NWT CanGrow Northern Greenhouse Technology Report

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Introduction

A commercial greenhouse operation faces several challenges, including: humidity control, proper air ventilation, and maintaining temperate interior conditions. For northern greenhouses, the challenge of maintaining an environment supportive of optimal plant growth is intensified by colder winter temperatures, shorter winter days, and higher energy costs (Yukon Cold Climate Research 2011). The following report explores technology-based strategies currently practiced in the north, as well as solutions taken on by growers at more southern latitudes. In all possible cases, research examples from northern locations are provided. The northern commercial greenhouse industry is very small and predominantly seasonal, so research and industry data is limited.

PROJECT BACKGROUND

This report is part of the NWT CanGrow Greenhouse Feasibility Study, developed by the Aurora Research Institute to examine the feasibility of commercial greenhouses in the Northwest Territories, Canada. Funding for this study was provided by the Canadian Northern Economic Development Agency and the Government of the Northwest Territories Department of Industry, Tourism and Investment. Data collection was carried out between October 2015 and March 2016.

READING THIS REPORT

Part one of this report provides a full literature review of cold-climate greenhouse technology, sources from academic literature, grey literature and profiles of northern greenhouse projects available online. This review formed the foundation of the project and guided the selection of experts to attend the NWT CanGrow Greenhouse Technology Workshop, held in Hay River, NT March 11-12, 2016, Part two of this report provides an overview of the workshop events. Part three provides recommendations on future directions for greenhouse technology in the Northwest Territories.

SPECIAL THANKS

Special thanks to our funders and partners on this project. Photos courtesy of Villiam Svalo of Vineland Research.

Northern growing today:
Low tech solutions at work in cold climates

Hoop houses (or high tunnels) are the most simple greenhouse structure and are the most common greenhouse structures used by market gardeners within the Northwest Territories (Wohlgemuth 2014). These simple, semi-closed structures consist of a metal frame with plastic polyethylene sheeting anchored across in either a Gothic arch or Quonset style design. These structures can effectively extend the growing season a month or more into both sides of the season (Smeenk & Nakazawa 2011). Since they have little to no automation, they must be manually vented to circulate air and moderate temperatures, watering and additional plant care must also be done by hand. Hand cranks or manual rolling of the poly sheeting cools the interior (Bartok 2013). Due to the lack of precise, automated environmental controls, these systems risk lower quality or quantity yield (Bartok 2013). Although these structures effectively prevent frost damage to crops (Bartok 2013), the internal nighttime temperatures are comparable to exterior temperatures (Kacira 2012) and can therefore restrict crop suitability into the later season.

Other low-tech thermal solutior

Chinese-style passive "solar" greenhouses are closed system greenhouses, designed to harvest and bank solar energy a sand-filled north and side walls (the "**thermal mass**"). This thermal mass stores energy for release during cooler nighttime temperatures. Other effective thermal masses include masonry walls, rock, and water masses (University of Minnesota 2013).

Thermal blankets and **interior energy curtains** can be utilized in both these structures to create insulating air pockets between the interior and exterior of the glazing, as well as on top of the crops themselves. Reflective thermal blankets provide even greater insulation (Simpkins et al. 1976). Black polyethylene sheeting, polyester or aluminum thermal screens can also be successfully used to reduce heat loss during winter months (Dawson & Winspear, 1976; Goebertus, 1989)). In the most low tech situations, these are draped manually, but automated systems are available.

During hot summer months, ventilation can be passively achieved through manual control vents built into the greenhouse structure. A completely passive system of opened lower channel with a vented roof can allow heat reduction during hot summer months. Thermal curtains or shades can also be used to lower the internal temperature (University of Minnesota, 2013).

A forked path:
The challenge and promise of increased automation

Any of the low-tech growing strategies presented in the previous section have the potential to be upgraded: mechanized, automated or combined with additional technologies to enhance interior environmental conditions. Although the technology upgrade enhances production quantity and quality, it also creates an electrical energy requirement where there was once none.

COOLING SYSTEMS

During the summer months, active systems including the **fan-and-pad** and **fog cooling systems** can be used to ventilate and cool the interior. **Active fan-and-pad systems** pass water through a cellulose pad, often made of corrugated cardboard, and exhaust fans are placed on the opposing wall; warm outside air is drawn into the greenhouse through the pad and the water absorbs the heat from the air. This system vents the greenhouse with cool, carbon dioxide rich external air. The **fog cooling system** works on the same principle as the fan-and-pad system. A high pressure piping system generates a fog made of fine water droplets where they stay suspended in the air evaporating and extracting heat from the surroundings. This water does not condenses on plants or surfaces.

Forced ventilation with heat exchange has been found to be the most promising ventilation method (Campen et al 2003; Maslak 2015). Forced air is effective for both heating and cooling. During the shoulder season, heat demand can be significantly reduced through the use of automated ventilation utilizing a heat recovery stage with controlled dehumidification (Coomans et al 2013).

HEATING SYSTEMS

In colder months, a more temperate climate can be maintained through active heat sources. Above or below ground heating can help extend the growing season and crop range. In ground heating is more effective and efficient than air heating (Yukon Research Centre 2013); below ground heating can include electrical heating cables or hot water piping buried 2 feet below the surface of the ground or plant bed.

Several systems serve both heating and cooling functions within a greenhouse. Subterranean heating systems circulate hot air from the top of the greenhouse down through in-ground ducts surrounded by rock and clay tile. This method can raise soil temperatures by 10-15C during the coldest months of the year and also regulates temperatures in the summer heat; automated controls can further enhance efficiency (University of Minnesota 2013).

Water can be used as a thermal conductor in both in-ground heating and radiant water-to-air heat exchange. Water can be heated geothermally through a system of underground piping which allows for earth-to-water heat exchange; this system will also help moderate temperatures during the summer. Water within these systems can also be heated through the use of a boiler system. Biomass presents a cheaper and accessible fuel source than conventional fuels, but have been found to be less energy efficient (Callahan et al 2010).

Glazing insulation is another greenhouse component that can help maintain heat. Glzing insulation capacity can be increased through the use of air-pump inflated double-poly sheeting (University of Minnesota 2013). Inflating devices used can be powered by a variety of sources including solar, air driven motors, or wind driven passive systems (Joplin 2014). The use of argon gas in place of air can further increase the glazing's insulation capacity (Zhang & Boris 2007).

GROWING SYSTEMS

In-ground growing with soil is the most common growing method for NWT growers. In communities where soil is readily available, this may be the best use of resources. For communities in the far north, where soil is in short supply and expensive to ship, soilless growing systems are more efficient.

Hydroponic systems are commonly used in highly efficient greenhouse designs(Aurora Research Institute 2013; Fabien-Ouellet, et al. 2013) – these systems grow plant roots in water and are able to maximize yields while minimizing the space required for growing – a boon to growers who would not wish to heat a large growing area in cooler seasons. Aeroponic systems have been substituted for hydroponic systems in some operations – these systems use water particles to deliver water and nutrients to root plant systems. Aeroponics attempts to maximize yields while making the most efficient use of space and water.

These systems are recommended for highly efficient operations with limited space. These systems can save growers in heating costs, but they also require energy to operate. With high energy costs throughout the NWT, this remains a barrier to wider implementation.

The future of growing:
Do high tech solutions hold promise for northern growers?

Over the last decade, there has been significant interest in high-tech agriculture solutions for implementation in the north. Research, in particular, has focused on high tech growth chamber greenhouses. These highly controlled environments are well insulated, rely completely or partially on artificial lighting, and require a high input of electrical energy. They usually employ highly automated systems, remote monitoring and specialized LED light “recipes” tailored to crop type and designed to maximize yield.

One operating hybrid greenhouse/growth chamber has been created through the Yukon Research Centre. During times of the year with high light intensity, high transmission is allowed through a quad-pane polycarbonate glazing (R-4). During the shoulder season, supplemental lighting is provided by LEDs. Insulated shading (R-26) is used during the cold, low-light winter months as LEDs become the primary source of lighting. The heavily insulated chamber is heated through in-bed heating and under-bed water reserves as a thermal storage. All environmental controls- including watering, lighting, ventilation, temperature, and shutters are mechanized (Mooney N.D.)

Also a hybrid system, the Canadian Integrated Northern Greenhouse (CING) design acts as a greenhouse during summer months and transforming into a closed growth chamber during the winter months. The operation is housed in a refurbished shipping container insulated with an extruded polystyrene rigid foam on all interior planes besides the south facing glazed surface. A radiant insulation blanket covers the glazed side in winter along with steel shutters. External air is passed through a heat exchanger chamber allowing for the intake and heating of fresh air, while recapturing the potential heat loss of the stale air exiting the system. A nutrient free water tank functions as a condenser for moisture buildup and temperature moderation. (Fabien-Ouellet et al 2013)

The theoretical designs proposed in AgNorth’s Modular Farm Concept also relies entirely on automated controls, mechanized systems, LED lighting, and a heat recovery ventilator. This growth style chamber utilizes a high density hydroponic growing system with LED lighting. Both the heat recovery ventilator and enthalpy/energy recovery ventilator (EVR) to reduce the amount of energy needed to heat up incoming air. EVR technology utilizes desiccants to capture airborne moisture. (Aurora Research Institute 2013)

Conclusions/Recommendations

The agricultural community in the NWT is still exploring models for growing that work best for the local conditions. There may be a place for technology in the future of northern greenhouse growing, as these technologies have been proven to maximize yields, minimize required growing area, make efficient use of water and energy. Still, the cost of electricity to run higher tech systems is a barrier. Systems that require only a small amount of energy may be feasible, if the grower is able to increase their produce sales as a result. The very high tech solutions have such high energy needs that they are not feasible without an independent energy source or a large subsidy from government funding.

Current initiatives have been quite successful – commercial greenhouses in Fort Smith, Yellowknife and Norman Wells have operated successfully for several years. These operations and others like the Northern Farm Training Institute have demonstrated that growing in the NWT does not require technological solutions. As the agricultural sector grows, there may be more demand for highly efficient technologies that help growers make the most of their space and resources.

It has been noted that technology is too complex and would alienate growers from the process of agriculture. That may be true at this time, since growers tend to be starting out and relying exclusively on lower tech systems. As the agricultural community develops and diversifies, however, there may be growers who have the skills and interest to expand into higher tech growing. Should there be an increased interest in high tech growing systems from NWT growers, it is advisable to support this interest with capacity-building and training opportunities to ensure that growers can remain active participants in the growing process.

There remain several knowledge gaps that require further research: how do these technologies perform in the north? What skills and knowledge level are required to implement different types of technology? Are there energy efficient solutions that can bring affordable technology to northern greenhouse growing? There are few rigorous studies that examine NWT greenhouse performance.

In addition to these areas of future research, grower-researcher partnerships would be ideal; growers could identify technologies they are interested in implementing and researchers can help establish the technology, then measure the outcomes. This is an area that holds a great deal of promise for both parties.

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NWT CANGROW Greenhouse Technology Workshop Report

INTRODUCTION:

The NWTCANGROW Greenhouse Technology Workshop is part ARI's larger food security project. Its purpose is to assess the feasibility of commercial greenhouse operations in the NWT. Funding of the workshop was provided by the Canadian Northern Economic Development Agency and the Government of the Northwest Territories Department of Industry, Tourism and Investment and the National Science and Engineering Research Council.

The aim of the workshop was to connect leading experts in the field of greenhouse technology from all across Canada with growers in the NWT. The eleven expert invitees were academics from a wide variety of disciplines and business representatives from companies offering innovative growing solutions. Farmers from across the NWT were invited – there were attendees from Hay River, Trout Lake, Fort Simpson, Yellowknife, Fort Good Hope, and Inuvik (See Appendix A for full list of attendees.) Over the two days of the workshop, experts and NWT growers presented ideas, discussed the unique challenges of cold-climate growing, and considered possible solutions.

WORKSHOP OBJECTIVES

1. Foster authentic connections between growers and visiting experts by engaging the NWT growing community to share their experiences and identify challenges.
2. Mobilize research expertise to tackle the specific challenges NWT growers are facing and encourage knowledge exchange.
3. Introduce new growing technologies to the NWT agriculture community, where technology has not been widely used to increase growing success.
4. Explore opportunities for research partnerships between academic institutes, industry partners and growers.

WORKSHOP SUMMARY

Workshop participants spent two days at the Northern Farm Training Institute, sharing presentations on innovative technologies and engaging in discussion about improving NWT agriculture. The agenda for the event was organized around four grower-identified challenges:

- *Keeping out the Cold: Cold climate technologies for Northern greenhouses*
- *Extending the growing season: Technologies to make the most of the Northern season*
- *Using energy efficiently: Technologies that save on energy inputs*
- *Growing all year 'round: Closed system growing solutions*

PRESENTATION SUMMARIES:

Day 1: March 11th

Keynote: Jackie Milne – President of the Northern Farm Training Institute

Jackie introduced the Northern Farm Training Institute, the organizations' goals and future directions. The campus is both a classroom and a sustainable farm that aims to establish a sustainable model through sales from farm products. Through education of growers from all over the territory, NTI hopes to improve food security by increasing the capacity to grow food in the north.

<u>Keeping out the Cold: Cold climate technologies for Northern greenhouses</u>

Low temperatures in the spring and fall limit the outdoor growing season significantly. Growers are interested in how they can extend the growing season into the colder months to take advantage of the shoulder season for more production. Tang Lee and Phalguni Mukhopadhyaya shared their thoughts on this challenge, while Wilfred (Junior) and Patricia McNeely spoke about their experience growing in Fort Good Hope. Their operation is one of the furthest north in the territory.

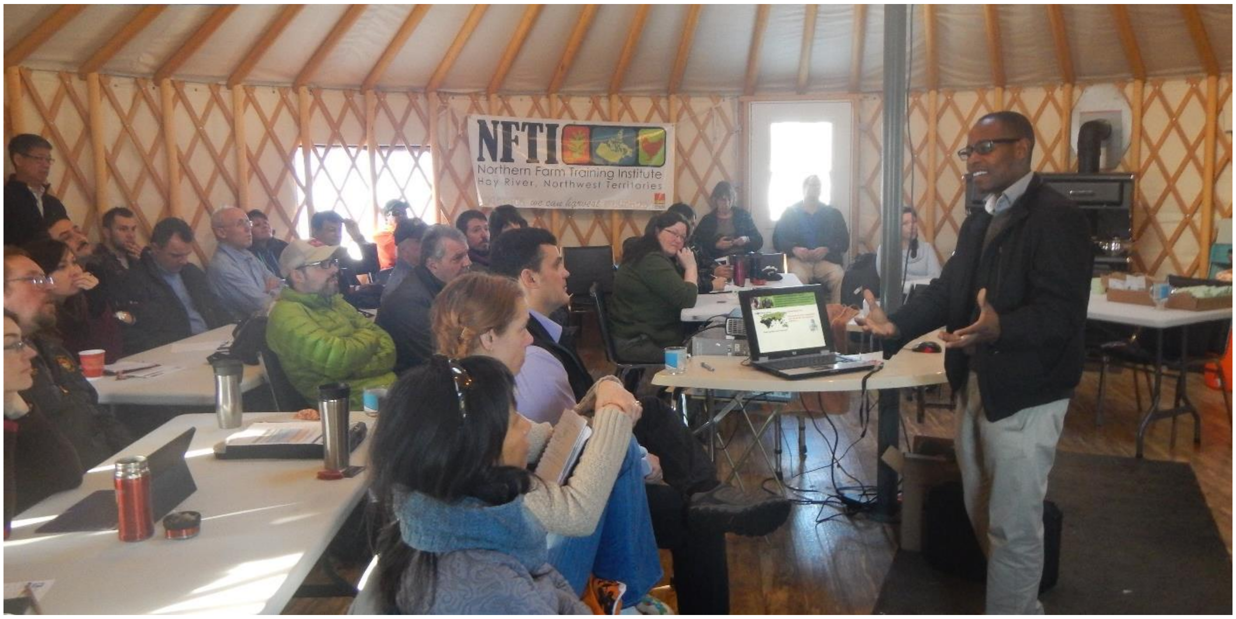
Dr. Tang Lee – University of Calgary:

Dr. Lee gave a comprehensive presentation on the complexities of building a highly efficient greenhouse. Capturing sunlight, storing energy, and growing that can create symbiotic growing operations, and making use of waste was a major talking point. Dr. Lee described his own commercial enterprise: a fish farm with aquaponic greenhouse. The fish and plants make use of the same heated space and the fish waste feeds the plants. By combining the fish farm and greenhouse he increases his operation's efficiency.

Dr. Phalguni Mukhopadhyaya - University of Victoria:

Dr. Mukhopadhyaya shared his work on building a net zero greenhouse – a structure that would produce as much energy as it consumes, or more. Net zero structures are an attractive concept, particularly in NWT communities where energy is often one of the highest annual costs for a greenhouse.

Dr. Mukhopadhyaya has been experimenting with vacuum insulated panel (VIP) insulation, which makes a net-zero structure possible, and is interested in exploring greenhouse designs that could make use to VIPs. VIP insualtion has a thermal resistance value as much as 3 times greater than the competition. This is possible because a vacuum does not conduct any heat. The drawback is that the panels lose their effectiveness when they get damaged. They are also expensive to produce, requiring a large expense upfront.



Eric Amyot - Modular Farms:

Modular Farms (MF) has developed several models of tech-supported growing systems: vertical growing towers, Zip Farms, and an entire modular farming operation, that allows a client to build their own closed system, scaled specifically to their needs. All MF products are engineered to be simple and easy to operate. All components are easily swapped out or can be repaired with a little training. Mr. Amyot offers a training program that is estimated to be able to educate anyone to use the equipment within a week. They also offer a robust support package, including video conferencing or phone support.

Modular farms is offering a complete package for anyone interested in hydroponic vertical farming. The product could be a small unit for a living room wall or fill an entire warehouse. They feature grow lights to make them more productive than with passive lighting.

Chief Wilfred (Junior) and Patricia McNeely, Fort Good Hope:

The McNeelys spoke about their experience starting a food production operation in Fort Good Hope. They shared the journey of establishing an operation in a remote community in the north. They experienced problems common with new growers: pests, regulating temperature and wildlife. The visiting experts were able to get some sense of the scale of farming operations in the NWT and the challenges facing local growers.

<u>Extending the growing season: Technologies to make the most of the Northern season</u>

Dr. Mark Lefsrud McGill University:

Dr. Lefsrud calls his project the CING: Canadian Integrated Northern Greenhouse. The CING is a growing unit made from a shipping container. With two clear polycarbonate panels – one on top and one on the side – the structure is able to trap the heat from the sun. A retractable roof and wall can cover these panels to increase heat retention and transform the unit into a growth chamber.

The CING features LED lights to supplement the chamber during low light conditions. It can support a range of growing systems, though he recommends a hydroponic system. The CING is designed to be a low cost solution for farmers to produce food in the north.

Dieter Krohmer – Advanced Technology Structures (ATS):

Mr. Krohmer presented his work on a prototype closed environment agriculture structure. ATS's structure is made from extruded PVC bricks that fit together with a rubber joiner. His structure's design is meant to be durable and to assemble quickly. The structure is then filled ATS's Novo Green Towers. These circular towers feature plants around the outside and rotate so that all sides are exposed to the lights evenly. The ATS structure makes use of the waste heat leaving the greenhouse by diverting rising hot air through a chimney that propels a small wind turbine, recapturing the energy.

Shelley Empey – Fort Simpson

Shelley owns and operates Forest Gate Gardens with her husband in Fort Simpson. She currently has two large hoop houses and an insulated greenhouse. The greenhouse has insulating walls on three sides made out Titanwall - a mold and fire resistant building panel with a high thermal resistance value. It has a polycarbonate south facing wall and is heated with a wood boiler. Shelley's operation is not limited to growing produce; her greenhouse also shelters chickens in the winter and she has experimented with aquaponics as well. Shelley identified temperature control as a key challenge for her greenhouse: it often ran too hot, or became too cold for her fish to survive. Forest Gate Farms is looking to expand to include bees and more animals in the future.

Day 2 March 12th

Keynote: Emanuel DaRosa – President and CEO of the Northwest Territories Power Corporation

Mr. DaRosa spoke about the opportunities for making the most efficient use of power and NTPC's work on increasing green power generation. He described the unique challenges facing the corporation, as it attempts to provide power to some of the most remote communities in the North. Wind energy projects in Inuvik hold promise for green generation in the future, and a large solar project in Colville Lake is exploring how energy from the sun can be captured and used to supply consistent, steady energy.

<u>*Using energy efficiently: Technologies that save on energy inputs*</u>

Tom Gross – Arctic Energy Alliance:

Arctic Energy Alliance is a local NGO based out of Yellowknife. In his presentation, Tom explored the programs available for saving on utilities used in commercial operations. The Commercial Energy Conservation and Efficiency program is one of the incentives available, which offers energy audits to businesses in order to help find possible savings.

Dr. Samuel Mugo - MacEwen University

Dr. Mugo is an analytical chemist who is experimenting with processes to reduce cellulose into smaller and smaller particles, ultimately creating nanocellulose. These compounds can be made into nanoporous hydrogel films, which can be used to trap heat for root zone heating, store and release nutrients, water and pesticides. We can even use them for biodegradable pots and packaging. Dr. Mugo's work aims to make the best use of waste and, with some chemistry, make better use of it.

Glen Scott - AgriArctic

AgriArctic has developed a closed environment agriculture (CEA) unit called the Agridome. One feasibility study have been completed with the Yukon Research Center, and the results were promising. The Agridome design makes use of already available construction materials. The structure itself is a converted Intershelter Dome, designed for northern survival. The systems feature an HVAC unit, vertical growing towers, computer monitoring and HPS lamps. The design is remarkably space-efficient (32 square feet) which reduces the amount of heat and light required. The computer equipment allows the grower to monitor and control the structure remotely. The Agridome can be linked together to expand the operation. The Agridome is relatively cheap to operate, does not require a large team of people and is scalable to individual needs. This option is feasible in even the high arctic where light and energy are limited.

The Agridome is not quite market ready, needing approximately 6-8 months of further research to explore how to improve the yields.

Growing all year 'round: Closed system growing solutions

Dr. Kameal Mina – Cambrian College

Dr. Mina recently completed a project to provide a passive solar greenhouse to the community of Espanola in Ontario. In partnership with Greenhouses Canada, the study examined the benefits a local greenhouse would have on the local economy and food security. The project found that there was promise for a local greenhouse to help keep food dollars in the local area and provide jobs. A follow up project underway. Dr Mina believes there are some parallels between the conditions experienced in northern Ontario communities and NWT communities and that a similar project could be promising here.

Dr. Viliam Zvalo - Vineland Research Center

As head of the world crops program at Vineland Research Centre, Dr. Zvalo has been experimenting with cold climate crops. He has been successful in acclimatizing new crop types to the climate in Canada and has experience cold hardying crops in Nova Scotia. Dr. Zvalo is interested in exploring crop types that succeed in Canada's northernmost climates.

Raygen Solotki – Inuvik Community Greenhouse

The Inuvik Community Greenhouse was converted from the Grolier Hall hockey arena to provide a space for community members to grow food almost 20 years ago. Most of the greenhouse is reserved for community members' use, but a small portion is designed as a commercial operation that sells mainly bedding plants to the community. Inuvik is a difficult environment for growing, and the greenhouse faces challenges including poor access to water, difficulty retaining heat and high repair costs.

David Brault - Inno-3B:

Inno-3B has developed a closed environment agriculture solution for growing greens with minimal inputs. The units are stackable, scalable, can run year round and are resource efficient. Inno-3B has targeted grocery stores and food producers, since greens do not have to travel, like those from southern suppliers, they have a longer shelf life and this prevents wastage for the vendor. This means that more product sells and more money stays within the north.

THE RESEARCH HACK

Inspired by hackathon events that are popular in the software development world, the Research Hack was a competition designed to encourage participants to develop research partnerships that address grower-identified challenges. Participants were given a set of problems and asked to develop a solution in the form of a research proposal. A panel of judges, including ARI, NFTI, NTPC and NSERC reviewed the proposals to determine which held the most promise. The winning proposal would have the opportunity to partner with NFTI and/or ARI to develop a project, seek funding and carry out the implementation.

APPENDIX A: ATTENDEE LIST

Researchers	Tang Gim Lee	University of Calgary
	Samuel Mugo	Macewen University
	Viliam Zvalo	Vineland Research
	Mark Lefsrud	McGill University
	Kameal Mina	Cambrian College
	Phalguni Mukhopadhyaya	U of Victoria/Vaccuum insulated panels
Industry	Glen Scott	Agri-Arctic
	Tom Gross	Arctic Energy Alliance
	David Brault	Inno-3B closed systems
	Dieter Krohmer	Advanced Technology Structures
	Eric Amyot	Zip Farm / Modular farms
	Kevin Wallington	Harbor communications
Growers	Patricia McNeely	
	Wilfred McNeely	
	Shelly Empey	
	Tamarah Pellisey	
	Kate Latour	
	Raygan Solotki	
	Fred Punch	
	Rena Chapple	
	Kathryn Scott	
	Nathalie Lavoie	
	Danielle Simandl	
ARI	Jessica Dutton	Ethics and Community Research Coordinator
	Jesse Evans	Research Assistant
	Chase Sellwood	Research Assistant
NFTI	Jackie Milne	President
	Kim Rapati	General Manager
	Helen Green	
	Leon Bouchard	
NTPC	Myra Berrub	Manger of Energy Services
NSERC	Kathleen Lorenzo	Research Partnerships Promotions Officer

APPENDIX B: AGENDA

	Friday March 11, 2016
8:00 AM	Shuttle pick-up at hotels
8:30 – 8:45 a.m	Check-in and Breakfast
8:45 – 9:00 a.m	Acknowledgement of Traditional Territory: Doug Lamalice
9:00 - 9:30 a.m	Keynote Address: Jackie Milne - President, Northern Farm Training Institute
9:30 – 10:00 a.m	NWT CanGrow Greenhouse Hack Introduction: Jessica Dutton, Aurora Research Institute
	Panel Presentations *Keeping out the Cold: Cold climate technologies for Northern greenhousing*
10:15 - 10:30 am	Tang Lee - University of Calgary, Alberta
10:30 - 10:45 am	Phalguni Mukopadhyaya - University of Victoria, British Columbia
10:45 - 11:00 am	Eric Amyot - Modular Farms, Ontario
11:00 - 11:15 am	Tish and Junior McNeely - NWT Grower, Fort Good Hope
11:15 - 12:00 pm	Panel discussion and audience Q&A: What other cold climate challenges can technology help to address?
12:00 - 1:00 pm	Networking Lunch
	Panel Presentations *Extending the growing season: Technologies to make the most of the Northern season*
1:00 - 1:15 pm	Mark Lefsrud - McGill University, Quebec
1:30 - 1:45 pm	Dieter Kromer - Advanced Technology Structures, Alberta
1:45 - 2:00 pm	Shelley Empey - NWT Grower,
2:00 - 2:45 pm	Panel discussion and audience Q&A: What other technologies would help Northern growers take full advantage of the growing season?
2:45 - 3:00 pm	Break
3:00 - 4:00 pm	Research Mobilization Session
4:00 - 5:00 p.m	Hay River Greenhouse Tour
5:00 - 7:00 pm	Shuttle back to hotels
7:00 PM	Evening social : Back Eddy Resturant

	Saturday March 12, 2016
8:30 AM	Shuttle pick-up at hotels
9:00 - 9:15 am	Welcome
9:15 - 10:00 am	Keynote Address: Emanuel DaRosa - President and CEO, NTPC
	Using energy efficiently: Technologies that save on energy inputs
10:00 - 10:15 am	Tom Gross - Arctic Energy Alliance, Northwest Territories
10:15 - 10:30 am	Sam Mugo - MacEwan University, Alberta
10:30 - 10:45 am	Glen Scott - Agri-Arctic Yukon Inc., Yukon
10:45 - 11:00am	Break and Trade show set-up
11:00 - 12:00 pm	Trade Fair
12:00 - 1:00 pm	Lunch/Trade Fair
	Panel Presentations
	Growing all year 'round: Closed system growing solutions
	Kameal Mina - Cambrian College, Ontario
1:15 - 1:30 pm	Ray Solotki - NWT Grower, Inuvik
1:30 - 1:45 pm	Viliam Zvalo - Vineland Research, Ontario
1:45 - 2:00 pm	David Brault - Inno 3b, Quebec
2:00 - 2:45 pm	Panel discussion and audience Q&A: What role do closed systems play in the NWT food network?
2:45 - 3:15 pm	Research Mobilization Session
3:15 - 3:30 pm	Break: Research Proposal Submission Period
3:30 - 4:00 pm	Grower Panel: Recommended research directions
4:00 - 6:00 pm	Shuttle to Frozen Falls or Hotel
6:30 - 9:00 p.m	Catered dinner, NFTI Campus

APPENDIX C: RESEARCH HACK INFORMATION

Research Hack Research Challenges:

- ***How can technology be used most efficiently to extend the short growing season?***
  Eg. Warming greenhouses in cooler months, increasing available light in darker months
- ***How can local resources be incorporated into greenhouse operations?***
  Eg. High wind in the far north, accessing local water
- ***How can the energy costs of greenhouse growing be most efficiently reduced?***
  Eg. Co-generation strategies, highly efficient operations
- ***How can technology make greenhouse operations more affordable for new food producers?***
  Eg. Less costly materials, using locally available resources, reducing energy costs

Research Hack Judging Criteria

ORIGINALITY: How original is the solution compared to other greenhouse tech already available?

USEFULNESS: Does the solution overcome one or more of the grower-identified challenges? Can it be deployed immediately? Is it useful in all regions of the north?

SCALABILITY: Can this solution be applied to small operations as well as large operations?

IMPACT: Does the intended outcome of the research proposal have immediate positive outcomes for cold climate growing community? Are there positive long-term outcomes?

ACCESSIBILITY: Can all growers make use of the solution?

VERSATILITY: Can this solution be applied elsewhere to improve quality of life? Can it be used for multiple purposes?

TECHNICAL ACHEIVEMENT: Did the proposal solve a difficult problem?

Photo Credit: Northern Farm Training Institute

For more information please contact

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