SELF ASSESSMENT and BEST MANAGEMENT PRACTICES of ENERGY, WATER AND WASTE IN ALBERTA GREENHOUSES

Growing Forward 2
A federal-provincial-territorial initiative

Alberta Government

Canada

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Project Background

In the winter of 2015, Alberta Agriculture and Forestry (AAF) completed energy and waste audits for a number of greenhouse facilities in Alberta. The purpose of the audits was to establish benchmarks for current energy use and waste management practices in the Alberta greenhouse industry, and to identify opportunities for improvement. This Best Management Practices document has been compiled based on the findings from the audits.

In developing this project, AAF recognized that many of the greenhouses in Alberta will need to make upgrades in order to remain competitive in the marketplace, and to meet increased demands towards sustainable environmental management. The goal of the project is to provide greenhouse owners with recommendations to help them achieve increased productivity, profit and market share through environmental improvements.

How to Use this Document

This document is split into two sections – a self-assessment and a list of best management practices.

Start by completing the self-assessment. The self-assessment is designed to help you identify aspects of your operation that may benefit from changes in management practices. As you answer each of the questions, take note of the referenced best management practices, especially for areas where you score on the low end of the scale.

Once you have completed the self-assessment, refer to the best management practices section for more detailed information on the recommendations made in the self-assessment, and resources you can use for further information.

When reviewing this document, remember that every greenhouse operation is unique. As a result, some of the Best Management Practices presented may not be directly applicable to your operation. When contemplating changes to your operation, consult with an engineer or qualified greenhouse designer to determine the best course of action for your facility.

Self-Assessment

The self-assessment focuses on seven areas related to energy, water and waste:

A. Heating system efficiency
B. Ventilation system efficiency
C. Lighting efficiency
D. Irrigation efficiency
E. Back-up systems
F. Energy procurement
G. Minimizing waste

For each question, there are generally four descriptions listed in separate columns, each having a number ranking. The practices described in Columns 3 and 4 result in improved energy efficiency, water efficiency and waste management. Conversely, the practices described in Columns 1 and 2 can be improved upon by implementing the best management practices identified in the bottom row of each Self-Assessment question.

As you read each question, check the box that most accurately reflects the current state of your facility. After completing the Self-Assessment, review the practices you identified as candidates for improvement.

A – Heating System Efficiency

The heating system in your greenhouse likely represents the majority of your energy expenditures. As a result, small improvements in efficiency can often result in significant savings.

A.1 – WHAT IS THE ENERGY SOURCE FOR YOUR HEATING SYSTEM?		
4	**3**	**1**
☐ One of the following: Natural gas *Clean burning* Biomass (wood, straw, etc.) Biogas *Renewable; however logistics can be a challenge*	☐ Propane *Suitable in areas without access to natural gas*	☐ Coal *Environmental concerns (CO_2 emissions)* *Health concerns (NO_x emissions, SO_x emissions, soot)*
Related BMP: 3		

	kg/GJ			kg CO2e/GJ
	CO2	**CH4**	**N20**	**Total**
Natural Gas	51.4	0.000992	0.000938	51.7
Coal	90.9	0.001563	0.001042	91.2

Source – Environment Canada. Canada's National Greenhouse Gas Inventory 1990-2012. Tables A8-1, A8-2, and A8-8.

Fuel choice significantly affects emissions from combustion. Operating a coal boiler has a number of environmental concerns. As illustrated in the table, the combustion of coal results in 76% more greenhouse gas emissions than burning an equivalent amount of natural gas. In addition to greenhouse gases, coal emissions contain a number of criteria pollutants, including sulfur oxides, nitrogen oxides, and particulate matter (soot), all of which have been linked to human health issues.

A.2 – WHAT EQUIPMENT IS USED TO GENERATE HEAT FOR YOUR GREENHOUSE?			
4	**3**	**2**	**1**
☐ One of the following: High efficiency boiler *Forced air burner, condenser/economizer* Combined heat and power (CHP) cogeneration *Generates heat & electricity*	☐ High efficiency furnace *Forced air burner, condensing furnace*	☐ Low efficiency boiler/furnace *Natural draft, no condenser/economizer*	☐ Electric heating and/or Portable space heaters
Related BMP: 1			

Heating fuel (natural gas, propane, etc.) often represents 80-90% of a greenhouse's energy expenditures. *As a result, even a small improvement in heating system efficiency (such as through installing a boiler economizer, installing a more efficient boiler, or even just performing neglected maintenance) can have a large payback. Estimate the savings you could realize through a 2% improvement in efficiency:*

Annual heating fuel expenditures: $_____ x 0.02 = $_____

A.3 – HOW IS HEAT DELIVERED TO THE GROWING AREAS?	
4	**3**
☐ Hot water heating *Heat is delivered where it is needed (adjacent to plants, below gutters, etc.)*	☐ Forced air heating *Heating the air in the greenhouse is generally less efficient than using hot water heating, but may be more practical in smaller facilities*
Related BMP: 1	

A.4 – WHAT STEPS DO YOU TAKE TO MAINTAIN UNIFORM CONDITIONS THROUGHOUT YOUR GREENHOUSE?			
4	**3**	**2**	**1**
☐ Utilize **both**: 1. Horizontal air flow (HAF) fans *Provide continuous air movement to maintain an even temperature throughout the facility* 2. Zone controls *Ensures heat is delivered to where it is needed*	☐ Utilize **one** of: 1. Horizontal air flow (HAF) fans *Provide continuous air movement to maintain an even temperature throughout the facility* 2. Zone controls *Ensures heat is delivered to where it is needed*	☐ Air movement only when furnace fan is running	☐ No air movement
Related BMP: 5			

A.5 – ONLY AREAS IN ACTIVE PRODUCTION ARE HEATED?	
4	**1**
☐ Yes *Zone controls and/or partitions are used to prevent heating areas not in active production*	☐ No *Large portions of the greenhouse that are empty are heated throughout the winter*
Related BMP: 7	

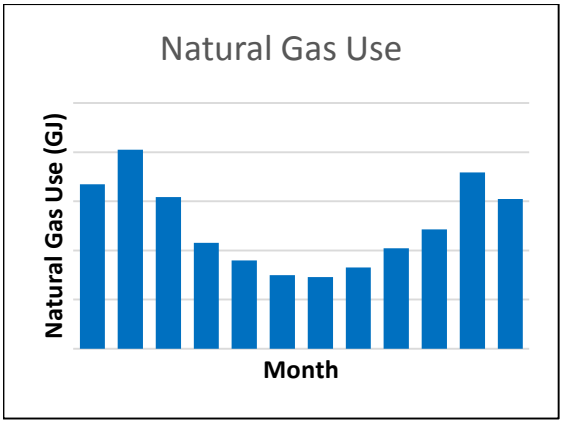
A.6 – WHAT IS YOUR HEATING SYSTEM MAINTENANCE PLAN?		
4	**2**	**1**
☐ One of the following: Annual maintenance performed by qualified service technician *Includes:* *- combustion analysis* *- heat transfer surface inspection & cleaning - safety tests* Boiler water treatment program in place *Helps increase boiler lifespan and prevent corrosion and scaling*	☐ Service technician is only called in when repairs are necessary	☐ No maintenance program in place
Related BMP: 2		

In addition to being a safety concern, an improperly maintained boiler/furnace will not operate at its peak efficiency, causing it to consume more heating fuel than would otherwise be required.

A boiler/furnace with an improperly tuned air/fuel ratio can result in a 5-10% drop in efficiency. Mineral scaling on the heat transfer surfaces of a boiler can result in a significant drop in efficiency if allowed to accumulate for a number of years. The life expectancy of a boiler is also significantly reduced without a maintenance program.

A.7 – IF UTILIZING A BOILER, IS YOUR FACILITY IN COMPLIANCE WITH ALBERTA BOILER SAFETY ASSOCIATION (ABSA) REQUIREMENTS?		
4	**3**	**1**
☐ Facility is in full compliance with ABSA requirements *Required safety checks are being performed and a log kept* *Staff member has the required certification to operate the boiler*	☐ Facility has a temporary permit from ABSA *Issued when no one on staff has the required certification to operate the boiler, but a plan is in place for someone to receive training*	☐ Facility is not in compliance with ABSA requirements *Contact your local ABSA inspector to determine the steps required to bring your facility into compliance*
Related BMP: 4		

A.8 – HOW DO YOU MONITOR YOUR HEATING SYSTEM PERFORMANCE?		
4	**3**	**1**
☐ Utilize manual records **plus**: Automated environmental control systems *Constantly monitors greenhouse conditions and adjusts mechanical systems (heating, ventilation, etc.) as needed*	☐ Manual record keeping *Monthly energy (heating fuel & electricity) use and expenditures are recorded and tracked*	☐ No record keeping
Related BMP: 6		



Creating a spreadsheet to record the amount of energy you use every month is a useful tool to help you stay on top of the performance of the mechanical systems in your greenhouse. Many Alberta energy retailers have online portals to offer you this data. Contact your retailer to ask if they offer this service for your site.

By plotting your energy consumption on a graph, you will easily be able to observe seasonal trends. In addition to this, you will be able to see the impacts of mechanical/operational changes you make in your facility (such as observing your natural gas consumption decrease due to the installation of a boiler economizer), and will be alerted of potential issues if your energy usage unexpectedly increases.

A.9 – ENVIRONMENTAL SENSORS ARE CALIBRATED REGULARLY?	
4	**1**
☐ Yes *The calibration of environmental sensors (thermostats, humidistats, etc.) is checked regularly to ensure optimal heating system performance*	☐ No
Related BMP: 6	

Temperature sensor

A.10 – HEATING WATER PIPES ARE INSULATED IN AREAS WHERE HEAT IS NOT REQUIRED?		
4	**3**	**1**
☐ Lines in **all** areas where heat is not required are insulated *Includes:* *- mechanical areas* *- supply/return headers within the greenhouse*	☐ Lines in **some** areas where heat is not required are insulated *Includes:* *- mechanical areas* *- supply/return headers within the greenhouse*	☐ No
Related BMP: 8		

A.11 – WHAT TYPE OF INSULATION IS USED ON HEATING SYSTEM PIPES?		
4	**3**	**1**
☐ Fibreglass/styrofoam insulation wrapped in metal cladding *Metal cladding protects the insulation and helps keep it dry*	☐ Fibreglass/styrofoam insulation	☐ No insulation or damaged/wet insulation
Related BMP: 8		

Insulate hot water pipes in areas where heat is not required, such as mechanical areas and supply/return headers within the greenhouse space.

Insulation should be checked regularly to ensure that it is dry and in good condition. Wrapping insulation in metal cladding helps protect it from damage and leaks.

A.12 – IS INSULATION CHECKED REGULARLY?	
4	**1**
☐ Yes *Insulation should be checked regularly to ensure it is dry and in good condition*	☐ No *Pipes wrapped in wet insulation can have **more** heat loss than uninsulated pipes*
Related BMP: 8	

A.13 – WHAT ARE THE GREENHOUSE WALLS CONSTRUCTED OF?			
4	**3**	**2**	**1**
☐ Wall type from column 3 **plus** insulated walls where light transmission is minimal *Areas such as the North wall of the greenhouse transmit very little light to the plants and should be insulated to improve energy efficiency*	☐ One or more of: - Double wall polyethylene (poly) - Double wall polycarbonate panels - Glass panels *Note – polycarbonate and glass panels must be sealed properly to prevent drafts.*	☐ Single wall polyethylene	☐ Poorly sealed polycarbonate or glass panels
Related BMP: 9			

A.14 – IS THE BUILDING ENVELOPE CHECKED REGULARLY FOR DRAFTS?	
4	**1**
☐ Yes *During the heating season, walk around the inside perimeter of your greenhouse every couple of days to check for drafts*	☐ No
Related BMP: 9	

HEATING SYSTEM SUMMARY	
QUESTION	**SCORE**
A.1 Energy source	0
A.2 Heating equipment	0
A.3 Heat delivery	0
A.4 Uniform conditions	0
A.5 Heat active areas	0
A.6 Maintenance	0
A.7 ABSA	0
A.8 Monitor performance	0
A.9 Sensors calibrated	0
A.10 Insulation not req'd	0
A.11 Pipe insulation type	0
A.12 Insulation checked	0
A.13 Greenhouse walls	0
A.14 Draft checks	0
Total:	0

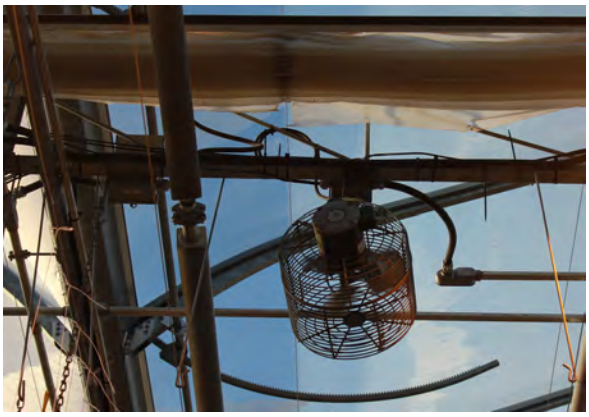
B – Ventilation System Efficiency

Ventilation is often required in a greenhouse to control humidity, and to prevent the structure from overheating during the summer months; however, operating ventilation systems when they are not required can waste large amounts of energy.

B.1 – WHAT TYPE OF VENTILATION/COOLING SYSTEM(S) DO YOU USE IN YOUR GREENHOUSE?			
4	**3**	**2**	**1**
☐ Natural ventilation (gutter vents, roll-up walls, etc.) *Requires minimal energy to operate*	☐ Mechanical ventilation (electric fans, etc.) with roll-up walls	☐ One of: - Mechanical ventilation (electric fans, etc.) - Evaporative cooling (misting, "swamp coolers") *Energy intensive*	☐ No ventilation *Facilities without ventilation are at risk of overheating during the warmer months, and may experience humidity issues*
Related BMP: 10			

Natural ventilation relies on the natural buoyancy of warm air and, as a result, requires far less energy to operate than mechanical ventilation systems. Proper design is critical to the performance of a natural ventilation system.

Mechanical ventilation systems utilize exhaust fans to push air out of the greenhouse structure.



B.2 – HOW IS YOUR VENTILATION SYSTEM CONTROLLED?	
4	**1**
☐ Automated controls *Automated controls monitor environmental conditions inside your greenhouse and ensure that ventilation systems only operate when needed*	☐ Manual control
Related BMP: 11	

B.3 – IF YOUR GREENHOUSE UTILIZES CARBON DIOXIDE DOSING, WHAT IS THE SOURCE OF CO_2?		
4	**3**	**1**
☐ One of the following: - Boiler/furnace exhaust during heating season **only** *Avoid operating heating equipment when heat is not required* - Liquid CO_2 from gas supply company -Waste CO_2 from industry *Possible sources include ethanol fermentation, natural gas power plants, etc.*	☐ Boiler/furnace exhaust operated year-round for CO_2 source *Boiler/furnace exhaust is an excellent source of CO_2 during the heating season* *Consider looking for alternative sources for times when heat is not required*	☐ Natural gas CO_2 generator *Difficult to operate during the summer months as they add heat to the greenhouse structure, increasing ventilation requirements*
Related BMP: 12		

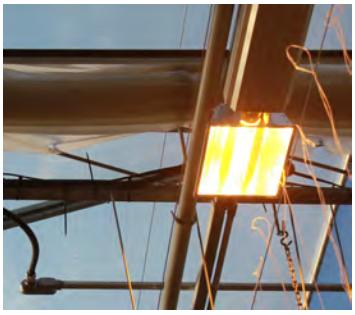
B.4 – DO YOU UTILIZE SHADE CURTAINS OR WHITEWASHING?	
4	**1**
☐ Yes *Shade curtains or white washing can help cut down on ventilation/cooling requirements during warm summer months*	☐ No
Related BMP: 10	

VENTILATION SYSTEM SUMMARY	
QUESTION	**SCORE**
B.1 Type of system	0
B.2 System control	0
B.3 CO2 source	0
B.4 Shade curtains	0
Total:	0

C – Lighting Efficiency

Some greenhouses in Alberta utilize artificial lighting to supplement the amount of light available during the short winter days. Operating growing lights can use substantial amounts of electricity, so it is important for growers utilizing them to ensure that it is being done as efficiently as possible.

C.1 – IF YOUR GREENHOUSE UTILIZES ARTIFICIAL LIGHTING, WHAT TYPE OF FIXTURES ARE USED?		
4	**3**	**1**
☐ One of: High pressure sodium (HPS) fixtures with electronic ballasts *Electronic ballasts are more efficient than mechanical ballasts* Light emitting diode (LED) lighting *- High efficiency* *- Allows more control over the spectrum (wavelengths) of light emitted*	☐ High pressure sodium (HPS) fixtures with mechanical ballasts *Mechanical ballasts may be the best choice in rural areas due to voltage fluctuations in the grid*	☐ Fluorescent fixtures or incandescent/halogen fixtures
Related BMP: 13		



When utilizing artificial lighting, pay attention to the rated lifespan of the bulbs used in your lighting fixtures. High pressure sodium bulbs typically have a rated lifespan of 10,000 hours. While the bulb may not fail after that time, the amount of light that it emits begins to degrade, making the fixture less efficient (as less lumens of light are put out from the same wattage).

C.2 – WHAT TYPE OF LIGHT FIXTURES/BULBS ARE USED IN UTILITY/MECHANICAL AREAS?		
4	**3**	**1**
☐ LED bulbs/fixtures or T5 fluorescent fixtures	☐ Compact fluorescent(CFL) bulbs or T8 fluorescent fixtures	☐ Incandescent bulbs or T12 fluorescent fixtures *As these fixtures/bulbs fail, consider upgrading to more efficient options*
Related BMP: 14		

LIGHTING EFFICIENCY SUMMARY	
QUESTION	**SCORE**
C.1 Greenhouse fixtures	0
C.2 Utility area fixtures	0
Total:	0

D – Irrigation System Efficiency

Managing the application of water and nutrients is crucial to the success of your crops. Ensuring that your irrigation system operates as effectively and efficiently as possible can have a major impact on the success of your business.

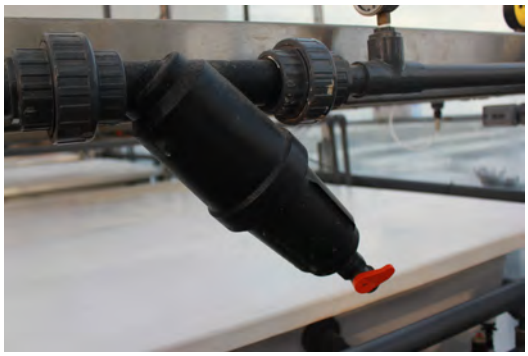
D.1 – WHAT IS THE SOURCE FOR YOUR IRRIGATION WATER?			
4	**3**	**2**	**1**
☐ Rainwater capture and storage with municipal/well water backup *Captured and stored in a suitable cistern*	☐ Municipal water *Consistent quality*	☐ Well water *Generally consistent quality*	☐ Pond/lake/river or other *Quality may be variable*
Related BMP: 15			

Consider installing a system to capture and store rainwater for use in your irrigation system. Many areas in Alberta receive over 400 mm of annual precipitation. ***By capturing rainwater from the greenhouse roof, many facilities would be able to supply up to 40% of their irrigation water requirements.*** *Capturing water from a wider area allows many facilities to meet their irrigation water requirements entirely from rainwater.*

D.2 – HOW FREQUENTLY DO YOU TEST YOUR IRRIGATION WATER QUALITY?		
4	**3**	**1**
☐ Routine testing **and** additional test when changing water sources *Routine testing ensures that fluctuations in water quality can be adjusted for*	☐ When changing water sources	☐ No water quality testing
Related BMP's: 16		

D.3 – WHAT WATER QUALITY PARAMETERS DO YOU TEST FOR?		
4	**3**	**1**
☐ Test **all** of: -Macronutrients -Micronutrients - EC, pH, salts	☐ Test **some** of: - Macronutrients -Micronutrients -EC, pH, salts	☐ No water quality testing
Related BMP: 16		

D.4 – DO YOU TREAT YOUR WATER BEFORE IRRIGATING?			
4	**3**	**2**	**1**
☐ No - Treatment is not necessary – testing indicates no treatment is required – **all** water quality issues identified by testing are corrected	☐ Yes – **some** of the water quality issues identified by testing are corrected	☐ No – water quality is not ideal, but no treatment is performed	☐ No – water quality unknown
Related BMP: 16			



Water treatment techniques utilized in Alberta greenhouses include filtration, acid addition, and reverse osmosis.

Consult with an engineer or a greenhouse irrigation specialist to determine the water treatment methods most suitable for your facility.

D.5 – WHAT TYPE OF IRRIGATION SYSTEM DOES YOUR FACILITY USE?			
4	**3**	**2**	**1**
☐ Drip irrigation **with** leachate collection and recycling *Precise amounts of water and fertilizer are delivered to individual plants* *Leachate is collected and recycled through the system*	☐ Drip irrigation *Precise amounts of water and fertilizer are delivered to individual plants*	☐ Spray boom irrigation or misting *Uneven distribution of water between individual plants* *Can cause humidity issues in the greenhouse*	☐ Hand watering or flood floor *Uneven distribution of water between individual plants*
Related BMP: 17			

Drip irrigation systems inject water and nutrients into the growing media that the plants are rooted in, minimizing waste of water and fertilizer.

D.6 –DO YOU MONITOR LEACHATE QUALITY AND QUANTITY?		
4	**3**	**1**
☐ Monitor **both:** 1. Leachate quantity *Some leachate is often desired to flush salts from the growing media* 2. Leachate quality *Test for macronutrients, micronutrients, pH, EC, salts and plant pathogens*	☐ Monitor **one:** 1. Leachate quantity *Some leachate is often desired to flush salts from the growing media* 2. Leachate quality *Test for macronutrients, micronutrients, pH, EC, salts and plant pathogens*	☐ No leachate monitoring *Excess leachate wastes water and nutrients* *Testing leachate for nutrient levels, pH, EC and salts can help monitor and optimize irrigation system performance* *Plant pathogens can accumulate in recycled leachate resulting in production issues*
Related BMP: 17		

Leachate volumes should be monitored regularly to ensure that the correct amount of water is being applied, minimizing the amount of leachate produced.

Leachate volume can be measured by collecting the nutrient water feed from one of the irrigation system drip tubes, and comparing it to the volume of leachate collected.

A sample of the collected leachate can then be analyzed to make adjustments in your fertility program, and to ensure that the leachate quality is suitable for recycling through the irrigation system.

D.7 – WHAT PORTION OF YOUR LEACHATE IS RECIRCULATED?		
4	**3**	**1**
☐ **All** leachate is collected and recycled in the irrigation system *Eliminates waste of water and nutrients*	☐ **Some** leachate is collected and recycled	☐ **No** leachate recycling
Related BMP: 17		

D.8 – HOW DO YOU MONITOR YOUR IRRIGATION SYSTEM PERFORMANCE?			
4	**3**	**2**	**1**
☐ Utilize record keeping plus: Optimize irrigation system operation based on monitoring and record keeping *Adjust irrigation system operation based on leachate volume/quality, atmospheric conditions (sunlight, temperature, humidity), and plant requirements*	☐ Water consumption is monitored (flowmeters, tank volumes, etc) and **recorded** Water distribution to individual plants is tested periodically	☐ Water flow meters are in place, but no record keeping	☐ No measurement of irrigation water consumption
Related BMP: 19			

IRRIGATION SYSTEM SUMMARY	
QUESTION	**SCORE**
D.1 Water source	0
D.2 Test water quality	0
D.3 Parameters	0
D.4 Water treatment	0
D.5 Irrigation system	0
D.6 Monitor leachate	0
D.7 Recirculate leachate	0
D.8 Monitor performance	0
Total:	0

E – Back-up Systems

Downtime in your greenhouse mechanical systems (heating, ventilation, lighting and irrigation) can be extremely detrimental. A heating system failure on a cold winter night can quickly result in ruined crops, and significant equipment damage from freezing. Having backup systems in place is an important tool for managing this risk.

E.1 – DO YOU HAVE AN EMERGENCY HEATING PLAN IN PLACE?			
4	**3**	**2**	**1**
☐ Items in column 3 plus: Plan in place for complete heating system failure *Rental emergency heating equipment, etc.*	☐ Redundancy in installed equipment *Installed spares, parallel systems (ex: boiler and furnaces)*	☐ Portable space heaters	☐ No backup equipment or plans
Related BMP: 20			

E.2 – DO YOU HAVE A BACKUP GENERATOR?		
4	**3**	**1**
☐ Yes – sized to handle all greenhouse systems *Related BMP:* 21	☐ Yes – sized to handle critical greenhouse systems	☐ No backup generator in place

All of the mechanical systems in your greenhouse (heating, ventilation, irrigation and lighting) are likely dependent on electricity. Having a backup generator in place to keep these systems running during electrical outages will help you manage this risk.

E.3 – DO YOU TEST BACKUP SYSTEMS REGULARLY?	
4	**1**
☐ Yes – backup systems are tested monthly *Testing your backup systems ensures that they will be available when needed*	☐ No *A backup system is of little value if it is not in running order when it is needed*
Related BMP: 22	

E.4 – ARE SENSITIVE ELECTRONICS PROTECTED FROM POWER SURGES?	
4	**1**
☐ Yes – surge protection systems are in place *Either your whole electrical system, or just sensitive devices such as controllers and computers, are protected by surge protection.*	☐ No
Related BMP: 21	

Some electronic devices in your facility (such as controllers, computers, etc.) may be sensitive to power surges, which can be common in rural areas. Consider implementing surge protection systems to protect these devices.

BACK UP SYSTEMS SUMMARY	
QUESTION	**SCORE**
E.1 Plan in place	0
E.2 Backup generator	0
E.3 Test backup systems	0
E.4 Surge protection	0
Total:	0

F – Energy Procurement

After labor, energy (heating fuel and electricity) is often one of the largest expenses a greenhouse facility incurs. Having an energy procurement strategy in place can help ensure that you are purchasing energy at favorable rates, helping to lower your cost of production.

F.1 – DO YOU REVIEW AND UNDERSTAND YOUR ENERGY BILLS?			
4	**3**	**2**	**1**
☐ Items in column 3 **plus:** - You understand which charges are fixed and which are variable (ie: depend on energy consumption) - You understand demand charges and the impact that changing your energy consumption will have on your energy bill	☐ Items in column 2 **plus:** - You understand the cost breakdown on your energy bills *Energy, distribution, and administrative costs*	☐ You check your energy usage every month and monitor seasonal trends	☐ No *You pay the bill every month but don't look at it closely*
Related BMP's: 23, 24			

F.2 – DO YOU HAVE AN ENERGY PROCUREMENT STRATEGY?			
4	**3**	**2**	**1**
☐ You have explored opportunities to purchase energy through wholesale providers and industry organizations/ cooperatives *Businesses using >2,500 GJ per year of natural gas and >250,000 kWh per year of electricity have the option to purchase their energy through wholesale channels which may offer more favorable rates and more flexible hedging opportunities*	☐ You have explored rates from various retailers and selected a contract that suits your business needs and your tolerance for risk *Considered both fixed and floating price contracts*	☐ You have signed a fixed price contract, but are unsure if it is at a good rate	☐ No. You are paying the regulated rate and have never looked into a fixed price contract
Related BMP's: 23, 24			

ENERGY PROCUREMENT SUMMARY	
QUESTION	**SCORE**
F.1 Review bills	0
F.2 Procurement strategy	0
Total:	0

G – Managing Waste

Greenhouse operations typically produce large volumes of plastic and organic waste, such as polyethylene cover material and spent growing media, which must be managed appropriately. While recycling these materials may not lead to direct financial savings, the increased societal awareness of environmental sustainability is leading to new demands from consumers and retailers. Having environmentally friendly avenues for disposing of waste will help position you as a low environmental impact producer.

G.1 – WHAT STEPS ARE YOU TAKING TO MINIMIZE PLASTIC WASTE?		
4	**3**	**1**
☐ Do **all** of: - Recycle plastic pesticide/ fertilizer containers - Recycle plastic shipping materials - Purchase supplies in large units (mini bulks, etc) rather than small plastic jugs/bags - Look for supplies with minimal packaging	☐ Do **some** of: - Recycle plastic pesticide/ fertilizer containers - Recycle plastic shipping materials - Purchase supplies in large units (mini bulks, etc) rather than small plastic jugs/bags - Look for supplies with minimal packaging	☐ No plastic recycling – all sent to landfill
Related BMP's: 25, 26		

G.2 – HOW DO YOU DISPOSE OF STRUCTURAL POLY PLASTICS?	
4	**1**
☐ Poly cover bundled for recycling when replaced Floor poly bundled for recycling when replaced *New avenues for recycling these products are being developed. Wrapping used poly into tight bundles/bales makes transporting the material for recycling more feasible.*	☐ Sent to landfill
Related BMP's: 25, 26	

G.3 – HOW DO YOU DISPOSE OF CULL PRODUCE?		
4	**3**	**1**
☐ Alternative uses *Many organizations have implemented programs to try cut down on food waste by selling misshaped produce to consumers.* *Contact local retailers or grower co-operatives to find a suitable use for your cull production.*	☐ Composting Land application	☐ Sent to landfill
Related BMP: 27		

G.4 – HOW DO YOU DISPOSE OF ORGANIC WASTE? (PLANT TRIMMINGS, SPENT GROWING MEDIA, ETC.)	
4	**1**
☐ Composting Land application *Organic waste from greenhouses (spent growing media, plant trimmings, etc.) can be a useful soil remediation product. Consider contacting local composting facilities or agrologists/farmers to find an avenue for disposing of your organic waste.*	☐ Sent to landfill *Landfilling large quantities of greenhouse waste may result in "tipping fees" being charged by the landfill.*
Related BMP: 28	

G.5 – DO YOU KEEP RECORDS OF SUPPLIES PURCHASED AND WASTE GENERATED?		
4	**3**	**1**
☐ Track **both:** - Supply purchases - Waste generated	☐ Track **one** of: - Supply purchases - Waste generated	☐ No record keeping
Related BMP's: 29		

MANAGING WASTE SUMMARY	
QUESTION	**SCORE**
G.1 Minimize plastic	0
G.2 Dispose of poly	0
G.3 Dispose of cull	0
G.4 Dispose of organic	0
G.5 Record keeping	0
Total:	0

Best Management Practices

This section contains a list of Best Management Practices (BMPs) for managing energy, water, and waste in Alberta greenhouses. After completing the self-assessment, refer to this section for more detailed information on the recommendations made in the self-assessment. At the end of this section, you will also find a list of resources that you may wish to review for further information.

Guiding Principles

The Best Management Practices have been grouped according to the guiding principles listed below:

1. Maximize heating system efficiency
2. Prevent unnecessary heat loss
3. Utilize ventilation efficiently
4. Minimize lighting electricity consumption
5. Manage irrigation water use
6. Ensure backup systems are in place and tested regularly
7. Implement an energy procurement strategy
8. Minimize the amount of waste being generated and dispose of it responsibly

GUIDING PRINCIPLES	GENERAL BMPs	SPECIFIC BMPs	DETAILS
1. MAXIMIZE HEATING SYSTEM EFFICIENCY	**1. Select high efficiency heating equipment** *Back to survey*	Obtain advice from an engineer/greenhouse designer	Utilizing the services of a professional engineer/greenhouse designer to assist with selecting equipment and designing the heating system is a worthwhile investment. An engineer will be able to perform heat load calculations to ensure that the heating system is properly sized for your greenhouse. An undersized heating system will struggle to keep the greenhouse warm during the winter months, while an oversized heating system results in higher than necessary capital costs. In addition to this, furnaces and boilers are most efficient when operating near their full rated load, meaning an oversized heating system will rarely operate at peak efficiency.
		Utilize high efficiency boilers/furnaces	When selecting heating equipment, consider the operating costs (fuel and maintenance) over the lifespan of the equipment along with the capital cost. Spending a little more upfront for more efficient burners and modern control systems often results in significant savings over the lifespan of the equipment through reduced fuel consumption. Forced draft boilers/furnaces (which utilize a fan to supply combustion air to the burner) are generally more efficient than natural draft boilers/furnaces, as they allow for more precise control of the fuel-air ratio. A modern forced draft burner will typically deliver combustion efficiencies of around 85% versus approximately 80% for a natural draft burner. In addition to this, natural draft boilers/furnaces require ideal conditions (clean, draft-free air) to achieve their rated efficiencies and as a result, often operate well below their rated efficiency.

GUIDING PRINCIPLES	GENERAL BMP	SPECIFIC BMPs	DETAILS
1. MAXIMIZE HEATING SYSTEM EFFICIENCY	1. **Select high efficiency heating equipment (Cont'd)** *Back to survey*	Utilize a boiler economizer or condensing furnace to recover heat from the exhaust gases	Even in a modern boiler/furnace, a significant amount of heat is lost through the exhaust gases. A boiler economizer or condensing furnace can be used to capture some of this heat and often results in a 5-10% improvement in the thermal efficiency of the heating system. Cooling the exhaust gas in an economizer or condensing boiler produces condensate, which is typically very acidic. Care must be taken to ensure that the condensate is drained in an appropriate manner.
		Consider combined heat and power (CHP) cogeneration	Combined heat and power (CHP) cogeneration systems aim to make the generation of electricity through combustion more efficient by utilizing the heat that is created in the process. Due to the large heating requirements of greenhouses, they are a natural fit for cogeneration systems. A CHP system can be connected to the Alberta grid in a net metering arrangement, allowing the system to feed electricity back into the grid and receiving a credit during times when electrical demand in the greenhouse is low. Installing a CHP cogeneration system is a significant undertaking, involving correct sizing, permitting and a substantial upfront capital cost. Seek advice from an engineer prior to pursuing the installation of a CHP system at your facility.

GUIDING PRINCIPLES	GENERAL BMP	SPECIFIC BMPs	DETAILS
MAXIMIZE HEATING SYSTEM EFFICIENCY	2. **Implement a heating system maintenance program** *Back to survey*	Annual boiler/ furnace combustion analysis	A combustion analysis involves measuring the composition of the exhaust gases. Adjustments to the air/fuel ratio are then made to ensure that the boiler/furnace operates at peak efficiency. A boiler starved for air will have unburned fuel in the exhaust while a boiler receiving too much air results in extra heat being carried out in the exhaust gas. A boiler/furnace with an air/fuel ratio that is out of adjustment can easily consume 5-10% more fuel than a boiler/furnace that is properly adjusted. A boiler/furnace combustion analysis should be performed by a qualified service company.
		Annual boiler heat transfer surface inspection Clean if necessary	Over time, combustion deposits and mineral scaling build up on the fireside and waterside heat transfer surfaces. These deposits act as insulators, reducing the boiler's ability to transfer heat, ultimately making it less efficient. The heat transfer surfaces should be inspected annually by a qualified boiler service company and cleaned if necessary.
		Boiler water treatment program	Utilizing treated water in a boiler prevents corrosion, which helps increase the lifespan of the boiler, and prevents scaling on the waterside heat transfer surfaces, which helps maintain boiler efficiency. A qualified boiler service company should be consulted for advice when implementing a boiler water treatment program. Look for food-grade treatment chemicals to ensure that the greenhouse crops are not damaged in the event of a heating system leak.

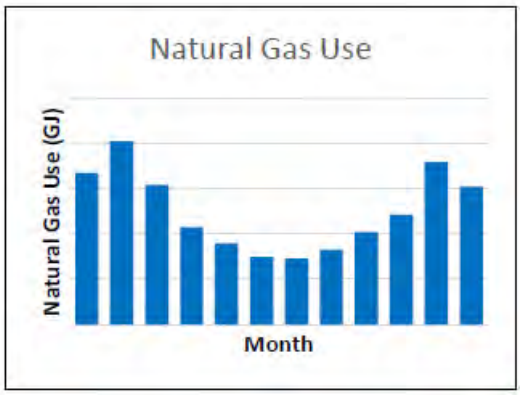
GUIDING PRINCIPLES	GENERAL BMP	SPECIFIC BMPS	DETAILS
1. MAXIMIZE HEATING SYSTEM EFFICIENCY	**3. Select an appropriate heating fuel** *Back to survey*	Heating fuel	When selecting a heating fuel, a number of factors such as cost, availability, operating and maintenance expenses, and environmental impact need to be considered. For most greenhouses in Alberta, natural gas is a suitable heating fuel. If your facility is not in an area with access to a natural gas supply, propane may be a suitable alternative. While coal is often less expensive than other fuels, there are other costs associated with operating and maintaining the mechanical systems required to use it (augers, conveyors, storage bins, etc) as well as transportation costs (hauling the coal to the greenhouse site) that must be accounted for. In addition to this, there are many environmental concerns with the use of coal. Greenhouse gas emissions from a coal boiler are often 75% higher than those from a natural gas boiler, and emissions from coal combustion contain a number of criteria pollutants, such as sulfur oxides, nitrogen oxides, and particulate matter (soot). Biomass (such as wood, straw, etc) may be an option for some greenhouse operators; however, similar to coal, the logistics of handling biomass and feeding it into the heating system will be more complicated than using natural gas and must be factored into your decision.

GUIDING PRINCIPLES	GENERAL BMP	SPECIFIC BMPS	DETAILS
1. MAXIMIZE HEATING SYSTEM EFFICIENCY	**4. Ensure heating system operator has required training and certification (Cont'd)** *Back to survey*	Power Engineering training	In order to meet ABSA requirements, greenhouses utilizing a boiler for heating may need to have a Power Engineer on staff designated as the boiler operator. Power Engineering training (4th or 5th class) can be completed through correspondence, and the required work experience obtained by operating the greenhouse boiler. Greenhouse operators utilizing boilers for heating should consider having a key staff member complete Power Engineering certification, or take the training themselves. Greenhouse operators should consult with their local ABSA inspector to determine what certification is required for their boiler operator.
		Consider energy efficiency training	Natural Resources Canada offers regular workshops to help "Spot the Energy Savings." Such workshops can pay for themselves many times over by making staff aware of opportunities for energy savings.
	5. Maintain uniform temperature throughout the greenhouse space *Back to survey*	Zone controls	In a large greenhouse structure, it is often advantageous to break the heating system up into separate zones, each with their own controls/thermostat. Utilizing zone controls helps maintain a more uniform temperature throughout the structure and can help reduce energy consumption (as only areas in the structure requiring heat receive it). In a greenhouse heated with hot water from a boiler, zone control can be implemented by using valves to start/stop the flow of hot water to each zone. In a greenhouse heated with forced air furnaces/unit heaters, zone control is implemented by allowing individual furnaces/heaters to turn on/off independently as required. Zone controls can also be used to shut off heat to areas of the greenhouse that are not in production, or to areas where heat is not required (such as the gutter heating loops when there is no snow on the greenhouse roof).

GUIDING PRINCIPLES	GENERAL BMP	SPECIFIC BMPS	DETAILS
1. MAXIMIZE HEATING SYSTEM EFFICIENCY	**5. Maintain uniform temperature throughout the greenhouse space (Cont'd)**	Air circulation	Along with zone controls, horizontal air flow (HAF) fans can be used to help circulate air within the greenhouse structure, reducing hot and cold spots and helping to maintain more uniform humidity. Utilizing dedicated HAF fans is more efficient, and will therefore use less electricity, than operating furnace fans continuously to circulate air.
	6. Monitor system performance *Back to survey*	Utilize automated environmental controls	An automated environmental control system can help maintain ideal growing conditions for your plants by constantly monitoring conditions in the greenhouse and making adjustments to the mechanical systems (heating, ventilation, etc.) as needed. Automated control systems will also generally record important environmental parameters (temperature, humidity, etc.), allowing you to monitor the performance of the greenhouse mechanical systems and ensure that the greenhouse environment stays within an acceptable range.
		Calibrate sensors	When electronic sensors are used to control the greenhouse mechanical systems (such as electronic thermostats or humidistats), check their calibration regularly (as per manufacturer's guidelines). A thermostat that is out of calibration may result in the actual temperature of the greenhouse being a few degrees off from your desired setpoint, which can have a negative impact on production.

Temperature sensor

GUIDING PRINCIPLES	GENERAL BMP	SPECIFIC BMPS	DETAILS
1. MAXIMIZE HEATING SYSTEM EFFICIENCY	6. **Monitor system performance (Cont'd)** *Back to survey*	Keep records of energy use	Creating a spreadsheet or database to record the amount of energy used each month is a simple, yet effective, way to stay on top of the performance of the mechanical systems in your greenhouse. Good records can enable you to spot trends, such as observing your energy consumption decrease due to the installation of high efficiency equipment, or alert you of a potential problem if energy use unexpectedly increases. Having good records of your energy expenditures will also help when performing cost of production calculations, and will help track the impacts that changing energy costs have on your bottom line. Contact your energy retailer to enquire if energy data trending is available online for your facility.
	7. **Only heat areas in active production** *Back to survey*	Partition off areas not in production	Many greenhouses elect to only operate part of their facility during the winter months. When this occurs, the areas not in production should be partitioned off and kept at a lower temperature. Zone controls on the heating system are helpful when operating in this arrangement. If the area in the greenhouse not in production contains equipment that could be damaged by freezing (such as heating water and irrigation lines), care must be taken to ensure that the temperature is not allowed to drop below freezing.



Energy Use Records

GUIDING PRINCIPLES	GENERAL BMP	SPECIFIC BMPs	DETAILS
2. PREVENT UNNECESSARY HEAT LOSS	8. **Insulate and maintain hot water pipes** *Back to survey*	Pipe insulation	When a hot water heating system is used, the water lines in the mechanical area should be insulated, as the boilers and other equipment in the mechanical area will radiate enough heat to keep the room warm. Additionally, lines within the greenhouse structure that run in areas where heat is not needed (such as supply and return headers that run along walls or near the roof of the structure, away from the plants) should be insulated. Ideally, lines should be insulated with fibreglass insulation and then covered with metal cladding to help protect the insulation and keep it dry.
		Check insulation regularly	Insulation should be checked regularly to ensure that it is dry and in good condition. Wet insulation is a sign of leaks and/or condensation. A pipe wrapped in wet insulation will often lose more heat than a pipe with no insulation.
	9. **Insulate and maintain building envelope**	Obtain advice from an engineer/greenhouse designer	When constructing a new facility, or performing a major renovation, consult with an engineer or greenhouse designer to determine the type of cover material most suitable for your facility.

Ideally, lines should be insulated with fibreglass insulation and then covered with metal cladding to help protect the insulation and keep it dry.

GUIDING PRINCIPLES	GENERAL BMP	SPECIFIC BMPs	DETAILS
2. PREVENT UNNECESSARY HEAT LOSS	9. Insulate and maintain building envelope (Cont'd) *Back to survey*	Select appropriate wall type	The majority of greenhouses in Alberta utilize a double polyethylene (poly) cover, with the second most frequent choice being glass. When selecting a cover material a number of factors need to be considered, including durability, insulation (R-value), light transmission, lifespan and cost. Double poly provides good insulation and durability against snow and hail; however the cover needs to be replaced every 4 to 6 years. Glass covers generally provide better light transmission, but are more expensive and can be more difficult to seal against drafts. Consider insulating the north wall of the greenhouse. Due to Alberta's northern latitude, very little light is transmitted through this wall. Styrofoam insulation panels with a reflective layer facing into the greenhouse are a suitable choice.
		Regular inspections of building envelope	During the heating season, the building envelope should be checked for drafts every couple of days. By doing a quick walk around of the inside perimeter of the greenhouse, drafts will be caught and repaired quickly, preventing excessive heat loss. When checking for drafts, pay attention to penetrations in the building walls, such as ventilation fans, louvers, and doorways, as drafts often occur in these areas. If ventilation fans are not used during the winter months, consider sealing them off with poly sheets or tarps to ensure that they do not allow cold outside air to infiltrate into the greenhouse. For double poly greenhouses, ensure that inflation fans are maintaining air pressure between the two poly layers.

GUIDING PRINCIPLES	GENERAL BMP	SPECIFIC BMPs	DETAILS
3. UTILIZE VENTILATION EFFICIENTLY	**10. Select appropriate ventilation type** *Back to survey*	Obtain advice from an engineer/greenhouse designer	When constructing a new facility, or performing a major renovation, consult with an engineer or greenhouse designer to determine the type of ventilation most suitable for your facility.
		Ventilation type 	Ventilation is often required to help circulate air within the greenhouse, to help remove heat from the greenhouse during the summer months, and to help control humidity. Mechanical ventilation systems utilize exhaust fans to push air out of the greenhouse structure, while natural ventilation systems allow buoyant hot air to leave the structure through gutter vents. Natural ventilation uses far less electricity than mechanical ventilation; however, the system must be designed correctly to function properly. Supplementary mechanical ventilation may still be required in facilities with high ventilation requirements. Regardless of the type of ventilation used, it is important that the ventilation equipment (fans, louvers, gutter vents, etc.) does not compromise the building envelope resulting in drafts during times when ventilation is not required.
		Shade curtains/white washing	In areas that experience high summer temperatures, taking measures to reduce solar heat gain (such as using shade curtains, or white washing parts of the greenhouse structure) can significantly reduce ventilation requirements.
	11. Ventilation controls *Back to survey*	Ventilation controls	While ventilation systems play an important role in maintaining suitable conditions inside the greenhouse, operating them when they are not required can waste large amounts of energy (such as electricity to run fans, and heating fuel if the heating system is running). Adding speed controls to ventilation fans can make their use more efficient, as full throttle operation may not be required during shoulder seasons. An automated control system can help ensure that ventilation systems only operate when required.

GUIDING PRINCIPLES	GENERAL BMP	SPECIFIC BMPs	DETAILS
3. UTILIZE VENTILATION EFFICIENTLY	**12. Carbon dioxide dosing** *Back to survey* 	Carbon dioxide source	Carbon dioxide supplementation is used to increase the productivity of many greenhouse crops. When implementing a carbon dioxide dosing system, potential sources of carbon dioxide may include combustion (exhaust from boilers/furnaces), natural gas carbon dioxide generators, and liquid carbon dioxide. Boiler/furnace exhaust is an excellent source of carbon dioxide during the heating season when boilers/furnaces are operating. However, running the heating system during the summer when little heat is required results in large amounts of energy being wasted. Carbon monoxide must also be monitored in the greenhouse to avoid unsafe levels. Natural gas carbon dioxide generators are difficult to use during the summer months since they add heat to the greenhouse structure, increasing ventilation requirements. Liquid carbon dioxide is a clean source of CO_2; however it is often more expensive than other sources of CO_2. When evaluating the economics of various carbon dioxide sources, be sure to include all costs (such as maintenance and depreciation of natural gas boilers/furnaces, transportation and distribution of natural gas, etc.). Many industrial processes produce natural gas. Consider contacting local industrial facilities to see if opportunities exist to utilize waste carbon dioxide.

GUIDING PRINCIPLES	GENERAL BMP	SPECIFIC BMPs	DETAILS
4. MINIMIZE LIGHTING ELECTRICITY CONSUMPTION	13. Utilize efficient artificial lighting *Back to survey* 	Utilize efficient lighting technology	Some greenhouse crops may benefit from using artificial lighting to supplement the hours of daylight available during the winter months when the days are short. The two most common artificial lighting technologies utilized in Alberta greenhouses are high pressure sodium (HPS) fixtures and light emitting diode (LED) fixtures. HPS fixtures have been around for a number of years and offer good efficiency at a reasonable cost. LED fixtures are significantly more expensive, but offer more control over the emitted light spectrum, which may be beneficial for some crops. The cost of LED lighting is dropping rapidly, and is expected to continue to decline. Even if the economics were not favorable a year ago, it may be worth revisiting with your electrical contractor. When investigating artificial lighting, consult with an engineer, greenhouse designer, or electrical contractor to determine the type of artificial lighting most suitable for your facility.
		Replace lamps after rated lifespan	High pressure sodium bulbs typically have a rated lifespan of 10,000 hours. While the bulb may not fail after that time, the amount of light that it emits begins to degrade, making the fixture less efficient (as less lumens of light are put out from the same wattage). To ensure that HPS fixtures operate as efficiently as possible, replace bulbs after 10,000 hours of operation.
		Utilize efficient ballasts	High pressure sodium light fixtures are available with mechanical or electronic ballasts. Fixtures with electronic ballasts are typically 5 to 20 percent more efficient than fixtures with mechanical ballasts, and are smaller and lighter making them easier to install. Conversely, fixtures with mechanical ballasts are often less expensive and are better able to handle the voltage fluctuations common on rural electrical grids.

GUIDING PRINCIPLES	GENERAL BMP	SPECIFIC BMPs	DETAILS
4. LIGHTING ELECTRICITY CONSUMPTION	**14. Utilize efficient utility lighting** *Back to survey*	Use efficient fixtures/bulbs for utility lighting	The electricity consumed by utility lighting in mechanical/staff areas is generally a small fraction of the total amount of electricity consumed in a greenhouse. As a result, replacing these fixtures before failure is often not economical. When fixtures/bulbs do fail, consider replacing with more efficient alternatives. Incandescent bulbs can be replaced with compact fluorescent or LED bulbs while T12 fluorescent fixtures can be upgraded to more efficient T8 or T5 fixtures.
5. MANAGE IRRIGATION WATER USE	**15. Select an appropriate irrigation water source**  *Back to survey*	Capture and store rainwater	The average irrigation water consumption in Alberta greenhouses is 1 m^3 per m^2 of greenhouse area. Many areas in the province receive over 400 mm of annual precipitation, meaning that up to 40% of the irrigation water requirements of a typical greenhouse can be satisfied by capturing rainwater and snow melt from the greenhouse roof. Capturing rainwater requires the installation of a cistern, storage tank, or lined pond to store the water until it is needed.
		Municipal/well water backup	When rainwater is used for irrigation, a backup water source is required as a supplemental source for times when there is not sufficient rainwater available. Municipal water provides very consistent water quality and can be used as potable water in staff facilities; however, it is not available in many rural areas, and can be expensive. Well water quality is highly dependent on location, with some areas suffering from issues such as high EC, high/low pH, salts, or iron, while other areas have very good water quality.

GUIDING PRINCIPLES	GENERAL BMP	SPECIFIC BMPs	DETAILS
5. MANAGE IRRIGATION WATER USE	**16. Monitor irrigation water quality** *Back to survey*	Test water quality periodically or when changing water sources	Prior to using a new water source for the first time (such as when a new well is drilled), a sample should be sent to a third party lab for analysis to confirm that it is suitable for use as irrigation water. When using the same water source, perform routine irrigation water analyses to ensure that quality remains acceptable. If the analysis finds that the water quality is not suitable for irrigation, consult with a qualified greenhouse irrigation specialist to determine if there are treatment systems that may be used to improve the water quality.
	17. Select an appropriate irrigation system design *Back to survey*	Obtain advice from an engineer/greenhouse designer	When constructing a new facility, or considering changes to the irrigation system in an existing facility, consult with an engineer or greenhouse designer to determine the type of irrigation system most suitable for your greenhouse.
		Utilize a system that minimizes waste 	The two most common irrigation systems utilized in Alberta greenhouses are drip irrigation and spray boom irrigation. Drip irrigation systems inject water and nutrients into the growing media that the plants are rooted in, minimizing waste of water and fertilizer. In spray boom irrigation, spray bars with rows of nozzles are suspending from rails above the greenhouse crops. The booms travel along the rails, spraying irrigation water onto the plants below. When using spray boom irrigation, care must be taken to avoid over-watering, as excess water runs off the plants, wasting water and nutrients. Spray boom systems also increase the humidity in the greenhouse, which can result in increased ventilation requirements.

GUIDING PRINCIPLES	GENERAL BMP	SPECIFIC BMPs	DETAILS
5. MANAGE IRRIGATION WATER USE	**17. Select an appropriate irrigation system design (Cont'd)** *Back to survey* 	Monitor leachate volume and quality	When irrigating, it is often desirable to have some water flow through the root system, to help flush salts from the growing media. This excess irrigation water is referred to as leachate. Leachate volumes should be monitored regularly to ensure that the correct amount of water is being applied, minimizing the amount of leachate produced. It is often desirable to also monitor leachate quality (pH, EC, etc.) to help manage irrigation system performance.
		Utilize a system that collects and recycles leached irrigation water	When designing an irrigation system, consider implementing systems to collect and recycle leached irrigation water. Recycling leachate reduces water consumption and cuts down on fertilizer use. When recycling leachate, it is often necessary to monitor and treat the leachate to ensure that plant pathogen populations do not accumulate. Consult with a qualified greenhouse irrigation specialist to determine the measures most suitable for your operation.
	18. Dispose of wastewater responsibly	Dispose of leachate responsibly	If leachate is not recycled in the irrigation system, it should be captured and stored for proper disposal. Leachate often has high concentrations of macro and micro nutrients which can have a negative impact on local groundwater if not disposed of responsibly. Consult with a qualified greenhouse irrigation specialist to determine suitable disposal options for captured leachate. Ensure that your leachate disposal practices satisfy any applicable local legislation.

GUIDING PRINCIPLES	GENERAL BMP	SPECIFIC BMPs	DETAILS
5. MANAGE IRRIGATION WATER USE	**19. Monitor irrigation water and fertilizer usage** *Back to survey*	Utilize flow meters to track irrigation water consumption	Monitoring irrigation system performance enables you to maximize production and use water and fertilizer as efficiently as possible. Total water consumption can be monitored in a number of ways, such as using inline flow meters, monitoring storage tank volumes, or from utility bills if water is from a municipal supply. Along with tracking total water consumption, the amount of water being delivered to individual plants in different areas of the greenhouse should be monitored to ensure that water is being distributed evenly. This can be done by periodically collecting and measuring the output from individual drip lines.
		Utilize a record keeping system to record daily irrigation water consumption	Creating a spreadsheet or database to record the amount of irrigation water used is an effective way to monitor irrigation system performance. Good records can enable you to spot trends, such as observing your water use increase/decrease due to changes in production practices or changes in the crops or varieties being grown. When water is being purchased from a municipal supply, having good records of water expenditures will also help when performing cost of production calculations.
		Utilize fertilizer efficiently	Steps should be taken to ensure that fertilizer is applied at the right time, at the right rate, and in the right form. Consult with an experienced greenhouse production specialist or Alberta Agriculture resources for advice on applying fertilizer to your crops
		Utilize a record keeping system to record fertilizer consumption	Creating a spreadsheet or database to track the amount of fertilizer purchased and used is an effective way to monitor your fertilizer use efficiency. Having good records of fertilizer expenditures will also help when performing cost of production calculations.

6. ENSURE BACKUP SYSTEMS ARE IN PLACE AND TESTED REGULARLY	**20. Develop an emergency heating plan** *Back to survey*	Utilize redundancy in installed equipment	Your greenhouse may utilize a variety of equipment to heat the structure, such as boilers, overhead furnaces, and unit heaters. As a result, it is often possible to temporarily maintain heat when one piece of equipment is down by relying on the equipment that is functioning. Horizontal air flow (HAF) fans can be used to distribute heat throughout the greenhouse in situations when the heat in one area is not functioning. When installed spares are utilized (such as backup circulation pumps or a spare boiler), operate them regularly to ensure that they are in operating order when you need them. Having a plan in place for dealing with downtime from each piece of heating equipment will ensure that you are prepared when a breakdown does occur.
		Have a plan in place for a complete heating system failure	If your greenhouse operates through the winter months, prepare a plan to deal with a complete heating system failure. Having names and contact information for local equipment rental companies that offer suitable emergency heating systems will enable you to restore heat to the structure as quickly as possible to try to prevent damage to crops and equipment.
	21. Develop a plan for a backup electrical supply *Back to survey*	Consider installing a backup generator	Your greenhouse is likely dependent on electricity for heating, ventilation, and irrigation. As a result, an extended electrical outage could cause significant damage to your crops and facility. Consider installing a backup generator to maintain critical mechanical systems during electrical outages. A backup generator should be sized to have enough capacity to run critical equipment until grid power is restored.

GUIDING PRINCIPLES	GENERAL BMP	SPECIFIC BMPs	DETAILS
6. BACKUP SYSTEMS	**22. Test backup systems regularly** *Back to survey*	Start back-up generator regularly (at least monthly)	Having a backup generator installed is of little value of it is not in running order when a power failure occurs. Start backup generators regularly (at least monthly) to verify that they are in operating condition. Ensure that fuel quality is suitable for winter use.
7. IMPLEMENT AN ENERGY PROCUREMENT STRATEGY	**23. Heating fuel procurement strategy** *Back to survey*	Review and understand the various types of contracts available	After labour, natural gas is often one of the largest expenses a commercial greenhouse facility incurs. It is important for greenhouse operators to be aware of and understand the different types of natural gas contracts available. Facilities that have not signed a contract purchase natural gas at the regulated rate option (RRO). The regulated rate varies depending on your location and fluctuates monthly. While the regulated rate may allow you to take advantage of low pricing during times when demand is low, you will also be exposed to spikes in prices during natural gas shortages. Alternatively, you may choose to enter into an agreement with a natural gas retailer offering you a fixed price for natural gas for a set amount of time (up to 5 years). The best approach for your facility will depend on your individual circumstances and tolerance for risk.

Consider installing a back-up generator.

GUIDING PRINCIPLES	GENERAL BMP	SPECIFIC BMPs	DETAILS
7. IMPLEMENT AN ENERGY PROCUREMENT STRATEGY	**23. Heating fuel procurement strategy (Cont'd)** *Back to survey*	Understand the difference between energy costs, delivery costs, and administrative costs	Every month, your natural gas bill will outline the breakdown between energy costs, delivery costs, and administrative costs. Energy costs cover the natural gas consumed at your facility; delivery charges cover the costs of transporting natural gas to your facility; and administrative costs cover your provider's costs for billing, customer service and other administrative costs. Delivery charges are set by the AUC (Alberta Utilities Commission) and can include a combination of fixed and variable (per GJ) charges. When evaluating changes to your natural gas consumption (such as considering installing a more efficient heating system), be sure to account for the full cost of natural gas (energy, delivery and administrative fees) in your calculations. Delivery and administrative fees can often make up 15-20% of a greenhouse's natural gas bill.
		Explore options for procuring energy through industry organizations or wholesale providers	Large consumers of natural gas in Alberta (with annual consumption >2,500 GJ) have the option to purchase their natural gas through wholesale channels, rather than from traditional natural gas retailers. Purchasing natural gas through wholesale channels may offer more flexible hedging options, and allow you to access lower rates.
	24. Electricity procurement strategy *Back to survey*	Review and understand the various types of contracts available	Similar to natural gas, facilities that have not signed a fixed price contract purchase electricity at the Regulated Rate Option (RRO). The regulated rate fluctuates throughout the year based on supply and demand. Alternatively, you may choose to enter into a contract with an electricity retailer offering you a fixed price for electricity for a set amount of time (up to 5 years).

GUIDING PRINCIPLES	GENERAL BMP	SPECIFIC BMPs	DETAILS
	24. Electricity procurement strategy (Cont'd)		The best approach for your facility will depend on your individual circumstances and tolerance for risk.
7. IMPLEMENT AN ENERGY PROCUREMENT STRATEGY	*Back to survey*	Understand the difference between energy costs, transmission and distribution costs, and administrative costs	Every month, your electricity bill will outline the breakdown between energy costs, transmission and distribution costs, and administrative costs. Energy costs cover the electricity consumed at your facility; transmission and distribution covers the cost of building, operating and maintaining the electrical grid; and administrative costs cover your provider's costs for billing, customer service and other administrative costs. Delivery charges are set by regulatory bodies and can include a combination of fixed and variable (per kWh) charges. When evaluating changes to your electricity consumption (such as considering installing artificial lighting), be sure to account for the full cost of electricity (energy, delivery and administrative fees) in your calculations. Delivery and administrative fees can often make up 25-50 % of a greenhouse's electricity bill.
		Explore options for procuring electricity through industry organizations or wholesale providers	Large consumers of electricity in Alberta (with annual consumption >250,000 kWh) have the option to purchase their electricity through wholesale channels, rather than from traditional electricity retailers. Purchasing electricity through wholesale channels may offer more flexible hedging options, and allow you to access lower rates. Shopping around for rate options is also advisable as wholesale rates change very frequently.

GUIDING PRINCIPLES	GENERAL BMP	SPECIFIC BMPs	DETAILS
8. MINIMIZE THE AMOUNT OF WASTE BEING GENERATED AND DISPOSE OF IT RESPONSIBLY	**25. Minimize the amount of plastic waste being generated** *Back to survey*	Maximize the lifespan of structural plastics	The majority of greenhouses in Alberta utilize double wall polyethylene (poly) cover material. This material degrades over time and needs to be replaced periodically, with a typical lifespan of 4 to 6 years. Take steps to maximize the lifespan of your greenhouse cover material, such as ensuring it is installed correctly, and repairing punctured or loose film as soon as the problem is spotted.
		Purchase supplies with minimal packaging	When purchasing supplies, look for products with minimal plastic packaging. If large quantities of a product are being used, order in large units (such as mini-bulks or totes) rather than small plastic jugs/bags.
	26. Minimize the amount of plastic waste that is sent to landfills *Back to survey*	Recycle plastic waste	Plastic packaging materials (such as discarded bags, trays, etc.) can be recycled through local municipal recycling programs. Pesticide containers less than 23 L can be recycled at participating landfills in Alberta through the CleanFarms Empty Pesticide Container Recycling Program.
		Explore new channels for recycling	Some of the plastic waste produced by greenhouses, including poly cover plastic, poly floor plastic, and growing media bags, cannot be recycled through traditional plastic recycling channels (like municipal recycling collection sites). Rather than sending these materials to landfills, seek out new channels for recycling them. The Alberta Plastics Recycling Association is currently working on a number of initiatives for recycling agricultural plastics (grain bags, silage bags, greenhouse plastics, etc.) and can connect greenhouse operators with suitable recycling facilities.

GUIDING PRINCIPLES	GENERAL BMP	SPECIFIC BMPS	DETAILS
8. MINIMIZE WASTE CONTINUED	**26. Minimize the amount of plastic waste that is sent to landfills (Cont'd)** *Back to survey*	Explore new channels for recycling	The Alberta Plastics Recycling Association can be reached at: Grant Cameron Executive Director, APRA Office: +1-250-558-7728 Cell: +1-780-690-3667 Email: albertaplastic@gmail.com
	27. Minimize the amount of plastic waste that is sent to landfills (Cont'd)	Consider alternative materials that are easier to recycle	Some materials are easier to recycle than others. For example, most types of plastic are accepted by municipal recycling programs, whereas many municipalities do not have the facilities or equipment necessary to recycle styrofoam. When possible, consider making changes that limit the amount of hard to recycle waste your facility is generating (such as switching from styrofoam growing trays to plastic ones).
	28. Minimize the amount of organic waste being generated	Explore options for cull vegetables	Greenhouses produce large volumes of organic waste, such as plant trimmings, spent growing media, and cull produce. While the production of plant material and waste growing media is unavoidable, steps can be taken to reduce the amount of wasted production. Many retailers and grower cooperatives have introduced programs to sell misshaped produce to consumers in an effort to reduce food waste. If selling direct to consumers, consider adopting a similar approach yourself.

8. MINIMIZE WASTE CONTINUED	**29. Avoid sending organic waste to land fills** *Back to survey*	Explore options for composting/land application	As mentioned above, greenhouses generate large amounts of organic waste including plant trimmings, spent growing media, and cull produce. Suitable methods for disposing of this waste include composting and land application Consult with local agrologists to find farmers that would allow the material to be applied onto their land. Contact commercial composting facilities to determine whether it would be feasible to deliver the material to them. Disposing of this material through landfilling can be expensive (if tipping fees are charged), and has significant environmental implications (the decomposition of organic waste in landfills produces methane, a potent greenhouse gas).
	30. Track materials and waste	Utilize a record keeping system to track supplies and waste	Implementing a record-keeping system to track your purchases of supplies (growing media, fertilizer, poly plastic, etc.) can be a useful tool to monitor how efficiently you are using them. Having this information compiled will also be useful when performing cost of production calculations. Tracking the amount of waste (cull vegetables, spent growing media, discarded poly, etc.) you facility is generating can help you spot trends and identify opportunities to reduce waste.

RESOURCES

- Alberta Agriculture and Forestry. *Components of the Greenhouse System for Environmental Control.* http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/opp2892
- Alberta Agriculture and Forestry. *Management of the Greenhouse Environment.* http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/opp2902#7
- Alberta Agriculture and Forestry. *Profile of the Greenhouse Industry in Alberta 2014.* http://www1.agric.gov.ab.ca/$Department/deptdocs.nsf/all/econ15525/$FILE/2014GHProfileFinalReport.pdf
- Alberta Agriculture and Forestry. *Productivity Improvement Initiative.* http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/cbd13043
- Natural Resources Canada. *Spot the Energy Savings Opportunities.* http://www.nrcan.gc.ca/energy/efficiency/industry/training-awareness/5475
- SAIT. *Power Engineering Technology.* (Courses for ABSA compliance) http://www.sait.ca/programs-and-courses/full-time-studies/diplomas/power-engineering-technology-course-overview.php
- NAIT. *Power Engineering Technology*. (Courses for ABSA compliance) http://www.nait.ca/program_home_77216.htm

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