort and feed utilization.

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