# SDTC Success Stories


SUSTAINABLE DEVELOPMENT
TECHNOLOGY CANADA

**30 cleantech leaders** share their journeys to commercialization

# Calling all Canadian cleantech innovators and entrepreneurs!

**Apply to SDTC for funding 365 days of the year, 24 hours a day.**

WANT TO SEE YOUR SUCCESS STORY PUBLISHED HERE?


Further information on SDTC's funding opportunities can be found online at **www.sdtc.ca**.

## TO APPLY FOR SDTC FUNDING

We invite interested and qualified parties to become part of SDTC's portfolio of cleantech companies. Please visit **www.sdtc.ca** to see if you might be eligible for SDTC funding or contact a **Technology Scout (613-234-6313)** to initiate the application process.

SUSTAINABLE DEVELOPMENT TECHNOLOGY CANADA


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**PUBLISHING DETAILS**

**Produced by:**
Blunt Strategic
bluntstrategic.com

**Printer:**
CBN Commercial Solutions
cbncs.com

**Published by:**
SDTC Office of Public Affairs
sdtc.ca




# Welcome to our 2016 Collection of SDTC Success Stories

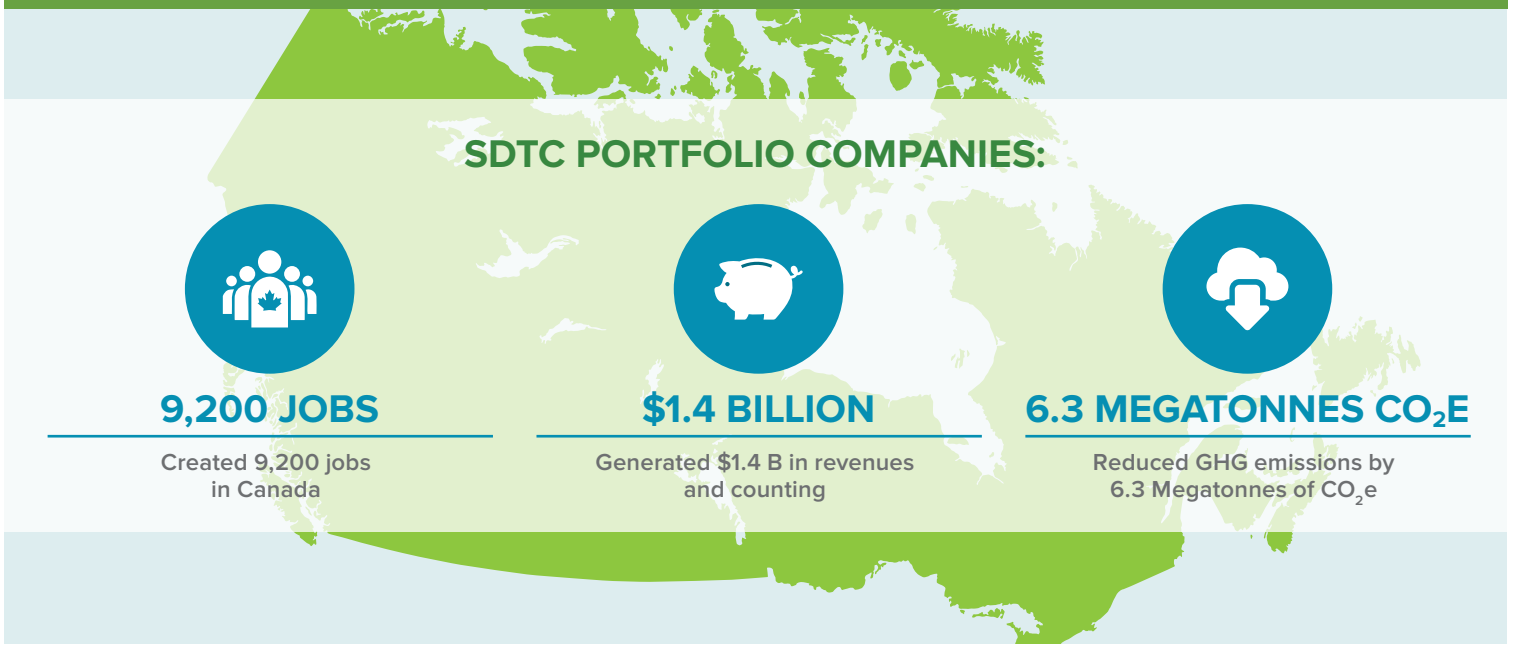
Since its inception in 2001, SDTC has funded more than 300 Canadian cleantech projects, bringing considerable economic and environmental benefits to Canada and Canadians. Our funded companies come in many shapes and sizes, and innovate in a number of key industries that drive the Canadian economy. From hybrid vehicles to waste management solutions to mining innovations, SDTC portfolio companies are tackling critical environmental issues and creating technologies that not only improve our air, land and water but do so more efficiently, competitively and sustainably than incumbent technologies.

Each of these companies has taken its own unique journey toward technology commercialization and has an interesting story to tell.

In 2016, we started to document some of these stories. Our 2016 collection of 30 SDTC Success Stories showcases the breadth and depth of cleantech experience in Canada and highlights how SDTC helped fund these companies at critical junctures on their road to market entry. We hope you enjoy reading about these Canadian pioneers, innovators, entrepreneurs and idea-makers that are revolutionizing key industries with their green solutions.

## SDTC PORTFOLIO COMPANIES DELIVER REAL RESULTS

Our profiled projects were completed by 30 companies that comprise but a fraction of SDTC's portfolio of more than 300 cleantech leaders creating quality jobs and driving economic growth in Canada. By the end of 2015, SDTC-supported companies had created 9,200 new jobs for Canadians, generated $1.4B in annual revenues and delivered meaningful climate-change mitigation benefits.



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AGRICULTURE

PRIMARY BENEFIT
CLEAN WATER

CO-BENEFIT
CLEAN SOIL

COMPANY NAME:
**SEMIOSBIO TECHNOLOGIES INC. (SEMIOS)**

PROJECT NAME:
**AREA-WIDE DEMONSTRATION OF AUTOMATED AND INTEGRATED PEST-MANAGEMENT SYSTEM**

**Key Products/Services:** Software-as-a-Service (Saas) platform for orchardists providing real-time monitoring and intelligence for pest management, frost mitigation, disease control and irrigation optimization.

**Operating Since:** 2010

**SDTC Support:** 2011 to 2015

**Mission:** Semios is an emerging leader in the development of Internet-of-things (ioT) technology for agriculture. We are at the forefront of a new wave of agricultural technology innovation involving precision agriculture, biological pest control and big data analytics.

**Consortium Partners:**
- University of British Columbia
- Okanagan Kootenay Sterile Insect Release Program
- University of Guelph

**SDTC Funding:** $4,980,000

**Leveraged Funding:** $11,053,807

**Total Project Value:** $16,033,807

**For more information:** **semios.com**


*"We are at a pivotal point in the company's growth. Adoption of our platform is accelerating and our growers are asking for more features and services. Funding from SDTC and other organizations had led to new levels of investor expertise and confidence, allowing us to accelerate the growth of our business and become more responsive to our clients."*

***Michael Gilbert***
*Founder and CEO*
*Semios*

SEMIOS' PEST-MANAGEMENT SYSTEM:

## At a Glance

Semios has developed an innovative pest-management system that utilizes mating-disrupting pheromones to prevent insect mating, thereby reducing the larvae populations that reside in apple orchards. Orchard growers suffer important yield and revenue losses annually as a result of insect-damaged fruit. Semios' automated pest-management system allows growers to perform real-time monitoring, quantify pests, control dispersion and collect data all with the goal of reducing pest quantity in their orchards. Semios' technology is more cost effective and less labour intensive than the incumbent solid-matrix, pheromone technology, and prevents soil and water contamination that can result from toxic chemical use in pesticide-spray applications.

## The Opportunity

Permanent crops—such as apples, pears and grapes—are expensive to produce and have traditionally necessitated the use of pesticides to bear healthy, consumer-ready fruit. Apples grown in an orchard without the use of pesticides, or other pest-reducing agents, can result in 50 to 75 per cent of damaged crop yield. Using apples as their preferred reproductive environment certain insects are specifically designed by nature to only lay eggs in apples—the fruit key to their reproductive activity.

Currently, there are two ways to control and prevent insects (e.g., butterflies, moths) from mating. The incumbent technology—95 per cent prevalent—is the use of a pesticide that acts as a nerve toxin and wholly debilitates the insect. Farmers use regularly scheduled calendar sprays to prevent insect mating, protecting their crop yields and revenues. In doing so, they release harmful pesticides, such as Phosmet, Carbaryl and Diazinon, into the soil and water, harming our environment and posing significant risks to farm workers. Further, pesticides are costly, and lead to increased prices of produce for the end consumer. An opportunity existed in the marketplace to displace the use of harmful chemicals. Through the use of pheromones–nature's own communication system—to prevent insect mating, permanent-crop production could become more cost effective and sustainable.

Insects don't talk; instead they emit pheromones to communicate with each other. By tapping into insect pheromone communication, scientists could disrupt the communication exchange prior to mating in a non-toxic manner, preventing the mating act and actively controlling pest numbers.

## Project Overview

Semios conducted their demonstration of an automated and integrated pest-management system in three main apple-growing regions in Canada: the Okanagan Valley, Southern Ontario and the Eastern Townships of Quebec. Through the use of pheromone dispensers that emitted mating-disrupting pheromones at times when insects were suspected of communicating, they aimed to disrupt the mating process, preventing the undesired behaviour and controlling harmful insect populations.

To showcase the potential of the technology, the demonstration area started out small—the first orchard being approximately 200 acres in size. Once efficacy was demonstrated (i.e., pheromone emitters were seen as effective in controlling the undesired behaviours in the specific insect species), Semios then had to demonstrate scale. The scope of the project was expanded to include larger farms in Michigan, Washington, California and Northern Italy, with orchard size climbing to nearly 5,000 acres, and crop varietals extending beyond apples to include almonds and pistachios. Semios effectively showed that they could apply their technology to a variety of fruit- and nut-producing crops across North America and parts of Europe.

### The Technology

Pheromones are extremely expensive. Therefore, pheromone emitters could not run continuously for the duration of a growing season (i.e., up to six months). Semios needed to wirelessly connect its pheromone-emitting sensors to a network so that they can be turned on and off, as necessary. The company was challenged to build a strong network that could communicate through hundreds and thousands of trees to remotely operate its sensors.

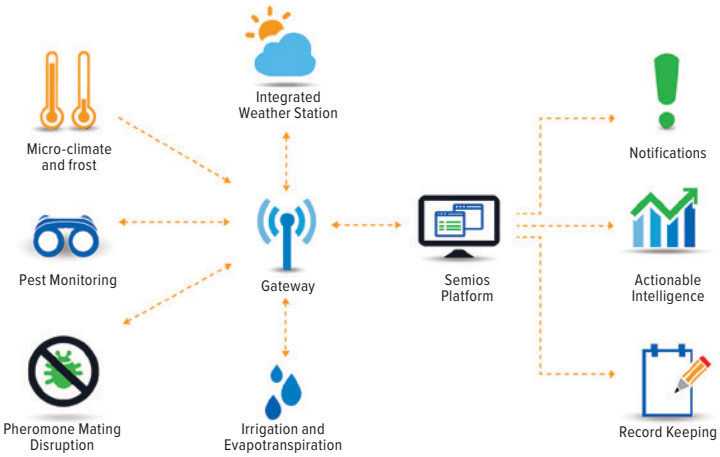
The result was the beginning of the company's Software-as-a-Service (SaaS) platform. Quickly expanding to meet growers' other needs, Semios moved beyond pest management to also include:

- frost mitigation – helping to control the fans that mix hot and cold air to prevent crop freezing,
- irrigation optimization – detecting soil moisture at different levels and advising of moisture requirements, and
- disease prevention – helping to manage diseases such as mildew through the appropriate application of antibiotics and antifungals.

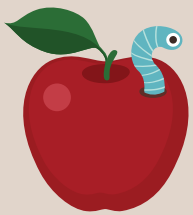
All of this was done through the use of Semios' sensing technology.

Semios platforms are now in use around the world, protecting tens of thousands of acres of crops from the risks associated with weather, pests, disease, frost and irrigation. Orchardists pay a subscription for the real-time services and analytics provided by Semios, which can be accessed by computer or Smartphone.

**The Semios Network: How it Works**




## KEY FACTS



If apples are left untreated (i.e., without the use of pesticides or pest-reducing agents),

**50% TO 75%**

**OF THEM WILL HAVE WORMS.**

Semios has **50,000 SENSORS** deployed over 10,000 acres of land worldwide on more than 200 farms.

By 2020, uptake of the Semios technology in Canadian apple orchards **CAN POTENTIALLY REDUCE** soil contamination by

**↓54 t/yr**

and water contamination by

**↓817 kg/yr,**

displacing the use of harmful pesticides.



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INDUSTRY
AGRICULTURE

PRIMARY BENEFITS
CLEAN SOIL

CO-BENEFITS
CLEAN AIR

CLEAN WATER

CLIMATE CHANGE

COMPANY NAME:
**TERRAMERA INC.**

PROJECT NAME:
**DEVELOPMENT AND DEMONSTRATION OF NEEM-BASED BIOPESTICIDE**

Terramera

**Key Products/Services:** High-performance biopesticides for agriculture, bee health and public-health applications

**Operating Since:** 2009

**SDTC Support:** 2013 to present

**Mission:** Terramera creates healthy, safe environments free of toxic chemicals, and makes sustainable and organic farming cheaper, more productive and abundant.

**Consortium Partners:**
- Institute for Sustainable Horticulture Kwantlen Polytechnic University
- Kalala Organic Estate Winery
- U.S. Department of Agriculture Agricultural Research Service
- Plant Sciences Inc.
- Evonik Corporation

**SDTC Funding:** $1,984,581

**Leveraged Funding:** $3,945,805

**Total Project Value:** $5,930,386

**For more information:** **terramera.com**

*"Terramera cultivates healthy homes and plants, making organic food and sustainable farming more productive and abundant by harnessing the power of natural plant defenses. The investment from organizations such as SDTC allows us to continue our rapid growth, helps fund our journey toward product commercialization and supports Terramera's advancement as a sustainable technology leader."*

***Karn Manhas***
*CEO*
*Terramera Inc.*

TERRAMERA'S DEVELOPMENT AND DEMONSTRATION OF NEEM-BASED BIOPESTICIDE:

# At a Glance

Terramera is developing a neem-based biopesticide that can replace the use of synthetic, chemical pesticides. Neem oil, derived from Southeast Asia's neem tree, has long been applauded for its natural pest-controlling characteristics. However, when used alone, neem oil can be unstable and has a short shelf life. Terramera has developed a proprietary delivery technology for neem oil that extends the product's shelf life and enhances its ability to penetrate the target, enabling higher efficacy in pest control. In this project, Terramera's neem-based pesticides are undergoing field trials to establish application rates and confirm their efficacy vis a vis the incumbent, conventional pesticides.

## The Opportunity

Growers rely on the use of chemical pesticides to deliver healthy, robust crops. The use of pesticides to control target pest populations is necessary to a successful agricultural operation. Without the use of pesticides, pests and diseases would attack and compromise a farmer's crops, yields and revenues.

Unfortunately, the use of pesticides has considerable drawbacks, including soil and water toxicity, and environmental persistence. Additionally, many insect species have developed resistance to common, conventional pesticides.

The negative environmental impacts of synthetic pesticides, such as methyl bromide, are recognized by regulatory agencies and are hence being phased out of use. To date, replacing chemical-based pesticides with biochemical alternatives has been unsuccessful, as biochemicals can be inconsistent and unstable. Terramera's proprietary delivery platform stabilizes and delivers complex plant biochemicals more effectively. Products created using Terramera's technology are equal or superior in efficacy to conventional chemical pesticides without the associated issues of toxicity and environmental persistence.

### Neem

Endemic to India, Burma and parts of Africa, neem (Azadirachta indica) is an evergreen tree, the oil of which can be used in a variety of medicinal applications. Its use dates back to 4,000 B.C. in India, where it was used for general health and skin care. With more than 150 bioactive compounds, neem oil helps treat fungal infections, lice, dry scalp, dandruff, and skin ailments and disorders.

Recently, neem oil has been used for agricultural pest control. Unfortunately, its use has been hampered by variable efficacy and hence, the product has not been widely commercialized for the purpose of agricultural applications.

## Project Overview

Terramera develops delivery technology for biochemicals. When a plant's oils are extracted and applied directly to another organism, the oil can behave variably with unpredictable efficacy. Terramera's technology effectively allows the active biochemical molecule to better penetrate and enter the target organism (i.e., pest) and hence enable the desired action (i.e., pest control). In this project, Terramera used its proprietary delivery platform to develop and demonstrate its neem-based biopesticides.

*Photo: Neem trees, endemic to Southeast Asia and parts of Africa, can live for several hundred years.*

Over the course of the last three years, Terramera's neem-based biopesticide has undergone a series of field trials on grapes and strawberries, respectively, in California and more recently, on row crops (i.e., corn, potatoes, cotton, peanuts soy beans) in the eastern United States. Initial testing on grapes started on small acreages of three acres or less and is planned to increase to 200-plus acres in the next year.

Using scheduled foliar sprays on table grapes, the neem-based pesticide is showing excellent disease control combined with a dramatic increase in yield, and the grade and quality of fruit, potentially doubling a farmer's revenues. With results in hand, Terramera is now actively working with growers to increase trials and demonstration acreage.

For strawberries, typically treated by soil fumigation—where a powerful chemical pesticide is injected into the soil to sterilize the target growth area—Terramera's neem-oil biopesticide is used in a soil-drip application to provide the necessary soil disease and nematode control. Applications of the neem-oil pesticide to row crops commenced in 2015. In addition to application of the neem-based biopesticide into the soil at planting, follow-up treatments via foliar sprays are also conducted throughout the growing season.

Terramera is working with conventional farmers who are interested in transitioning to organic farming, tying in their product to existing application protocols. Terramera's goal is to convince conventional growers—95 per cent of the farming market—to use organic pest-control products, substituting biopesticides for conventional pesticides, without the need to change any other part of their farming practices.

As part of this project, Terramera hopes to also be able to register its neem-based, pest-control products for sale in Canada. Terramera's current product line—household and professional biopesticides for bedbugs—are EPA approved and available in the U.S. through distributors such as Walmart and Home Depot, and online.

## KEY FACTS

Neem trees start bearing fruit in three to five years, **BECOME FULLY PRODUCTIVE IN TEN YEARS,** and from then on produce up to **50 KG** of fruit annually.

With a long history of combating various illnesses, **NEEM OIL CAN BE USED TO COMBAT** fungal infections, lice, dry scalp, dandruff, and skin ailments and disorders.

**TERRAMERA IS USING NEEM OIL TO CREATE BIOPESTICIDES THAT ARE:**

- as effective as chemical pesticides
- organic and environmentally friendly
- not harmful to beneficial insect species, such as bees

Terramera's non-toxic Proof® (household) and Cirkil® (professional) products are sold in the USA and are the only EPA-approved, **100%-EFFECTIVE** sprays available to control dust mites, bed bugs and their eggs.



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INDUSTRY
AGRICULTURE

PRIMARY BENEFIT
CLEAN AIR

CO-BENEFITS
CLEAN WATER

CLEAN SOIL

CLIMATE CHANGE

COMPANY NAME:
**AGRISOMA BIOSCIENCES INC.**

PROJECT NAME:
**CARINATA OILSEED**

AGRISOMA

**Key Products/Services:** Resonance Carinata seeds

**Operating Since:** 2001

**SDTC Support:** 2009 to 2016

**Vision:** Leading the way in sustainable solutions for biofuels.

**Consortium Partner:**
• National Research Council of Canada

**SDTC Funding:** $3,275,000

**Leveraged Funding:** $7,573,340

**Total Project Value:** $10,848,340

**For more information:** **agrisoma.com**

*"Thanks to funding from agencies such as SDTC, Agrisoma was able to bring to market its next-generation agricultural products, providing a sustainable solution for renewable energy. We have successfully commercialized Resonance® Carinata, Canada's first non-food crop that produces oil uniquely suited for biofuel production. In a demonstration of its capabilities, our carinata-based oil fueled the first 100-per-cent-renewable-fueled biojet flight here in Canada."*

***Steve Fabijanski***
*President and CEO*
*Agrisoma Biosciences Inc.*

AGRISOMA'S CARINATA OILSEED:

## At a Glance

As part of this project, Agrisoma continued the development of its Brassica carinata (B. carinata or carinata) seeds, with the goal of further improving the crop's drought and heat tolerance, and agronomic robustness, enabling growth on marginal lands not suitable for growing food crops. In addition to acreage planted across Canada to demonstrate agronomic objectives, the project included a demonstration of Agrisoma's carinata-based renewable biojet fuel in flight. The demonstration proved up B. carinata's unique ability to grow under extreme climate conditions while providing renewable oil that met required fuel-quality objectives, displacing the need for fossil-derived fuel.

## The Opportunity

Prompted by climate change goals and underlying environmental concerns, in 2007, the biofuel industry saw a marked resurgence. Alternative fuel sources like ethanol and biodiesel (derived from crops such as canola) were highly sought after to meet government-mandated, fuel-blending targets. Agriculturally, there was increased pressure for growers to meet both fuel and food demand, sustainably and in an environmentally friendly fashion.

Biotechnology had an important role to play in increasing the economic and environmental performance of renewable fuels. Additionally, Canada's rich history in agronomy—specifically past commercialization of oilseed crops such as canola—led Agrisoma, then a nascent bioscience company, to explore past research into bio-oils, looking for other sustainable crops suitable for biofuel production.

### Brassica carinata

Agrisoma's journey led to the rediscovery of Brassica carinata (B. carinata or carinata), a non-food crop seed from the mustard family. Previously overlooked due to its inability to act as a human food source, Agrisoma saw carinata's potential as an oilseed. The company then applied its proprietary crop improvement technologies to develop high-performance, commercial varieties of carinata. Carinata had several advantages: a biomass crop, it could grow on fallow land and in challenging growth areas as part of a sustainable agricultural system; a rotation crop, carinata revitalized the soil in which it grew, supporting and enhancing food crop production; and it could be harvested and processed within the existing value chain to produce—under certified, sustainable-production schemes—bio-oil and high-value, nutritious animal meal, without the need for new infrastructure.

## Project Overview

With the support of SDTC-funding, Agrisoma embarked on a project that would demonstrate full-lifecycle viability of B. carinata. Working with the National Research Council of Canada (NRC), Agrisoma proved up carinata's potential: how it could be grown, harvested, and processed to produce oil and meal in a sustainable fashion. The crop was tested across the entirety of the value chain, demonstrating its viability as an environmentally friendly, sustainable alternative.

The demonstration project was conducted on fallow acreage in Southern Saskatchewan in 2012 with approximately 6,000 test acres of production. With several pre-determined benchmarks, carinata successfully met and exceeded targets for crop yields, animal-feed production, soil improvements, water use, and biofuel production. The produced biofuel was then tested by the NRC's Aerospace Institute, demonstrating its performance capabilities.

### From Seed-to-Sky: Jet Testing

Beyond performing in environmentally challenging conditions, Agrisoma's carinata-based biofuel was put to the ultimate test. Working with the NRC, Agrisoma developed a seed-to-sky approach that saw its bio-oil used in a series of flights, ultimately leading to the world's first 100-per-cent-renewable-fueled biojet flight. During the test flight, emissions were measured, demonstrating a 50 per cent reduction in carbon footprint. Further, the flight showed increased fuel efficiency versus the incumbent jet fuel, without any changes required to existing fuel systems or to the aircraft.

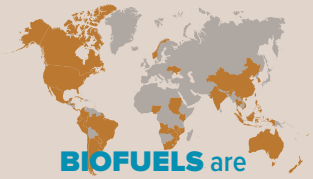
*Photo: Agrisoma's carinata oil powered the world's first 100-per-cent-renewable-fueled biojet flight, demonstrating a 50% reduction in GHG emissions and better fuel efficiencies than conventional jet fuel.*

### B. carinata Today

Marketed as Resonance® Carinata, Agrisoma's carinata seed has been grown on over 32,000 acres of crop globally—from Western Canada to the Northern U.S., Florida and even South America. With carinata's ability to be used in crop rotations and/or as a second crop option, Agrisoma is now expanding its production in these key global regions.

Still in its relative infancy as a fuel source, working together with growers, Agrisoma is managing the entire carinata value chain—from growth to fuel production—as biofuel technologies specific to the oil from that seed are being optimized. With carinata's similarity to canola, there is no need for additional capital outlay for new infrastructure, as existing crushing facilities are utilized to extract the seed oil and resulting meal. The oil is then moved to biofuel facilities and integrated into existing and new biofuel production processes to maximize production and quality. As the biofuel value chains for carinata are established, Agrisoma is focused on delivering the highest performing carinata varieties to local farmers, providing them with distinct environmental and economic benefits.

## KEY FACTS

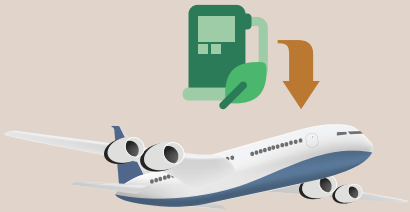


**BIOFUELS** are currently mandated in **62** countries in the world; biofuel production will reach 60 billion gallons by 2020.

**BRASSICA CARINATA**, a non-food seed of the mustard family, is a certified-sustainable, high quality feedstock used for the production of **BIO-BASED FUELS**.

Carinata-based biofuel has one of the **LOWEST CARBON FOOTPRINTS** of any biofuel in the world today.

Carinata can annually supply:



**20 BILLION GALLONS OF OF BIOJET FUEL** (1/3rd of global demand)

**54 MILLIONS TONNES OF ANIMAL FEED**



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INDUSTRY
**ENERGY EXPLORATION & PRODUCTION**

PRIMARY BENEFIT
**CLEAN SOIL**

CO-BENEFIT
**CLEAN WATER**

COMPANY NAME:
## HIFI ENGINEERING INC.

PROJECT NAME:
## PIPELINE MONITORING USING HIGH FIDELITY FIBER OPTIC SENSORS

hifi

**Key Products/Services:** Preventative pipeline leak detection

**Operating Since:** 2007

**SDTC Support:** 2014 to present

**Vision:** To become the world-class standard for intelligent monitoring of pipelines supporting the achievement of 100 per cent safety in the industry.

**Consortium Partners:**
- General Electric
- Enbridge Inc.

**SDTC Funding:** $2,000,000

**Leveraged Funding:** $3,926,220

**Total Project Value:** $5,926,220

**For more information:** **www.hifieng.com**

*"We feel the support that SDTC and the Government of Canada have provided us has absolutely accelerated Hifi's ability to develop and commercialize our HDS technology. This next-generation platform sensitivity and fidelity is going to enhance the energy industry's future and achieve the goal of 100 per cent safety."*

***Steven Koles***
*President and CEO*
*Hifi Engineering*

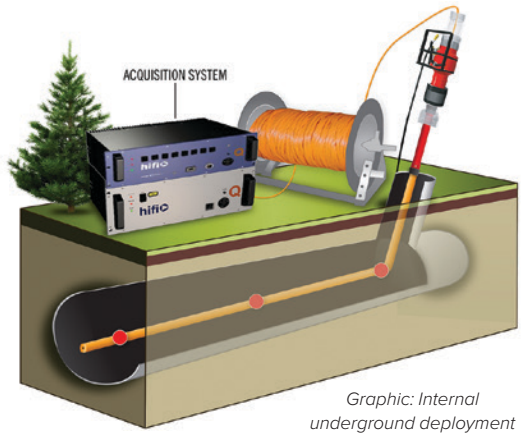
HIFI ENGINEERING'S PIPELINE MONITORING PROJECT USING HIGH FIDELITY FIBER OPTIC SENSORS:

# At a Glance

Building off its success developing periodic-monitoring technology for oil and gas wellbores, Hifi Engineering is developing a continuous monitoring system for oil and gas pipelines that will quickly identify and characterize low-level leaks in new and existing pipe. Using specially designed fiber optic cables installed beside or even within pipelines, Hifi is able to monitor up to 100 kilometres of pipeline at a time with a single system on a continuous basis and is focusing initial market rollout of its technology to environmentally sensitive or densely populated areas.

## The Opportunity

Every day, a Canada-wide network of more than 800,000 kilometres of natural gas, crude oil and natural gas liquids pipelines—from big-inch transmission systems stretching from Alberta to Ontario and beyond, to smaller feeder pipelines connecting producing wells to regional and national pipeline grids—carry more than three million barrels of oil equivalent of crude oil, liquids and natural gas. The industry's leak record is unparalleled, with 99.999 per cent of the products moved arriving safely at their destination. The small minority of leak incidents, however, can cause major public relations headaches for pipeline companies, particularly if leaks go unnoticed for a period time. More robust pipeline monitoring and leak detection technologies could make such occurrences a thing of the past, and move the industry to its long-term target—100 per cent safety.




*Graphic: Internal underground deployment of Hifi's HDS system.*

## Project Overview

For a number of years, Calgary-based Hifi Engineering has been providing high fidelity dynamic sensing (HDS) on a one-time basis to oil and gas producers, enabling them to analyze conditions in oil and gas wellbores. With advances in optical technology development, Hifi's proprietary fiber optic cable is used as an actual sensor, with the ability to continuously measure parameters such as acoustic energy, temperature, strain and vibration along the fiber with very high precision.

The capability of continuously and simultaneously gathering this parameter-based data over several kilometers of fiber is called distributed monitoring. By installing Hifi's fiber optic line directly along a pipeline, critical services such as leak detection and prevention, asset and perimeter security, and precise fluid-flow measurements are made possible.


*Photo: Hifi's technology is presented at GE's demonstration space.*

### The Technology

The HDS platform can monitor acoustic energy, temperature, strain and vibration along the full length of the line, and deliver real-time, continuous monitoring at the speed of light. In this respect, it represents a step-change improvement over traditional flow-meter monitoring, which has been in place for more than 25 years, but has significant limitations with respect to accuracy and timeliness. The challenge in distributed monitoring, however, has been making sense of the data captured by the fiber, ensuring it is, in fact, real-time data and guaranteeing its accuracy and results. To be effective and useful, the data needs to be strong and clear, and delivered with high fidelity.

Hifi's HDS system—estimated at 200 times more sensitive than conventional monitoring technologies—includes the Hifi fiber-optic-sensing cable, an optical computing platform that receives the data from the cable, and an intuitive, easy-to-use software dashboard that allows clients to understand, characterize, visualize and generate reports of all data, in real time.

### Refining the Technology

In 2014, Hifi Engineering set out to refine its HDS system for permanent monitoring applications for underground pipelines. The process began with rigorous testing where Hifi's technology was tested against other competing platforms to monitor and detect leaks in various lab and field based tests. Hifi has achieved 100 per cent success in all these tests, which were undertaken by a number of pipeline operators.

Since the summer of 2015, Hifi Engineering has been rolling out its HDS system, in various pilot projects, commercial pilots and commercial installations, a number of which are now in place. While the goal of the system is to provide 100 per cent pipeline safety, Hifi's HDS monitoring system provides other benefits as well. Payback analysis suggests the system will pay for itself in less than a year by preventing incidents from evolving into leaks; while operational monitoring of flows, density changes, volumes of flow and the health of pumps provide advantages that are less about safety and more about operational efficiency.

## KEY FACTS

Between 2002 and 2013, Canadian Energy Pipeline Association member companies transported oil and natural gas with a **99.999%** **SAFETY RECORD.**

Hifi's sensing technology has been deployed in over **1,000** **WELLS IN NORTH AMERICA.**

**OVER 800,000 KILOMETRES** of pipeline comprise the Canada-wide network of natural gas, crude oil and natural gas liquids pipelines.

Sensitivity increase using Hifi's HDS technology is **200** **TIMES GREATER** than using conventional monitoring technologies.



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INDUSTRY
**ENERGY EXPLORATION & PRODUCTION**

PRIMARY BENEFIT
**CLIMATE CHANGE**

COMPANY NAME:
## MEG ENERGY CORPORATION

PROJECT NAME:
## HI-Q® MEG FIELD UPGRADING PROCESS

MEG Energy

**Key Products/Services:** Extraction of oil sands, upgrading of oil sands

**Operating Since:** 1999

**SDTC Support:** 2008 to present

**About:** MEG Energy is a Canadian oil sands company focused on sustainable in situ oil sands development.

**Consortium Partner:**
• Western Research Institute

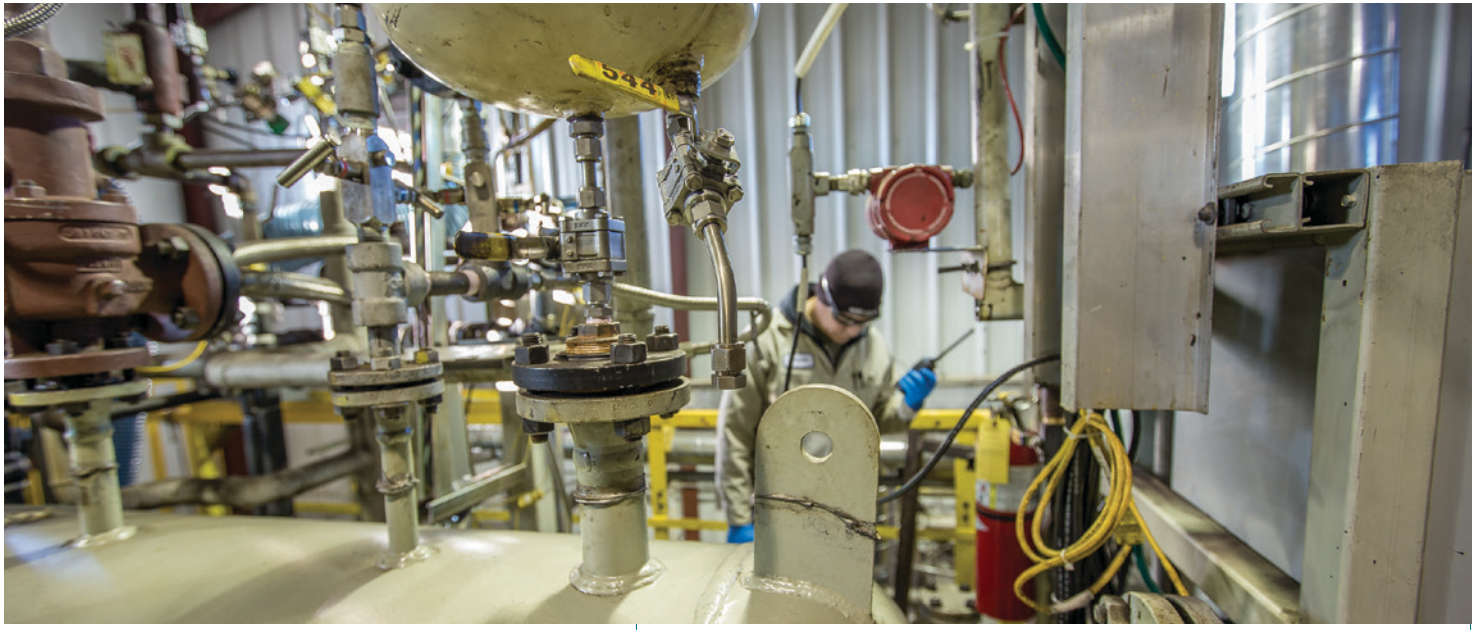
**Associated Project:** MEG HI-Q® Process Pre-Commercial Field Demonstration

**SDTC funding:** $4,270,000

**Leveraged funding:** $9,246,606

**Total project value:** $13,516,606

**For more information:** **megenergy.com**



*"SDTC has been a great partner, contributing in many ways to MEG's successful demonstration of field upgrading. In addition to funding, the SDTC team provided the expertise to test and clarify the environmental benefits, the business impetus, and the industry context for MEG's technology. This collaboration has not only increased MEG's confidence in the technology but fueled our desire to move the project to commercial demonstration."*

***Tom Corscadden***
*Vice President, Marketing, Engineering and Operations*
*MEG Energy Corporation*

MEG FIELD UPGRADING PROCESS:

# At a Glance

MEG has successfully demonstrated a field upgrading technology that negates the need for the expensive diluent that has traditionally been required for bitumen transportation. In addition to reducing the costs of bringing Alberta oil to market, MEG's solution also reduces the energy intensity of upgrading by more than 20% compared to current technology and increases the usable portion of bitumen. The major benefits of the technology include: lower greenhouse gas emissions, higher netbacks for producers as a result of a reduced bitumen price differential, elimination of diluent, and enhanced access to downstream markets. In addition, the upgrading byproduct (asphaltene) can be used as feedstock for a clean energy technology, which converts asphaltenes into synthetic natural gas (syngas), hydrogen, or fuel for steam generation (with integrated carbon capture).

## The Opportunity

Bitumen extracted from oil sands requires upgrading before it can be fed to a conventional refinery for final processing into usable end products. Upgrading is an energy, greenhouse gas, and capital-intensive process. Additionally, shipping bitumen via pipeline to a central upgrader or coking refinery requires blending with diluent to reduce viscosity and facilitate bitumen flow. Diluent is the largest component of bitumen production and transportation costs and consumes valuable pipeline shipping space.

An innovative solution to upgrading—eliminating the need for diluent—has the potential to help Alberta bitumen producers create a sustainable, lower-carbon oil industry. Changing how heavy oil is processed, and partially upgrading it close to source, helps meet climate change goals while creating high-value jobs in the province.

Regardless of oil prices—but particularly in times when prices are low—a homegrown partial upgrading technology creates considerable value for Western Canadian producers, making our oil more competitive in the global arena. An oil sands competitiveness study completed by Alberta Innovates - Energy and Environment Solutions in 2015, found that partial upgrading of 500,000 barrels per day in the province could create a $5 billion annual increase in value to Alberta, and all of Canada.

## Project Overview

The main goals for MEG's field upgrading development are to lower the costs and emissions of bitumen processing and shipping. By eliminating the need for costly diluent, producers can avoid approximately one-third of production costs. No economic, commercially viable technologies to eliminate or reduce diluent currently exist in the marketplace, spurring MEG to invest in its own development program.

At the time, Western Research Institute (WRI) was already investigating a mild thermal cracking update to vis-breaking that would lead to a reduced need for diluent. MEG partnered with WRI and added a targeted-solvent de-asphalting unit to the upgrading process. In this manner, existing technology was repurposed and improved, and new elements were integrated to meet the project needs. The change to the design reduced process intensity and resulted in a product that met pipeline-shipping specifications.

The process was named and patented as HI-Q® (Heavy Improved Quality) and at present, bears two patents in Canada, two more in the U.S., and one in Australia.

### HI-Q® in Demonstration

Based on a successful pilot, MEG is advancing project development to the next phase with the construction of a HI-Q® commercial demonstration facility in Bruderheim, Alberta. Increasing scale by 300 from a pilot plant capable of producing 5 barrels per day (bbls/d) and scaling up to 1,500 bbls/d is no small feat. The demonstration plant will use industrial-scale equipment and when completed, be capable of upgrading 3,000 bbls/d. This facility is expected to be completed in 2017 with considerable progress made to date, including the purchasing of land and equipment; permitting; detailed engineering; and the completion of initial site preparation, earthworks and foundations.

### A New Alberta Crude

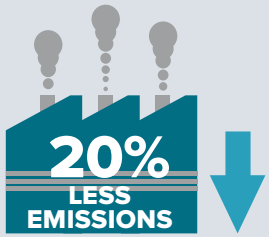
MEG is a bitumen producer. Using steam assisted gravity drainage (SAGD), MEG produces approximately 80,000 bbls/d, blends it with diluent and moves the resulting 115,000 bbls/d of dilbit to market.

MEG's HI-Q® process will result in a new crude oil, an Alberta medium sour crude that will fetch a considerably higher market price than diluted bitumen. MEG will look to license HI-Q® to its Alberta peers, with the goal of bringing 300,000 bbls/d of the new crude to market (the required quantity to create a new crude marker). By doing so, MEG will not only create a new product, but will also expand the market for Alberta bitumen, bringing considerable value to the province.

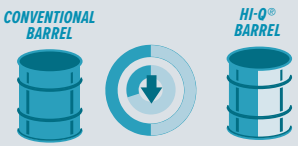
*Top Photo: MEG Energy's above-ground pipelines*

*Bottom Photo: MEG Energy's in situ development*

## KEY FACTS




**MEG's field upgrading process plans to reduce greenhouse gas emissions by 20% as compared to conventional upgrading.**




**Oil from HI-Q® is expected to produce**

**30-50%**

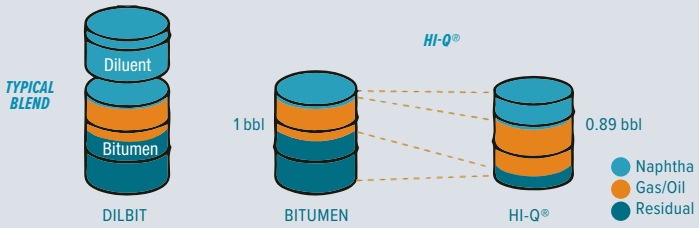
**LESS GHG**

**than common US crude imports and upgraders on a well-to-tank basis.**

**1,200**

**CONSTRUCTION JOBS**

**will be created during the four-year construction of a 100 kBPD upgrading facility.**




**Shipping HI-Q® by pipeline frees up space that would have otherwise been used for the movement of diluent and asphaltenes. Additional volumes can then be used to ship as much as**

**62% MORE PRODUCT.**



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INDUSTRY
ENERGY EXPLORATION & PRODUCTION

PRIMARY BENEFIT
CLEAN AIR

CO-BENEFITS
CLEAN WATER

CLIMATE CHANGE

COMPANY NAME:
**R.I.I. NORTH AMERICA INC.**

PROJECT NAME:
**BUZZARD PILOT PROJECT (SOLVENT THERMAL RESOURCE INNOVATIONS PROCESS – STRIP)**

RII North America

**Key Products/Services**: Enhanced Oil Recovery, Downhole Steam Generation, Low-Emissions Oil Recovery Technology

**Operating Since:** 2008

**SDTC Support:** 2012 to present

**Vision:** Redefining the Western Canadian oil industry using clean recovery technologies.

**Consortium Partner:**
• Rock Energy Inc.

**SDTC Funding:** $6,453,754

**Leveraged Funding:** $18,401,119

**Total Project Value:** $24,584,873

**For more information: www.riina.ca**

*"R.I.I. North America Inc. is pleased by SDTC's decision to fund its Buzzard pilot project. While an increase of even one per cent of the total remaining Buzzard core area oil reserves represents a significant opportunity, R.I.I. North America Inc.'s STRIP technology has the potential to prolong the operations of Saskatchewan's heavy oil basin."*

***Alfred W. Schneider***
*Chairman and CEO*
*R.I.I. North America*

R.I.I. NORTH AMERICA'S STRIP TECHNOLOGY:

## At a Glance

Primary oil recovery methods in Saskatchewan's heavy oil basin extract between five and ten per cent of the available resource, with the vast majority left in the ground and recoverable only through Enhanced Oil Recovery (EOR) methods. Traditional heat-based EOR generates steam in surface facilities and injects it underground to mobilize the oil for production, with considerable energy losses inherent in the process. R.I.I. North America's STRIP technology (Solvent Thermal Resource Innovations Process) moves the steam generator underground, reducing the operating and capital costs of a surface thermal production facility by 50 per cent and 70 per cent, respectively, and saving more than 30 per cent of the energy typically required for thermal production.

## The Opportunity

The existing methodology to produce heavy, viscous oil from reservoirs has been to heat the reservoir with steam, which is generated at the surface and then piped through injection wells. The warmed crude oil is then pumped to the surface through production wells, drilled in a pattern either surrounding the injector well or, in the case of steam assisted gravity drainage (SAGD) projects, horizontally beneath the injector well.

Surface steam generation is inherently inefficient, however, and about 50 per cent of the thermal energy of the steam is lost in transporting it to the reservoir. The energy-intensive process is also environmentally taxing, as large volumes of greenhouse gas emissions in the form of carbon dioxide are released into the atmosphere.

Several initiatives over the past 30 years have attempted to develop a more efficient way to generate steam in the reservoir, but all have encountered considerable mechanical reliability and process-control issues.

## Project Overview

In 2008, R.I.I. enlisted several global research institutions to perform preliminary analysis and computer simulations of its Solvent Thermal Resource Innovations Process (STRIP), which effectively moves steam generation from the surface into the reservoir. The analyses—including burner design and optimization, preliminary reservoir simulations and CO2 sequestration modelling—confirmed that STRIP technology was well-positioned to overcome the technical challenges that had hindered previous attempts at downhole steam generation.

The STRIP Pilot Project, enabled by funding from SDTC, comprises two staged development phases—Phase I, which was a proof of concept phase, and Phase II, a proof of production phase. The overarching goal of both phases is to demonstrate the technical and commercial viability of STRIP for enhanced oil recovery (EOR). Phase I was completed in April 2014, after the STRIP technology was implemented in an existing heavy oil property near Neilburg, Saskatchewan.

Phase II was originally planned for completion later that year in the same location, but the proof of production target of 20,000 barrels was deemed economically prohibitive due to unfavourable reservoir conditions at the Neilburg site. R.I.I. identified a new site near Buzzard, Saskatchewan for Phase II Pilot Project operations. Completion of surface facilities, initially expected by the end of February 2016, was delayed by about six weeks while a fuel gas supply line was installed from Saskatchewan's TransGas distribution network, eliminating the need to rely temporarily on expensive, trucked-in compressed natural gas. Surface facilities were nearly complete at the end of March, the supply line is expected to be completed by mid April with pilot project injection activities anticipated to start shortly thereafter.

*All Photos: Burner wellheads at R.I.I. North America's Buzzard pilot project in Saskatchewan, where STRIP technology is being tested.*

### How it Works

In the STRIP process, a gas-fired burner, attached to a casing string with multiple concentric tubing strings that carry oxygen, methane fuel, nitrogen and water, are lowered through a vertical well to the top of the target reservoir. The burners—envision upside down Bunsen burners—are fueled by methane, eliminating carbon-dioxide emissions at the surface, instead sequestering them in the reservoir, where the CO2 enhances the recovery process. Water injected through the casing string cools the burner shroud as it flows by, producing steam as it comes in contact with the burner flame within the reservoir.

### The Potential

STRIP has the potential to help reposition Canadian oil as a cleaner, more environmentally responsible alternative to oil produced elsewhere, unlock an estimated 100 billion barrels of heavy crude left behind in legacy fields, and increase recovery factors in those fields from five to ten per cent to as much as 40 per cent.

## KEY FACTS

Fuel derived from oil sands is
**9% MORE**
**GHG INTENSIVE**
than the average crude oil consumed in the United States.

In 2014,
**2.2 MILLION**
**BARRELS PER DAY**
were produced from the oil sands—including 1.6 million barrels per day from in-situ projects.

If the STRIP process replaced just 20,000 barrels per day of in-situ capacity,
**ANNUAL GHG SAVINGS WOULD EQUAL**
**400,000 TONNES $CO_2E$.**

RII's STRIP technology results in a
**50% TO 70%**
**REDUCTION IN GHG EMISSIONS**
during the recovery phase as compared with average GHG emissions of in-situ oil sands projects.



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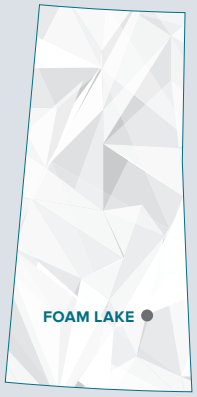



INDUSTRY
ENERGY EXPLORATION & PRODUCTION

PRIMARY BENEFIT
CLEAN AIR

CO-BENEFIT
CLIMATE CHANGE

COMPANY NAME:
**MILLIGAN BIOFUELS INC.**

PROJECT NAME:
**SYSTEM FOR THE VALORIZATION OF DISTRESSED SEEDS**

MILLIGAN BIOFUELS
Celebrating 20 Years
1996 2016

**Key Products/Services:**
Canola-based products: penetrating oil, diesel-fuel conditioner, rust inhibitor, canola meal, road-dust suppressant, asphalt-release agent

**Operating Since:** 1996

**SDTC Support:** 2009 to 2013

**Mission:** Creating value out of canola that doesn't make the grade.

**Consortium Partners:**
- Saskatchewan Transportation Company
- Saskatoon Transit (City of Saskatoon)
- O&T Farms

**SDTC Funding:** $7,004,493

**Leveraged Funding:** $21,137,121

**Total Project Value:** $28,141,614

**For more information:**
**milliganbiofuels.com**


*"Milligan Biofuels Inc. was incorporated in 1996 by a novel and innovative concept to extract canola oil from damaged or off-spec seed and then convert that oil into canola-based biodiesel. Milligan commercialized the biodiesel production process in 2001 and then began its quest to acquire the funding required to realize the potential of the project. With the help of SDTC and other investors, Milligan built the first dual-purpose facilities able to process canola seed to oil for biodiesel conversion while creating high-energy animal feed from the byproduct of the seed-crushing operation."*

***Rick Johannesson***
*General Manager*
*Milligan Biofuels Inc.*

MILLIGAN BIOFUELS' SYSTEM FOR THE VALORIZATION OF DISTRESSED SEEDS:

# At a Glance

Milligan Biofuels Inc. (Milligan) demonstrated the first hub (biodiesel production plant) and spoke (for bio-oil and meal production) system for the valorization of distressed canola seed. As part of this project, Milligan developed and optimized a mechanical seed-crushing and extraction process to access the oil and meal contained within canola seeds, without the use of toxic chemicals, such as hexane, used in the standard wash process. The produced oil was then converted to biodiesel in a production process developed and optimized by Milligan.

## The Opportunity

In early 1990s, an enterprising group of farmers in Foam Lake, Saskatchewan, gathered to discuss the production of canola in the area. The crop—made popular in the 1970s when research at the University of Manitoba led to the first consumable canola variety—grew very well in the Foam Lake area and the farmers grew a lot of it. Canola was not without its problems, however, with approximately eight per cent of crops unused due to damage. Too green, too wet, too hot or frost-damaged seed was unusable—the crop yield was wasted and disposed of in ravines or remote, unused acreages. The farmers thought there had to be a more economically and environmentally viable solution to utilize this wasted production.

At the time, considerable global R&D efforts into the production of biofuels were already underway in Europe. Crop producers on that continent were extracting bio-oil from a variety of seeds and incorporating the resulting product into commercially available fuels. Looking to replicate some of that success here in Canada, in 1996, the farmers incorporated Milligan Biofuels with the goal of creating biodiesel from wasted canola seed. In short order, they partnered with Agriculture Canada and the University of Saskatchewan to commence the R&D work required for the creation of the new biodiesel.

In 2001, the team successfully produced the biodiesel—in small quantities and lab conditions—and proved up the technologies and processes required to convert canola to biodiesel. A pilot project was now necessary to move the lab-scale process to full production.

## Project Overview

With the help of SDTC funding, Milligan Biofuels constructed the only integrated canola-to-biodiesel facility in the world. As part of their operation, Milligan procures damaged seed from farmers and crushes it; the resulting canola meal is sold as animal feedstock and the oil converted into biodiesel. In the process, Milligan has developed proprietary blending methodologies that convert seed to bio-oil with optimal economics.

Construction of Milligan's current-day facility commenced in 2010. The facility consists of a crush plant—capable of processing 200 metric tonnes (MT) of canola seed per day—and a biodiesel facility with a nameplate capacity of 20 million litres per year. Damaged canola is purchased from Western Canadian producers at competitive prices. With production underway in 2011 and continuing to ramp up operations, in 2015 the facility processed approximately 50,000 MT of canola.

*Photo: Milligan Biofuels sources the majority of its canola from Western Canadian farmers.*

### The Technology

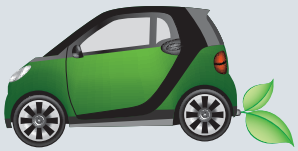
When seed arrives at Milligan's crush plant, it is sorted into bins; different seeds are put into different bins based on the per cent of damaged product. The seed is cleaned, conditioned and dried, as required. It is then blended for optimal extraction, conveyed into the crushing plant and run through a cold-press operation—the resulting meal is sold as high-energy animal feed, and the oil filtered to remove waxes and gums. Stored in tanks, the oil is then moved to the biodiesel production facility where it is mixed with an appropriate catalyst and undergoes a proprietary sequence of events (including full-transit verification) required for biodiesel conversion. The biodiesel produced at Milligan's plant meets and exceeds both American and Canadian specifications.

### The Potential

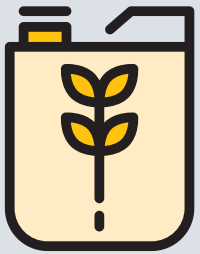
Milligan is actively selling their product into the North American market place, selling every litre of production. The canola-based biodiesel provides great lubricity and is recognized by blenders as a premium product. With increasing pressure for GHG-reducing technologies post the Paris Agreement of 2015, the Canadian Government is working with the provinces to evaluate emerging technologies that could be either released or ramped up to meet new GHG-reduction. As part of this initiative, Milligan has submitted three proposals to increase the capacity of its plant (to either 100, 200 or 250 million litres per year) utilizing alternative feedstocks together with canola.

## KEY FACTS

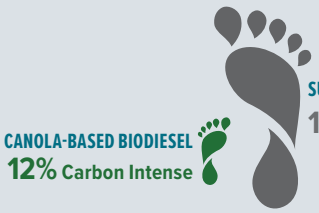
**CANOLA**
(then called rapeseed)
**WAS FIRST INTRODUCED TO CANADIAN FARMERS DURING WWII;**
its oil was used as a lubricant.



The Canadian Government mandates that all commercially available diesel consists of a minimum of
**2% BIODIESEL**
(B2 Blend); the remainder is petroleum diesel.



In 2015, Milligan produced and sold
**15 MILLION LITRES**
of its biodiesel—selling every ounce of production.




Milligan's canola-based biodiesel is
**12% CARBON INTENSE**
vs. the incumbent 100% carbon intense sulfur-based diesel.
(FOB their operation.)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INDUSTRY
**ENERGY EXPLORATION & PRODUCTION**

PRIMARY BENEFIT
**CLIMATE CHANGE**

COMPANY NAME:
## INVODANE ENGINEERING

PROJECT NAME:
## UNPIGGABLE PIPELINE INSPECTION

### INVODANE ENGINEERING

**Key Products/Services:**
Engineering services (i.e., product development, design, manufacturing, testing) for pipeline, manufacturing and mining projects

**Operating Since:** 1999

**SDTC Support:** 2010 to 2014

**Mission:** InvoDane provides deceptively simple solutions. This is our mission, creating deft engineering solutions that increase our clients' efficiency, productivity, and profitability.

**Consortium Partners:**
- Enbridge Gas Distribution Inc.
- Northeast Gas Association

**SDTC Funding:** $2,467,125

**Leveraged Funding:** $7,567,625

**Total Project Value:** $10,034,750

**For more information:**
**www.invodane.com** or **pipetelone.com**

*"The majority of inspections we have completed in our history have been done without shutting down the pipeline. Our Explorer robots are tetherless and self-propelled, uniquely designed to work in live conditions without the need for costly service interruptions or environmentally harmful gas venting."*

***Paul Laursen***
*Founder and President*
*InvoDane Engineering*

INVODANE'S UNPIGGABLE PIPELINE INSPECTION PROJECT:

## At a Glance

Current inspection methods for unnavigable natural gas pipelines require the pipeline to be shut down, its gas vented to the atmosphere. InvoDane demonstrated a technology that detects anomalies or weaknesses in the pipe while the pipeline remains in service, allowing operators to determine the pipe condition and schedule repairs, as required, thereby minimizing the interruption to gas service and avoiding the venting of trapped gas. The technology aims to reduce the number of gas-pipeline failures and the associated costs, environmental impacts and risks to human safety.

## The Opportunity

In 2002, the US Department of Transport mandated operators to engage in new and improved pipeline integrity management programs for natural gas pipelines in high consequence areas (i.e., those with high population densities). Mitigating the risk of pipeline leaks and failure was seen as a critical task that necessitated new approaches and technologies; detection of pipeline weaknesses and vulnerabilities early on would allow operators to make the necessary repairs and fixes before emergency situations occurred.

The ruling led many in industry, government and academia to take meaningful action. In 2004, research and development (R&D) undertaken by the Northeast Gas Association's (NGA's) NYSEARCH division resulted in a ground-breaking, robotic pipeline-inspection technology that was refined—and later, commercialized—by InvoDane Engineering.

### Unpiggable Pipelines

Many pipelines are capable of inspection by "pigs", an industry term for an instrument that is sent down the pipe to perform various cleaning, inspection and/or maintenance operations without stopping the flow of the pipeline. The pigs—that range from 4 to 56 inches in diameter—are propelled using the flow and pressure of the gas in the pipe to move through the pipeline. "Unpiggable" pipelines—pipes that are low-pressure, smaller-diameter, or highly jointed and cannot be inspected by conventional pigs—posed a particular challenge for pipeline operators and necessitated a new approach for integrity management.

## Project Overview

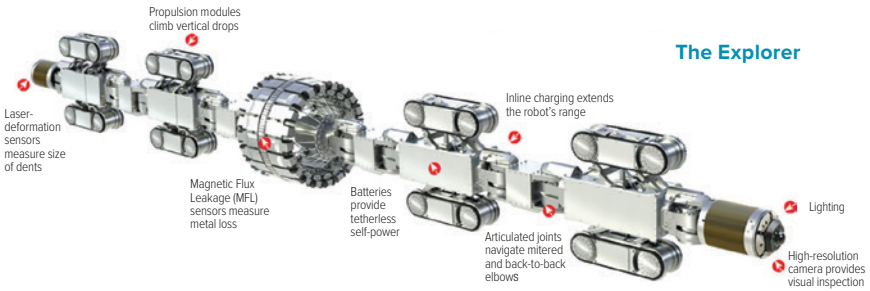
During this project, InvoDane worked with Enbridge and NYSEARCH to produce a commercially viable robotic pipeline inspection tool. The prototype technology required further testing beyond the lab; the tool itself had a number of components that needed to be assembled and refined to work properly. Software development had to be optimized, and data-collection and analysis capabilities demonstrated. The robot had to undergo stringent testing in a variety of live-pipe conditions and meet predetermined benchmarks for success.

The result of the project was the commercial launch of the Explorer, an inspection robot that provides pipeline operators with accurate and relevant information on the state of their unpiggable pipelines in live conditions. The technology allows for the acquisition of critical pipeline data so that repairs can be performed at scheduled times, rather than on an emergency basis. By not taking the pipe out of service to conduct these inspections, the Explorer avoids costly service interruptions and prevents gas venting, protecting our atmosphere from damaging greenhouse gas emissions.

### The Technology

The Explorer's robotic linked sections are self propelled, reversible and use magnetic flux leakage (MFL) sensors to detect anomalies in the pipe. The Explorer can be launched at any accessible location while the pipeline is under pressure and can change its shape to negotiate pipeline features; the articulated joints allow for bending and movement. The wireless system accesses a live feed from its camera to enable inner-pipe navigation and is powered by an onboard power source. A report is generated at the end of the inspection, advising of problem areas in the inspected pipe section(s). Appropriate maintenance action can thus be scheduled and commenced. InvoDane markets and sells the Explorer technology and services through its commercial division, Pipetel Technologies Inc.

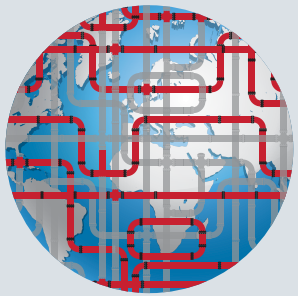
**The Explorer**



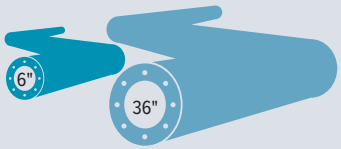

### Product Evolution

Since its launch in 2011, a number of gas pipeline operators in North America have adopted the Explorer technology; as an organization, Pipetel has doubled in size. The company is enhancing the sensing capabilities and range of the robots, improving laser and video operations, and adapting the robot for use in new sizes of pipe. Aggressive corporate growth—30 to 40 per cent—is expected through to 2018 and product deployment is planned beyond North America, to overseas markets.

## KEY FACTS



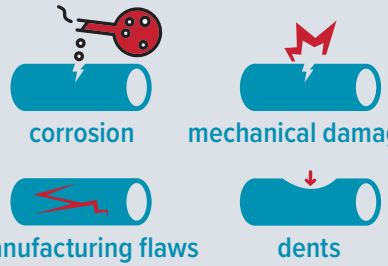
It is believed that about **40% OF OIL AND GAS PIPELINES** around the world are unpiggable and cannot be cleaned or inspected using conventional methods.




InvoDane's Explorer technology works in **UNPIGGABLE PIPES** between **6 TO 36 INCHES** in diameter.

The Explorer can explore pipes in live conditions (without shutting down the pipe) **UP TO PRESSURES OF 750 PSI**.

**THE EXPLORER** detects, locates and measures common pipeline threats including:



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INDUSTRY
**ENERGY EXPLORATION & PRODUCTION**

PRIMARY BENEFIT
**CLEAN AIR**

CO-BENEFIT
**CLIMATE CHANGE**

COMPANY NAME:
## AIREX ENERGY

PROJECT NAME:
## BIOMASS TORREFACTION DEMONSTRATION PLANT

AIREX ENERGY

**Key Products/Services:** CarbonFX™ biomass torrefaction systems, biocoal pellets, biochar, biocarbon

**Operating Since:** 2014 (Airex Energy was spun out of Airex Industries in 2014)

**SDTC Support:** 2013

**Vision:** Mitigate climate change by turning biomass into biocoal, a clean and renewable alternative to fossil coal.

**Consortium Partner:**
- Lauzon Bois Energétique Recyclé

**SDTC Funding:** $2,700,000

**Leveraged Funding:** $7,381,082

**Total Project Value:** $10,081,092

**For more information:** **airex-energy.com**


*"SDTC has been extremely supportive during the entirety of this project. We had a major setback right at the beginning of the project when we lost our strategic and financing partner. As a result, we had to find a new partner and engage in a new round of financing. SDTC funding and SDTC staff collaboration were instrumental to attracting and securing new investors for our project."*

***Sylvain Bertrand***
*CEO*
*Airex Energy*

AIREX ENERGY'S BIOMASS TORREFACTION DEMONSTRATION PLANT:

# At a Glance

Biocoal is an environmentally preferable alternative to conventional coal and heavy fuel oil. It can be made from a variety of available and renewable biomasses; burns "cleaner" and results in more energy produced than incumbent technologies, such as the wooden-pellet counterparts currently in industrial use. Airex has developed an innovative torrefaction—or roasting—process, and built a demonstration facility to produce biocoal from Canada's abundant supply of waste biomass.

## The Opportunity

By 2025, global wood-pellet demand is expected to reach 55 million tonnes per year. Biocoal pellets are a new class of processed biomass that is expected to capture a significant portion of that demand. Biocoal pellets have a number of advantages over traditional wood pellets: energy density is greater; capital investment requirements at power plants are lower; they are weather resistant; and they can be easily and cost effectively co-fired at coal burning facilities.

More robust European climate-change policies targeting 20 per cent greenhouse gas emission reductions, improved energy efficiency in power generation, and increased renewable power generation were the impetus for biomass advances. Biocoal is a response to that impetus, and there is a strong export potential for the product in Europe, where the industrial energy market is expected to increase from current levels around 12Mt/yr to between 29Mt/yr by 2025. Various jurisdictions in Canada and the United States, meanwhile, are phasing out coal-fired power generation, opening the door for biomass coal substitutes.

## Project Overview

Airex Energy Inc. is a spin-off of Airex Industries Inc., a private company founded in 1975 that specializes in industrial air filtration and air-handling equipment. In 2010, in response to customer demand for a cleaner fuel than coal or bunker fuel, Airex Industries started developing a proof of concept of the torrefaction-based CarbonFX™ biocoal pellet technology. Torrefaction is a controlled carbonization process during which biomass is heated to high temperatures with little oxygen. The resulting product is biocoal, a renewable, carbon-neutral fuel that can replace fossil coal and fuel oil in combustion and metallurgical applications.

Airex's proof of concept initiatives led to the development of a 250 kg/h pilot plant in 2012. In 2014, Airex Energy was created following a successful financing with two venture capital firms. With the support of SDTC, Airex Energy began to design and build a commercial-scale torrefaction demonstration facility in Becancour, QC, with a production capacity of 2,000 kg/h. The plant was completed in 2015, and commissioning operations—testing equipment, testing control loops and producing small amounts of biocoal—are expected to take about 12 months, targeting 90 per cent uptime by December 2016.

*Photo: Airex Energy's patented CarbonFX unit.*

*Photo: Airex Energy's torrefaction plant in Becancour, QC.*

### The Technology

The CarbonFX™ system is a small cyclonic bed reactor that was developed from the cyclones that were central to Airex Industries' dust-collection technologies. By adapting the cyclones with patented technology that injects hot gases into the reactor, residence times of particles in the reactor—in this case biomass feedstock—can be controlled by varying time and temperature. The torrefaction process, which effectively 'roasts' the biomass particles, can be completed in about three seconds, versus 30 minutes for incumbent technologies. The process produces a black powder, which is then sent through a pellet mill in order to increase its density; the resultant biocoal pellets are 6 millimetres in diameter and 20 millimetres in length.

A single 2,000 kg/h CarbonFX™ unit operating at 100 per cent uptime would produce 15,000 tonnes/year of biocoal. Users can run multiple units in parallel for easy scale-up to virtually any desired size, but plants are optimally rated at 5,000 kg/h, which is the typical intake capacity of pellet mills.

### The Market

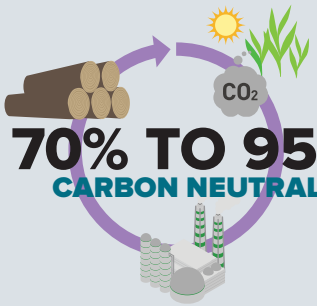
Target customers for biocoal are generally cement manufacturers and power utilities, but the target market for the CarbonFX™ technology is much broader in scope: virtually any wood product company that is interested in monetizing its waste to produce value-added products could be a potential customer, and so could any other company that produces large volumes of organic waste. In this respect, CarbonFX™ can be deployed around the world.

## KEY FACTS

More than
**40 MILLION**
**TONNES**
of biomass could be sustainably harvested from Canada's forests.

**GLOBAL ELECTRICITY PRODUCTION FROM COAL-FIRED POWER PLANTS**

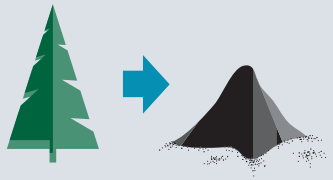

Coal-fired power plants currently fuel 41% of global electricity production; Canada alone consumes
**35 MILLION**
**TONNES PER YEAR**
for power generation.




**70% TO 95%**
**CARBON NEUTRAL**

Lifecycle analyses show biocoal is about 70%-95% carbon neutral from baseline when used as a fuel for power generation.

The innovative reactor design of the CarbonFX™ technology can turn biomass into biocoal in just
**THREE**
**SECONDS.**





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INDUSTRY
ENERGY UTILIZATION

PRIMARY BENEFITS
CLIMATE CHANGE

CO-BENEFITS
CLEAN WATER

CLEAN AIR

CLEAN SOIL

COMPANY NAME:
**COOLEDGE LIGHTING LTD.**

PROJECT NAME:
**MICROLED LIGHTING SYSTEM DEMONSTRATION**

COOLEDGE

**Key Products/Services:** Simple, scalable and uniform lighting solution for ceilings, walls, displays, and architectural elements

**Operating Since:** 2009

**SDTC Support:** 2011 to 2016

**Mission:** To initiate a paradigm shift that will transform lighting as we know it—from legacy bulbs and fixtures—to one that functions as a building material.

**Consortium Partners:**
- British Columbia Hydro and Power Authority
- The Governors of the University of British Columbia

**SDTC Funding:** $4,469,000

**Leveraged Funding:** $8,246,131

**Total Project Value:** $12,715,131

**For more information:**
**Cooledgelighting.com**

*"SDTC funding was a key enabler in the initial development and demonstration of the Cooledge technology. Cooledge is now the leader in light-sheet technology for large luminous surfaces and the SDTC project played an important role in assisting the early development of our current products."*

***William J. Sims***
*CEO*
*Cooledge Lighting*

COOLEDGE LIGHTING'S MICROLED LIGHTING SOLUTION:

## At a Glance

Cooledge has created a microLED-based lighting solution for large-area lighting in retail, office, entertainment, and hospitality environments. Cooledge's cost-competitive microLED light-sheet technology is more energy efficient, mercury free and can provide better quality lighting than the incumbent fluorescent lighting solutions. Cooledge's flexible LED-lighting solutions are sustainable, energy efficient, and match the cost and performance of the fluorescent-based equivalents. They can be integrated into design and architectural elements, providing lighting designers and architects the ability to put light where it is desired, instead of where it fits, thereby creating a new paradigm for the way light is incorporated into buildings and structures.

## The Opportunity

In 2010, LED (light-emitting diode) lighting was the new kid on the block, poised to change the illumination industry as we knew it. LED lighting was more efficient than the incumbent conventional light bulbs (30 to 40 per cent efficient vs. 10 to 15 per cent efficient) with considerable environmental benefits. At the time, one of the biggest drawbacks of LED lighting, however, was its cost. Engineers and scientists were working to develop lighting solutions that incorporated higher-powered, higher-luminosity LEDs, with the goal of using fewer of them for lighting installations. Despite their higher efficiency, increasing the power of the LEDs also required the use of larger and more expensive heat sinks—typically aluminum add-on elements that help dissipate the heat generated by the LEDs—that added cost, heft and bulk to the systems.

Cooledge's work with LED lighting took them down a different path of product refinement. Correctly forecasting the market and predicting a drop in the prices of individual LED units, Cooledge principals bucked the market trends and worked to develop a different approach to LED lighting that would lead them to revolutionize the lighting industry.

## Project Overview

Instead of producing bigger, higher-powered, higher-luminosity LEDs, Cooledge decided to use smaller, lower-powered LEDs that produced both less light and heat per unit. Due their size, heat dissipation was easier to manage, hence eliminating the need for bulky heat sinks. Further, the small, compact LEDs could be evenly spread out over a large area, facilitating the uniform light distribution required for ambient lighting solutions and eliminating the glare associated with high-powered LED lighting systems. The microLEDS could be embedded onto very thin plastic substrates—leading to the design of light sheets that could be easily cut to fit virtually any space—and produced using low-cost manufacturing techniques.

With the help of SDTC, Cooledge worked to develop and demonstrate its light-sheet technology. The project itself met a number of milestones related to colour consistency, efficacy, manufacturability and length of life. Additionally, the technology demonstrated three-fold environmental benefits over fluorescent and incandescent light bulbs:

1) it used less energy, reducing the GHG emissions associated with power-plant generation;
2) due to the small size of the LEDs, it reduced the need for balance-of-system components such as heat sinks;
3) and it eliminated the end-of-life disposal requirements for mercury, a requirement for fluorescent lighting.

*Photo: Cooledge's thin sheets of light (only 1mm thick) can be cut to size and conformed to different shapes, uniformly illuminating spaces and displays.*

### A Designer's Dream

At project onset, Cooledge's technology was aimed at the OEM (Original Equipment Manufacturer) market; the microLEDs would be incorporated into traditional lighting fixtures. However, shortly after product introduction into the market place, there was a pronounced interest from architects and lighting designers who saw the potential to integrate the compact, scalable and adaptable light sheets into building architecture. The unique, constant-voltage architecture allowed for the sheets to be cut to size without changing the light intensity; it made them ideal for uniformly illuminating irregularly sized ceilings, walls, decorative panels and backlit signage. The systems were thin, saving considerable space, and came at a lower cost than the incumbent fluorescent solutions. Together with easy installation and no requirement for additional safety certifications, the LED-light sheets were a highly attractive design proposition that revolutionized the way that light could be incorporated into buildings and structures.

### Cooledge Today

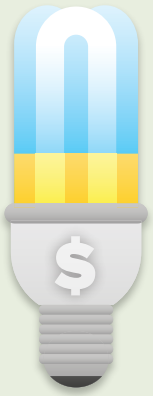
Cooledge is changing the way light is materialized and integrated in architectural design, offering creatives the ability to transform their design environments. The company's portfolio includes four product ranges for ceiling, wall, display and perimeter installations. Today, Cooledge is widely used by high-profile customers like Calvin Klein, Coach and Top Shop; its lighting technology is illuminating lobbies, casinos, museums, retail areas and signage around the world with installations in North America, Europe, Japan and the Middle East. A recipient of a number of prestigious lighting awards, Cooledge is being widely recognized for its innovative approach to advancing lighting technology.

## KEY FACTS

Globally, lighting accounts for about **20% OF BUILDING ELECTRICITY CONSUMPTION** and about **7% OF TOTAL WORLDWIDE $CO_2$ EMISSIONS.**

*Sources: IEA and Lighting Lab*

The United Stated Department of Energy estimates that US energy costs associated with lighting **CAN BE REDUCED TO 25%** of their current value by 2035 through the introduction of LED-based lighting.



Cooledge's LED-based light-sheet system is energy **EFFICIENT, SIMPLE, SCALABLE AND CONFIGURABLE**. It can be integrated into the architecture and materials of buildings.

Cooledge holds more than **75** issued patents covering its **LED LIGHTING TECHNOLOGY.**



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INDUSTRY
ENERGY UTILIZATION

PRIMARY BENEFIT
CLEAN AIR

CO-BENEFITS
CLEAN WATER

CLIMATE CHANGE

COMPANY NAME:
**NSOLV CORPORATION**

PROJECT NAME:
**BEST (BITUMEN EXTRACTION SOLVENT TECHNOLOGY) FIELD PILOT PLANT**

**Key Products/Services:** Patented technology that uses warm solvent vapour to extract bitumen in situ

**Operating Since:** 2003

**SDTC Support:** 2010 to 2014

**Mission:** We are devoted to solving the operational and environmental problems of heavy oil extraction.

**Consortium Partners:**
- Suncor Energy Inc.
- Hatch Ltd.

**Associated Projects:**
- Enhanced solvent extraction process for in situ oil sands
- Demonstration of a low GHG, zero water process for extracting in situ oil sands

**SDTC Funding:** $10,000,000

**Leveraged Funding:** $44,085,607

**Total Project Value:** $54,085,607

**For more information:** nsolv.ca

*"By helping to bring ground-breaking clean technologies to market, SDTC is a visionary player in Canada's fight against climate change. At Nsolv, we are extremely appreciative of SDTC's support, which has enabled us to take a huge step forward for the energy industry by bringing environmental and economic sustainability to oil sands development."*

*Joseph Kuhach*
*CEO*
*Nsolv*

NSOLV'S BEST FIELD PILOT PLANT PROJECT:

## At a Glance

Canada has 170 billion barrels of recoverable crude oil stored in the oil sands, of which 80 per cent are too deep to be mined and are currently recoverable using in situ processes such as steam assisted gravity drainage (SAGD), which is both water and energy intensive. Nsolv has developed a low temperature in-situ production technology for bitumen reserves using a pure, condensing solvent. As compared to SAGD, the Nsolv technology produces only one quarter of the greenhouse gas emissions, eliminates process-water consumption, reduces operating and capital costs and is applicable in a wider variety of reservoir conditions.

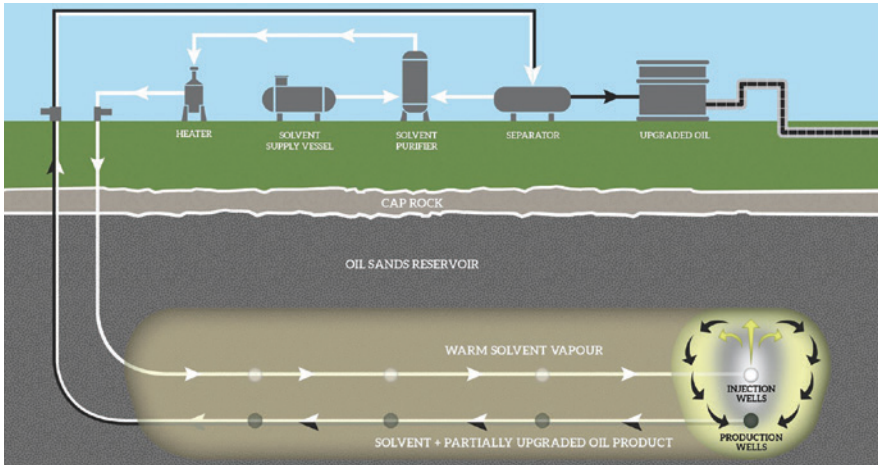
## The Opportunity

Western Canada's remaining bitumen reserves in the oil sands have been estimated at more than 170 billion barrels, the vast majority of which is in reservoirs that are too deep to be extracted using surface mining methods. In the last decade, steam assisted gravity drainage (SAGD) has been deployed as the technology of choice to produce these recoverable reserves, but at great cost, not only economically but environmentally. On both fronts, the major costs in SAGD recovery are related to water, specifically the volumes needed to raise the steam required to soften the bitumen and allow it to flow to production wells. At the same time, burning natural gas to heat the water to generate that steam poses a major economic cost but also a significant environmental cost in the form of greenhouse gas emissions.

### The Technology

With the help of earlier funding from SDTC, Nsolv founder, John Nenniger, built on the work of his father, Emil, to perfect the in-situ production technology. In the Nsolv process, a warm, purified solvent—usually butane or propane—is injected into a reservoir using horizontal well pairs. The upper well carries the solvent in its gaseous state; once in the reservoir, the gas condenses into a liquid, which thins the bitumen so that it can flow, via gravity, to the lower production well. Asphaltenes and heavier carbons remain in the reservoir. The produced oil/solvent mixture is separated at the surface into three main components: partially upgraded oil, solvent that is recycled back into the process, and gas that is used to fuel the solvent heater. The process uses no water, and because the solvent is warmed only to 40 to 60 degrees Celcius, the amount of natural gas burned is reduced, and greenhouse gas emissions are cut by as much as 75 per cent from levels associated with SAGD developments.

**Nsolv's in-situ production technology (using proprietary condensing solvent)**




## Project Overview

After proving the technology in the lab, Nsolv teamed up with Suncor Energy in 2012 to put the technology to the test in the field via a pilot project at Suncor's Dover lease near Fort McKay, Alberta. To prove the performance of the pure solvent under actual reservoir conditions, Nsolv drilled and completed a 300-metre producer and injector well pair and completed final engineering and construction of a supporting 300-barrels-per-day surface facility.

Production from the Bitumen Extraction Solvent Technology (BEST) field pilot plant started in the spring of 2014 with good success. Several industry firsts were established using Nsolv's technology, including: lowest reservoir operating pressure, 95 per cent recovery of solvent, and the highest quality (14-degree API) of produced, partially upgraded oil. The quality of the oil is so high, it needs no additional diluent for transportation to market, providing yet more savings.

### The Potential

The Nsolv process offers higher rates of return than SAGD, and remains economically viable even in low oil-price environments. It also makes thin-pay, shallow-depth and low-pressure zones economically viable targets.

To date, over 100,000 barrels of partially upgraded crude oil has been produced from the pilot, and Nsolv is working on finding partners for the next stage of the technology's development—commercialization of the solvent technology through the construction of a commercial demonstration facility. This facility will be a 15 times scale-up of the pilot project and is expected to produce 2,500 barrels per day of cleaner and more valuable Canadian oil.

## KEY FACTS

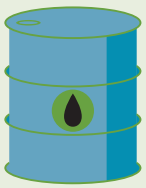
**AS COMPARED TO SAGD, NSOLV'S IN-SITU PRODUCTION TECHNOLOGY USING ITS PROPRIETARY CONDENSING SOLVENT:**

1. 

Significantly
**LOWERS**
**CAPITAL AND OPERATING COSTS**

2. 

Uses
**ZERO**
**WATER**

3. 

Produces oil of a
**HIGHER QUALITY**
**(13-14-DEGREE API) VS. SAGD (8-DEGREE API)**

4. 

Emits
**75%↓**
**LESS GHG EMISSIONS**



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INDUSTRY
ENERGY UTILIZATION

PRIMARY BENEFIT
CLEAN WATER

CO-BENEFITS
CLEAN AIR

CLEAN SOIL

COMPANY NAME:
**PURE TECHNOLOGIES LTD.**

PROJECT NAME:
**ROBOT DEVICE FOR PIPE INSPECTION**

pure™ TECHNOLOGIES

**Key Products/Services:** Solutions for critical infrastructure management

**Operating Since**: 1993

**SDTC Support:** 2007 to 2012

**Mission:** At Pure, we work to protect the critical infrastructure necessary for everyday life.

**Consortium Partners:**
- City of Hamilton
- Halifax Regional Water Commission
- City of Calgary Water Services
- Hanson Pressure Pipe

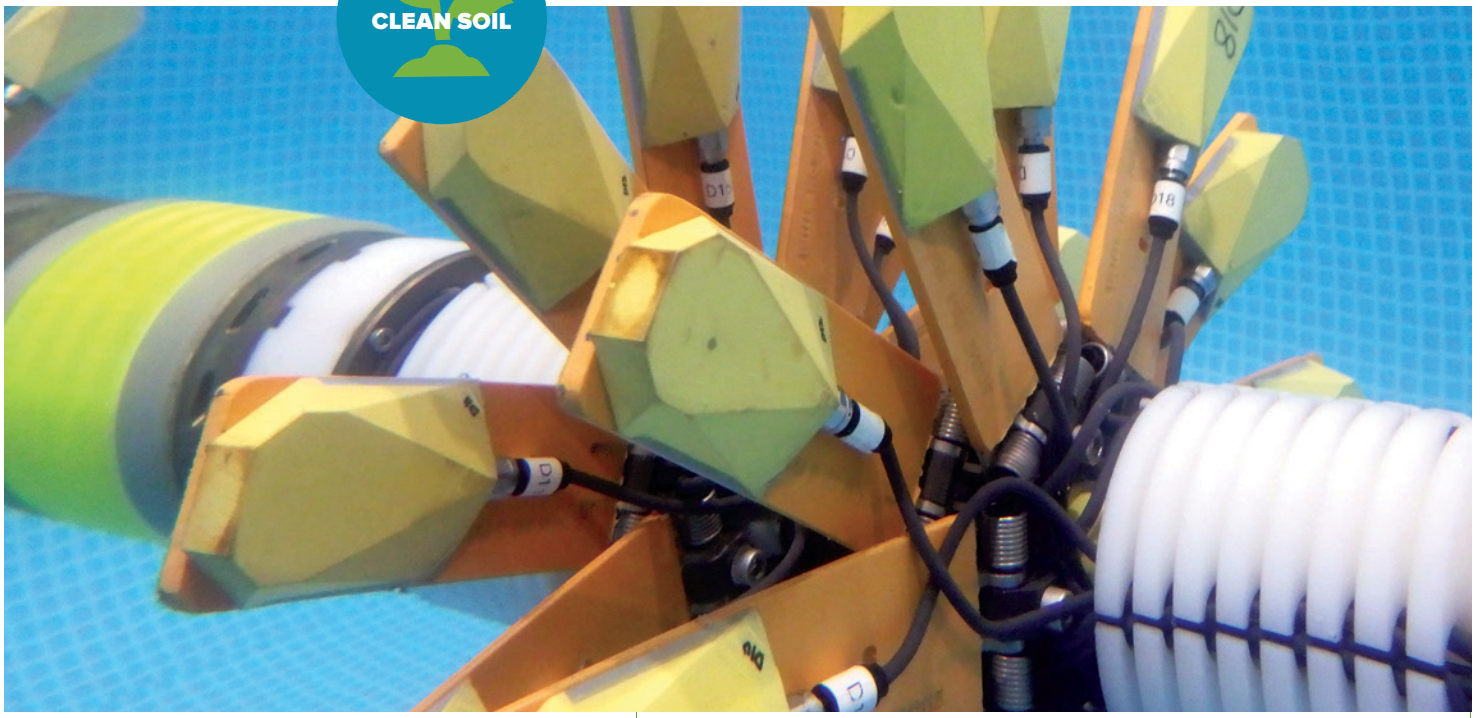
**Associated Projects:**
- Advancements to Sahara leak detection technology
- Extra high resolution MFL for water pipelines
- Innovative and cost-effective in-line leak detection tool for gas pipelines

**SDTC Funding:** $2,200,000

**Leveraged Funding:** $4,640,562

**Total Project Value:** $6,840,562

**For more information:**
**www.puretechltd.com**



*"SDTC was instrumental in our ability to develop the free-swimming PipeDiver® platform. Their continued support throughout each phase of the project allowed us to reach our milestones and improve upon the original scope to provide more features to our clients."*

***Xiangjie Kong***
*Vice President, Research and Development*
*Pure Technologies*

PURE TECHNOLOGIES' ROBOT DEVICE FOR PIPE INSPECTION:

# At a Glance

Pure Technologies has developed and demonstrated a suite of PipeDiver® inspection tools that assess the condition of pre-stressed concrete cylinder pipe (PCCP) and metallic pipes used for water and wastewater transportation. The devices enable the identification of damaged pipe, enabling utilities to minimize operational risks, optimize their capital spending, and extend the safe and economic life of their pipelines.

## The Opportunity

Across North America, in large cities and small rural towns, buried pipeline infrastructure—namely, water-supply pipes and sewer mains—is amongst the most valuable assets a municipality can own. Replacing this infrastructure can cost as much as $2 billion for a large municipality serving 1.2 million people, and the average cost of one large-diameter pipe failure can reach as high as $1.5 million—even more if there is litigation arising from damages caused by the failure. Assessing the integrity of these systems, and targeting necessary repairs where they are most needed before failures occur, can cost a fraction of the cost of replacement, a key consideration for municipal politicians and taxpayers. Most incumbent assessment technologies, however, require the pipeline to be dewatered and taken out of service prior to inspection, a costly exercise both in terms of dollars spent and service provided.

*Photo: Pure's SmartBall® inspection tool (an associated product to PipeDiver) is placed in an oil pipeline to help detect pipe failures.*

*Photo: The PipeDiver tool is hoisted into the air in preparation for insertion into a pipeline.*

## Project Overview

In 2005, Pure Technologies (Pure), a provider of various structural monitoring and leak-detection technologies, set about to develop a pipeline assessment tool that could monitor and report on the condition of pre-stressed concrete cylinder pipes (PCCP) utilized in municipal water and sewer systems. The tool's competitive advantage would be accurate assessment decoupled from the need to first dewater the systems—a costly and timely endeavour.

Pure's initial efforts focused on a tool that could travel through an in-service PCCP network and identify areas where wire wraps, which give strength to the concrete pipe, are corroded and broken. Too many broken wraps would eventually cause the concrete pipe to degrade to the point where it would burst.

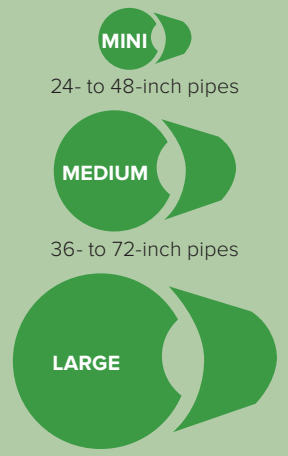
Prototypes based on existing electromagnetic-sensor technologies were first tested in Pure Technologies in-house flow loop—essentially a large pipe in its warehouse that can be pressurized to mimic a true pipeline system. In the test loop, experiments were conducted to check the buoyancy of the tool, its ability to flow with the water, and the ability of the electromagnetic sensors to identify defects in the test pipe.

### Field Testing

Since no lab test—or even a controlled, simulated loop test—can accurately replicate real-world conditions, the next stage of testing the PipeDiver tool was to subject the platform to field testing. For this phase, Pure drew on the strong relationships it had with existing utility customers, especially those who had previously identified a need for pipeline-integrity testing. Over the course of the prototype testing, refinements were made to the electromagnetic sensors and to the overall design of the PipeDiver tool. Additionally, data collected during field tests allowed the participating utility to avoid replacing certain portions of the pipeline, resulting in a significant saving.

The first iterations of PipeDiver for PCCP are now commercially available and are widely accepted as the best way to manage PCCP systems.Pure is continuing to assess PCCP water systems around the world, with recent projects in Ontario, the United States and South Africa, and is beginning to deploy the tool for assessment of metallic pipeline networks.

### PipeDiver® sizes

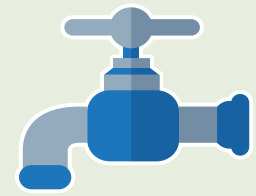



### PipeDiver® clients

- Halifax Water
- Miami-Dade Water and Sewer Department
- Washington Suburban Sanitary Commission
- City of Calgary

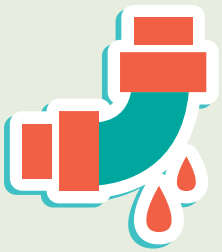
* select clients only

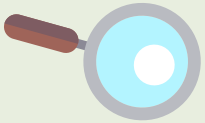
## KEY FACTS



**20%**
**OF TREATED WATER**
never reaches the tap due to leaks and pipeline failures.

**30%**
**OF CANADA'S $441-BILLION WATER AND SEWER INFRASTRUCTURE**
is considered to be in fair, poor or very poor condition.





**1,200 KILOMETRES OF PIPE**
have been inspected by PipeDiver® in locations around the world.

Utilities can often inspect, manage and renew their water and sewer networks for between
**5% AND 15%**
**OF REPLACEMENT COSTS.**



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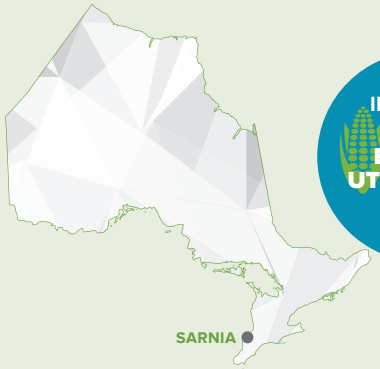



INDUSTRY
ENERGY UTILIZATION

PRIMARY BENEFIT
CLIMATE CHANGE

COMPANY NAME:
**BIOAMBER SARNIA INC.**

PROJECT NAME:
**SUCCINIC ACID DOWNSTREAM PURIFICATION DEMONSTRATION PROJECT**

**Project was expanded in 2014 to include the demonstration of an optimized yeast organism.**

bioamber™

**Key Products/Services:** Bio-based succinic acid

**Operating Since:** 2008*

**SDTC Support:** 2011 to 2016

**Mission:** To be a fast growing producer of chemical intermediates that use sugar instead of fossil fuels; to sell competitively priced, sustainable chemicals with strong profit margins and the cleanest environmental footprint in the industry.

**Consortium Partner:**
• Mitsui & Co.

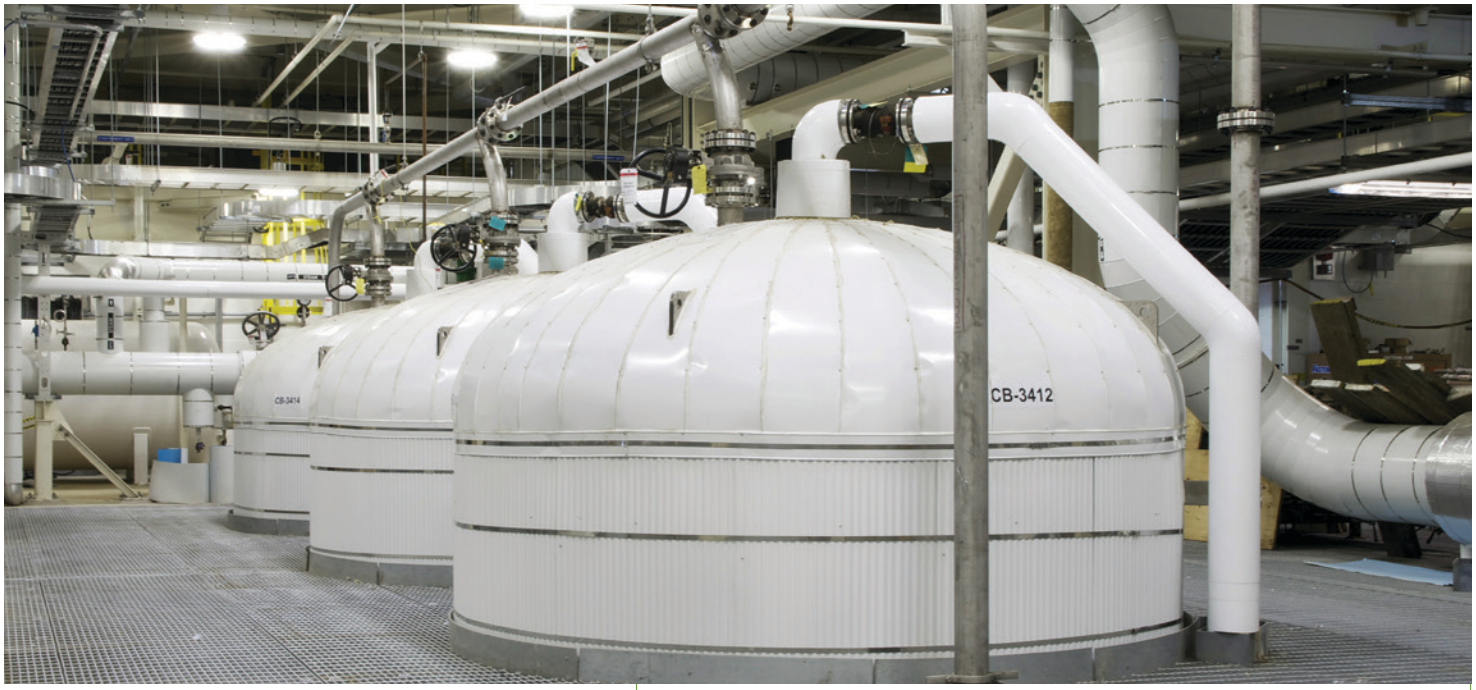
**SDTC Funding:** $14,513,650

**Leveraged Funding:** $29,183,754

**Total Project Value:** $43,697,404

**For more information:** **bio-amber.com**

**Incorporation date of BioAmber Inc., parent company of BioAmber Sarnia Inc.*




*"The due diligence that SDTC performed and their willingness to share this expertise was an important factor in gaining the support of other organizations, both public and private. SDTC's support and participation gave a lot of credibility to the process, especially for those who didn't have as much knowledge of the market."*

***Mike Hartmann***
*Executive Vice President*
*BioAmber*

BIOAMBER'S SUCCINIC ACID DOWNSTREAM PURIFICATION DEMONSTRATION PROJECT:

## At a Glance

BioAmber has developed a novel bio-based technology, which ferments glucose into succinic acid, making it significantly less expensive than traditional petroleum-based succinic acid and more environmentally sustainable. BioAmber produces succinic acid—by fermenting sugars at an industrial scale using a patented yeast—which is then filtered and purified. The demonstration project sought to improve BioAmber's downstream purification process while incorporating the use of an optimized yeast organism in the upstream process.

## The Opportunity

In 2004, the US Department of Energy recognized bio-succinic acid as a renewable building block chemical with great technical feasibility and commercial potential. Manufactured using small amounts of sugar, bio-succinic acid is a platform chemical that can be used in a broad range of markets, from high-value niche applications such as food additives and personal care; to large volume applications such as polyurethanes, resins, artificial leather, and coatings.

As a "drop-in" replacement for traditional petroleum-based succinic acid, bio-succinic acid has demonstrated performance, health, and safety benefits. It reduces our global dependency on oil, helping to address the critical challenge of climate change, and better aligns with shifting consumer preferences for lower-carbon alternatives. Independent market research—by Global Industries, IHS, and Allied Research, respectively—projects that the global market for succinic acid could see a compound annual growth rate of 30 per cent between 2012 and 2020.

### Succinic Acid: How It's Made


*Any type of sugar can be used as feedstock*

*BioAmber's proprietary yeast is key to the process*

*$CO_2$ provides roughly 25% of the carbon in succinic acid*

*BioAmber's succinic acid is 100% bio-based*

## Project Overview

BioAmber's original project with SDTC sought to demonstrate succinic acid downstream purification (using e-coli as an upstream input in the process). Based on the results of the lab- and pilot-scale trials, however, the project scope was expanded in 2014 to include the demonstration of an optimized yeast organism in the upstream process (in place of the originally demonstrated e-coli). Even though both e-coli and yeast were able to successfully produce succinic acid, the yeast technology was favoured as a lower-cost, lower-risk and less-energy-intensive alternative.

### The Technology

The fermentation process is key to the production of bio-succinic acid. The fermenters used by BioAmber in its upstream process are some of the largest in the world, and the second largest for the production of chemicals. Much like making beer, yeast, $CO_2$ and sugar combine in the fermenter and undergo a chemical reaction. Instead of producing alcohol, however, when using BioAmber's proprietary yeast, they create succinic acid.

On the downstream side, BioAmber uses existing, proven technology for purification of the upstream product. Tried, tested and well-understood technology is utilized, in order to not further complicate the process and remain cost competitive vis a vis the incumbent petroleum-based technology. During the downstream process, water—and other inputs—added during fermentation are removed, resulting in highly pure, crystalline succinic acid. The bio-process uses 60 per cent less energy than the petroleum-derived process, which translates into a savings of over two trillion BTUs annually.

*Photo: BioAmber's Sarnia plant opened in August of 2015.*

### BioAmber Sarnia

In August of 2015, BioAmber Sarnia was opened for production. It is the first commercial plant in the world to produce bio-based succinic acid. Using glucose from southern Ontario agricultural suppliers, BioAmber Sarnia is producing over 30,000 MT of succinic acid a year. The BioAmber process promises a 100 per cent reduction of Greenhouse Gas (GHG) emissions compared to the equivalent production process that uses petroleum.

With production underway and orders coming in, BioAmber is expecting to ramp up sales in 2016 once customers have completed qualification testing. Over 50 per cent of the capacity of BioAmber Sarnia is sold under "take-or-pay" contracts where buyers agree to buy BioAmber's product regardless of market variables.

BioAmber's global customer base includes chemical distributors and manufacturers in Asia, Europe and North America. Bio-based succinic acid is used in a variety of everyday products. With a global multi-billion dollar market projected for bio-based succinic acid, for BioAmber this is just the beginning. The company is already preparing for growth, planning to build additional plants (for new products) and developing new markets.

## KEY FACTS

BioAmber's Sarnia plant is the largest succinic acid plant in the world producing **30,000 METRIC TONS** (MT) of product.


The Sarnia plant represents a **$140 MILLION USD** investment and the creation of 60 highly skilled jobs.

The Sarnia plant reduces GHG emissions by **210,000 TONS** per year or the equivalent of:

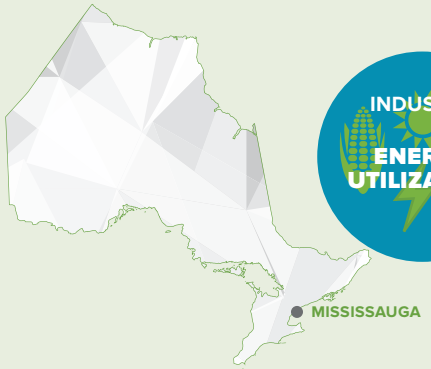

Taking **45,000** medium-sized cars off the road annually.

**5.6 MILLION** tree seedlings growing for 10 years.

Keeping **508,000** barrels of oil in the ground each year.



Funded by the Government of Canada | Canada




INDUSTRY
ENERGY UTILIZATION

PRIMARY BENEFITS
CLEAN WATER

CO-BENEFIT
CLIMATE CHANGE

CLEAN SOIL

COMPANY NAME:
**ECHOLOGICS – A MUELLER TECHNOLOGIES COMPANY**

PROJECT NAME:
**SMART AUTOMATED LEAK-DETECTION SYSTEM**

echologics
A Mueller TECHNOLOGIES COMPANY

**Key Products/Services:** Acoustic technologies for leak detection on buried water pipelines.

**Operating Since:** 2003

**SDTC Support:** 2011 to 2014

**Mission:** Helping water resources go further–and water systems work smarter.

**Consortium Partners:**
- Pennsylvania American Water
- Mueller Systems
- American Water
- City of Ottawa

**SDTC Funding:** $1,051,926

**Leveraged Funding:** $2,165,464

**Total Project Value:** $3,217,390

**For more information:** echologics.com

*"Efficiently managing existing water assets, systems and infrastructure is critical to protecting global water supply for current and future generations. Echologics' EchoShore-DX technology works with existing municipal infrastructure to protect our water mains, identifying areas of water loss. We are thankful to forward-thinking organizations such as SDTC for their funding and support in helping to bring this ground-breaking technology to market."*

***Shabbir Yusuf***
*Vice President, Research and Development*
*Echologics, A Mueller Technologies Company*

ECHOLOGICS'S SMART AUTOMATED LEAK-DETECTION SYSTEM:

## At a Glance

Echologics developed and demonstrated an integrated, non-intrusive acoustic leak-detection system called EchoShore-DX™. Using built-in antennas to send acoustic sensor data to central or local sites, the system is capable of detecting leaks in a variety of commonly used, potable water pipes. With numerous advantages over incumbent technologies, EchoShore-DX can detect leaks in pipes located in traditionally difficult locations such as those with aging water-pipeline infrastructure prone to leaks and breaks, and noisy urban areas.

## The Opportunity

According to Environment Canada, up to 30 per cent of the total water entering the country's supply-line systems is lost through leaking pipes. This water represents not only a loss of revenue for the utility but also a loss of available, treated potable water. Growing cities and expanding industries depend on water utilities and system operators to fulfill today's increasing water demands, yet efficiently manage water resources to meet the needs of future generations. Unpredictable climate changes combined with aging water distribution infrastructure are the biggest threats to sustainable water management. With North America's water mains predicted to take 50 to 60 years to replace, billions of gallons—and billions of dollars—continue to be lost to water pipe leaks and breaks every year. Utilities are searching for cost-effective, user-friendly technologies to better manage their water systems.

### The Move to Automated Leak-Detection

Historically, leak-detection systems were hand-held products that combined correlators and listeners to measure the sound within the pipes, and based on those measurements, predict the location of the leak. This approach required the deployment of field crews—a skilled labour source—for regular monitoring. Scarcity of labour and the intermittent monitoring capabilities (vs. real-time) associated with hand-held, people-led monitoring necessitated a better approach.

By automating leak detection, appropriate monitoring infrastructure could identify leaking pipes before they lost significant amounts of usable water, or caused bigger issues due to breakage. Through early detection of leaks, utilities could better manage their water main assets to help avoid undesired consequences while creating significant operational efficiencies and optimizing capital investments.

## Project Overview

Early on, Echologics identified the opportunity for improved leak-detection monitoring in water mains. Specifically targeting transmission mains—pipes of 16 inches and above—the company set out to develop and demonstrate an automated, non-invasive, integrated leak-detection system. With the support of the National Research Council, Echologics developed the smart node, its patented sensor technology, and signal processing capabilities. At around the same time (2011), Mueller Technologies—a company with an established communications network—acquired Echologics. A commercial pilot was now necessary to prove up the technology in real-life conditions.

Working with the City of Ottawa and American Water, the SDTC-funded demonstration would examine three critical areas of the Echologics leak-detection system. Tested in three phases—acoustic and leak detection capability; communications ability; and 3) power (battery life)—the pilot was conducted over a three-year period. Through active field testing and benchmarking, the project aimed to find leaks that would otherwise be undetected using the incumbent approach. The test period took place over several season changeovers—times of highest leak occurrences.

*Photo: An Echologics field technician inspects an Echoshore-DX installation situated on a city fire hydrant.*

The results led Echologics to refine its technology—creating a new, stronger sensor that could be mass-produced with ease—and develop a next-generation network with extended-range capabilities and a higher level of tolerance for communication interference.

### The Technology

Echologics' Echoshore-DX utilizes existing city assets—fire hydrants—to detect existing or emerging leaks. Using acoustical sensor nodes fitted onto a standard fire-hydrant pumper nozzle cap, the system communicates with other sensors in the area, as well as a central collection hub. Each node establishes an accurate acoustical baseline for its respective monitoring zone, ensuring highly accurate detection.

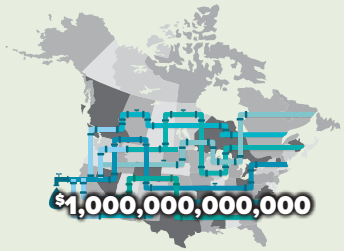
Data is collected via radio frequency or cellular networks, allowing for near real-time data analysis. The user interface is highly intuitive and enables simplified verification of points of interest by field personnel. The data provided by the system enables a utility to not only identify a leak, but also to monitor its progression and prioritize its repair, optimizing the deployment of crews.

The Echoshore-DX system is one of the first Internet of Things (IoT) enabled technologies for water systems, providing highly accurate visibility to distribution networks with thousands of kilometres of pipe. As a result, Echologics has a growing list of satisfied customers and is expanding to include new regions, new types of pipe and new networks.

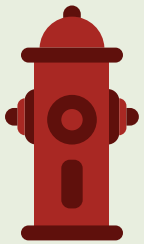
## KEY FACTS

Up to **30%** of the total water entering the country's supply-line systems is **LOST THROUGH LEAKING PIPES.**

*(Source: Environment Canada)*




It would cost an estimated **$1 TRILLION TO REPLACE THE NORTH AMERICAN WATER SUPPLY-LINE SYSTEM.**



Echologics' EchoShore-DX uses existing city assets—**FIRE HYDRANTS**—to house its smart-node sensor network.

Echologics has completed over **400 LEAK-DETECTION PROJECTS** across a variety of sectors.



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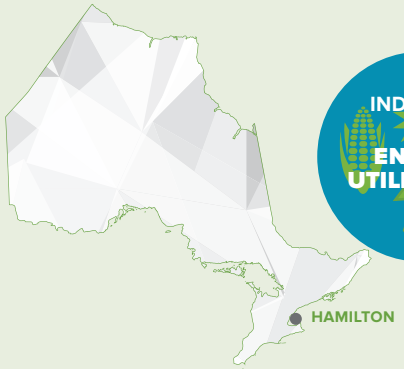



INDUSTRY
ENERGY UTILIZATION

PRIMARY BENEFIT
CLEAN WATER

CO-BENEFIT
CLIMATE CHANGE

COMPANY NAME:
**FIBRACAST LTD.**

PROJECT NAME:
**HYBRID MEMBRANE TECHNOLOGY**

FIBRACAST

**Key Products/Services:**
Water Filtration Membranes

**Operating Since:** 2010

**SDTC Support:** 2011 to 2014

**Vision:** To create the next generation of membrane filtration technology that will improve on the robustness, performance and operational flexibility of existing membrane designs.

**Consortium Partners:**
- Alpha Plan
- ANAERGIA

**SDTC Funding:** $1,947,736

**Leveraged Funding:** $3,954,493

**Total Project Value:** $5,902,229

**For more information:**
**www.fibracast.com**

*"FibrePlate™ membranes are a game changing technology—they are the first 100-per-cent newly designed membranes that the industry has seen in a long time. The hybrid membrane combines the best advantages of hollow-fibre and flat-sheet technologies to deliver significant capital and operating cost advantages to our clients—and none of it would have been possible without funding support from SDTC."*

***John Tomescu***
*CEO*
*Fibracast*

FIBRACAST'S HYBRID MEMBRANE TECHNOLOGY:

## At a Glance

Fibracast has developed a membrane manufacturing technology that creates a tubular membrane panel—FibrePlate™. The novel hybrid membrane combines the high packing density and backwash capability characteristics of hollow-fibre membranes with the high-strength and low-manufacturing-cost benefits of flat-sheet membranes.

## The Opportunity

In recent years, water has been characterized as the 'new oil'—a finite resource expected to experience a supply/demand imbalance of 56 per cent by 2025. The annual global water market is already a $500 billion industry, and is forecast to reach $20 trillion by 2025, when an estimated two-thirds of the world's population will live in water-scarce regions. Against that backdrop, the market for membrane modules is expected to reach $25 billion by 2018, while the market for membrane bioreactors—water treatment facilities comprised of various membrane technologies—will see 22 per cent growth annually over the next few years, reaching $3.4 billion by 2018.

(SOURCE: FROST & SULLIVAN)

*Photo: Membrane cassettes (pictured) are combined to make trains, which are placed into wastewater- and water-treatment plants.*

*Photo: Fibracast hybrid membranes are installed at the Delphos Wastewater Treatment Plant in Ohio.*

## Project Overview

In 2010, Fibracast was created to lead the development of a hybrid membrane technology that incorporates the best features of the then-current incumbent membrane technologies—hollow fibre and flat sheet.

Initially modelled on a computer, then proved in a full-scale pilot manufacturing facility built in Ontario, Fibracast's FibrePlate™ is a game-changing application of membrane technology for wastewater treatment; the technology molds hollow channels into standard polyethylene terephthalate sheets, which are then coated with polyvinylidene fluoride membrane. Sixteen sheets are combined to create a module and modules are combined to make cassettes, which can then be used to create trains that are placed into wastewater treatment plants.

### The Benefits

The packing density of FibrePlate—500 square metres of membrane surface area in a one-cubic-metre tank—is significantly greater than either hollow fibre (260 square metres per cubic metre) or flat sheet (100 or 120 square metres per cubic metre), reducing the footprint of plants that incorporate the technology. The transmembrane pressure of the hybrid membrane (around two pounds per square inch (PSI)) is nearly as low as the 1.5 PSI for flat sheet membranes, and considerably lower than the four to five PSI of hollow fibre membranes; lower pressure reduces clogging, and FibrePlate can be effectively cleaned using a built-in backwash process that eliminates the downtime typically associated with removing flat sheet and hollow fibre membranes out of service for cleaning purposes.

The resulting sustainable flux—the amount of water that can be treated by the membrane for long periods of time—for FibrePlate is 60 per cent higher than for flat sheet membranes and up to 33 per cent higher than using hollow fibre membranes.

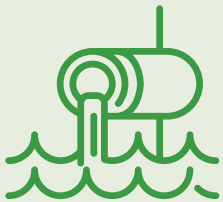
FibrePlate can be retrofitted in existing facilities that currently use incumbent flat sheet or hollow fibre membranes, offering capacity improvements and energy savings within the existing plant configuration.

The fundamental advantage of FibrePlate, however, is that it represents a step-change improvement vis a vis existing technologies. Incorporating highly engineered equipment to design the membranes improves the precision and accuracy of the manufacturing process. Combined with higher levels of automation, manufacturing costs for FibrePlate—a North American produced technology—are lower than those of incumbent products manufactured in Asia.

### Global Markets

Currently, Fibracast is marketing FibrePlate internationally, and has provided turnkey installations at eight operating wastewater treatment plants in North America, Europe and Asia. Five more projects are currently under development using the same business model; one such contract switched to FibraCast (from another provider) during development, when it was proven that incorporating FibrePlate™ would double the plant's output while maintaining the original footprint.

## KEY FACTS



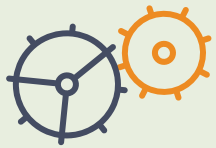
The worldwide water- and wastewater-treatment market represents a

**$100-BILLION GLOBAL OPPORTUNITY.**

(SOURCE: BCC RESEARCH)

The two million square metres per year of membrane-production capacity at the Fibracast Hamilton plant provides water treatment capacity equal to a

**323-MILLION-GALLONS-PER-DAY WASTEWATER FACILITY.**



Peak processing capacity of Fibracast membranes is

**27% HIGHER THAN COMPETING TECHNOLOGIES.**

The market for membrane modules is expected to reach

**$25 BILLION BY 2018.**



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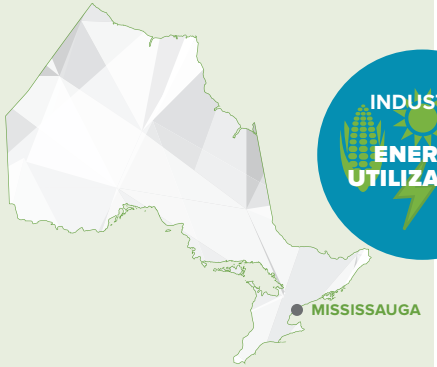



INDUSTRY
ENERGY UTILIZATION

PRIMARY BENEFIT
CLEAN AIR

CO-BENEFITS
CLEAN WATER

CLIMATE CHANGE

COMPANY NAME:
**INTEGRAN TECHNOLOGIES INC.**

PROJECT NAME:
**ENVIRONMENTAL ALTERNATIVE FOR HARD CHROME PLATING**

INTEGRAN
TECHNOLOGIES INC.
AS9100C:2009 ISO9001:2008 CERTIFIED

**Key Products/Services:** NanoCobalt, industrial manufacturing, R&D in advanced materials and nanotechnology

**Operating Since:** 1999

**SDTC Support:** 2008 to 2012

**Vision:** Break new boundaries, push limits, and drive innovation in advanced material technology to improve the human condition.

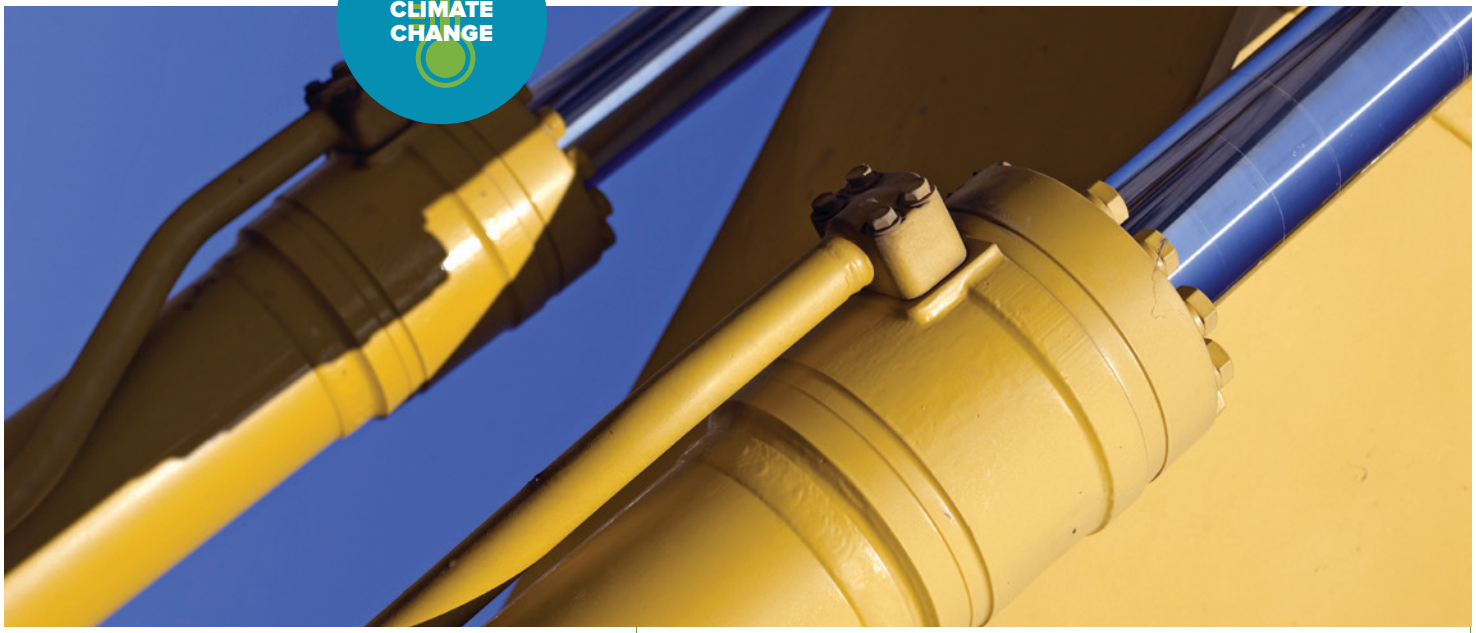
**Consortium Partners:**
- Pratt & Whitney Canada
- Morph Technologies

**SDTC Funding:** $1,481,328

**Leveraged Funding:** $2,983,194

**Total Project Value:** $4,464,522

**For more information:**
**www.integran.com**



*"Our NanoCobalt technology delivers exceptional corrosion protection in the most challenging environments, outperforming the toxic hard chrome coatings it is replacing. With SDTC's support, Integran has been able to take this technology from the early development phase through to industrial demonstration and qualification."*

***Gino Palumbo***
*President and CEO*
*Integran Technologies*

INTEGRAN'S ENVIRONMENTAL ALTERNATIVE FOR HARD CHROME PLATING:

## At a Glance

During this project, Integran Technologies Inc. demonstrated its nano coating—an environmentally-compliant nanocrystalline cobalt-phosphorus alloy used to protect parts from wear and corrosion in aerospace, automotive-shock, and industrial applications. The NanoCobalt electroplating process replaces the incumbent technology, hard chrome plating, which gives rise to potential health hazards due to the use of hexavalent chromium emitted during operation. The nano-coating process eliminates chromium and is, therefore, expected to result in fewer occupational health and safety risks; it is also more energy efficient than traditional processes, resulting in reduced greenhouse gas and air-pollutant emissions.

## The Opportunity

Viewed as potentially toxic and associated with numerous health risks—such as lung cancer, and nasal-septum and skin ulcerations—the use of hexavalent chromium in hard chrome plating has long been questioned; a search for a healthier, alternative technology with equivalent or better performance has been underway since the 1980s. In 1999, in the face of possible legislative action to dramatically decrease permissible exposure limits for workers in the hard chrome plating industry, a consortium of aerospace leaders was tasked with identifying and evaluating potential replacement technologies. At the time, Integran had just been spun-out of the former Ontario Hydro, with a mandate to develop new advanced nanomaterials by electroplating; its primary focus was on the electroplating of nickel on various components of Hydro's nuclear power facilities.

The United States government was intrigued by Integran's initial success with nickel and retained the company to explore cobalt-based alternatives for plating. With initial funding from the U.S. Department of Defense (DoD), Integran pursued lab-scale development of a coating process using a cobalt-phosphorous alloy. Integran used its breakthrough nano-technology to rapidly develop a new lab-scale process that allowed users to convert their existing chrome plating lines by dropping in a new nanocrystalline plating technology, which was safer and outperformed incumbent hard chrome plating technologies.

### Cross-border Testing

Integran's coatings have the potential to dramatically extend component life, particularly in components for extreme-use vehicles such as naval ships, municipal waste-disposal trucks and military vehicles. As such, the U.S. DoD's Naval Air Command (NAVAIR) was very interested in Integran's solutions and instrumental in the early testing of their coating process, launching a demonstration/validation line at its Jacksonville, Florida facility in 2006 where plated components were successfully tested on a variety of naval aircraft and ships. At around the same time, Integran worked with key industrial players in the fluid power and hydraulics industry—including Missouri-based Enduro Industries—to validate the use of the coating on piston rods.

## Project Overview

In light of the successful testing by NAVAIR and Enduro, and with the assistance of SDTC funding, in 2008, Integran aimed to take its NanoCobalt technology from late-stage development to commercial use. In order to do so, Integran needed to test and validate its technology (and resulting components) in automotive and aerospace applications.

With its consortium partner, aircraft engine manufacturer Pratt & Whitney, Integran successfully demonstrated its plating technology on aircraft engine components—its NanoCobalt technology met the technical requirements of a hard chrome replacement. The process was less expensive than hard chrome plating and demonstrated significant health and environmental improvements vis a vis the incumbent technology. Due to its strong results during this demonstration phase, Integran was able to develop internal material specifications for the coating.

*Photo: Integran's coatings are applied to a variety of components, extending their product life.*

### The Way Forward

Integran is rolling out its technology on two fronts: 1) Integran is accepting components from Tier 1 suppliers and applying its coating at its own facilities; and 2) Integran is licensing third-parties as approved applicators of the NanoCobalt solution. (e.g., NAVAIR and Enduro are licensed users in the U.S.)

A long time in the works, in early 2015, the U.S. DoD issued a military specification MIL-DTL-32502 for Integran's NanoCobalt process. This means that Integran's plating process can now be used in all sorts of DoD applications—including military vehicles that will replace the iconic Humvee (HMMWV). Integran can now aggressively pursue other military contracts for thousands of components throughout North America and Europe for use in the most aggressive of environments.

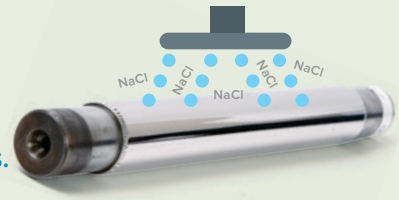
## KEY FACTS

Integran holds more than **200** **INTERNATIONAL PATENTS.**

NanoCobalt boasts **90%** **DEPOSITION EFFICIENCY,** versus 25% or less for hard chrome.

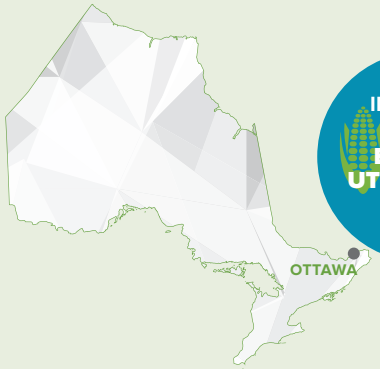
NanoCobalt is **FIVE TIMES** **MORE EFFICIENT** than hard chrome in converting energy to form protective coatings.

NanoCobalt delivers more than **2,000** **HOURS OF CORROSION PROTECTION** in salt spray compared to the industry standard of just 96 hours.






Funded by the Government of Canada | Canada




INDUSTRY
ENERGY UTILIZATION

PRIMARY BENEFIT
CLEAN AIR

CO-BENEFIT
CLIMATE CHANGE

COMPANY NAME:
**RANOVUS INC.**

PROJECT NAME:
**ENERGY EFFICIENT DATA CENTRE INTERCONNECT**

RANOVUS

**Key Products/Services:** Optoelectronics components and transceiver subsystems for the information technology industry

**Operating Since:** 2012

**SDTC Support:** 2013 to present

**Mission:** Develop and manufacture advanced solutions for the next generation of interconnects for the telecommunications and information technology industries.

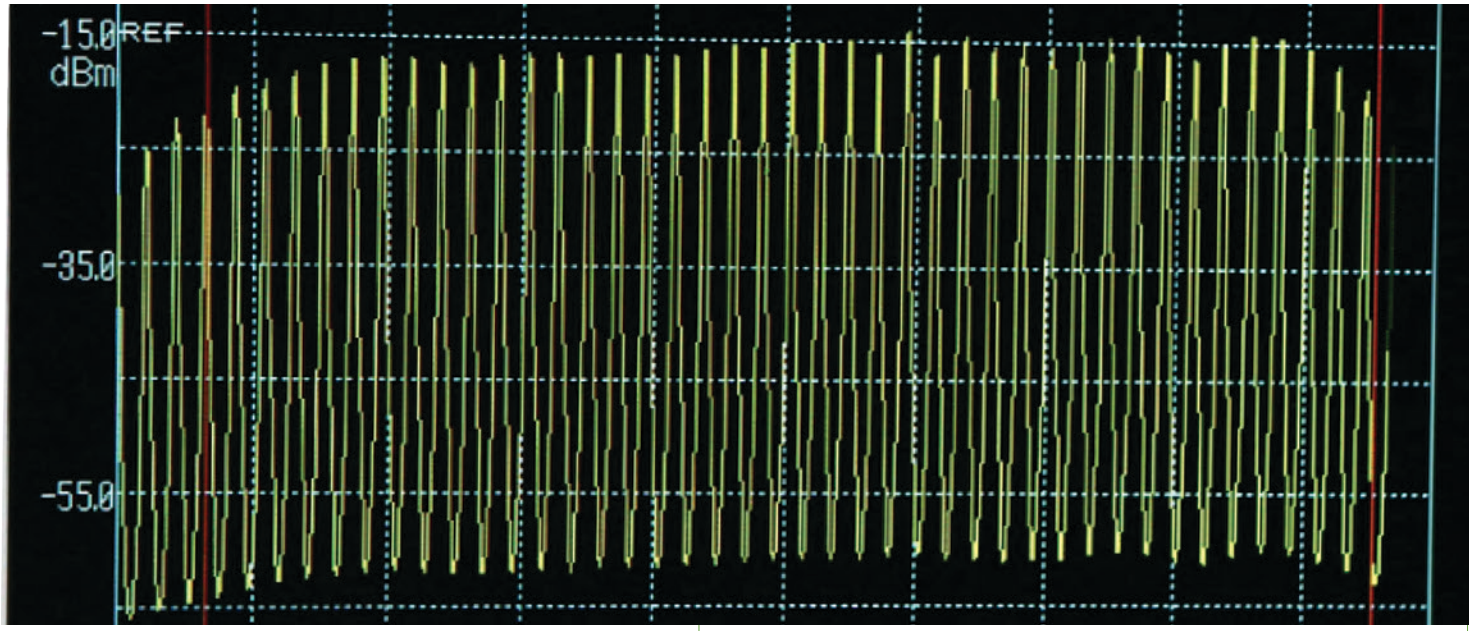
**Consortium Member:**
• National Research Council of Canada

**SDTC Funding:** $4,250,000

**Leveraged Funding:** $10,253,317

**Total Project Funding:** $14,503,317

**For more information:**
**www.ranovus.com**




*"The Internet has become an integral part of our society with growth in mobility, social networking and cloud computing. Data centres play a pivotal role in providing instantaneous service to meet our daily network demand and, in the process, leave behind a very large carbon footprint. The energy required for data centres accounts for two per cent of the world's electricity consumption and is growing. The support of the Government of Canada and SDTC will enable Ranovus to build a world-class Canadian capability to tackle the energy efficiency of data centres around the world."*

***Hamid Arabzadeh***
*Chairman and CEO*
*Ranovus Inc.*

RANOVUS INC.'S ENERGY EFFICIENT DATA CENTRE INTERCONNECT PROJECT:

## At a Glance

When users post photos or update their status on major social networks, or when they use the "cloud" to back up their data, it creates digital traffic within data centres around the world. For every kilobit of information received on a device, 1,000 kilobits/second (kbps) of traffic is generated inside data centres. The energy required for data centres is massive and continues to grow at a rapid rate. Today, there are no power-efficient, cost-effective and scalable solutions to support impending future bandwidth requirements. In this project, Ranovus brings together technologies, namely a multi-wavelength quantum dot laser (MWQDL) and silicon photonics, to streamline the way data flows through a data centre.

## The Opportunity

In today's interconnected world, data centres touch virtually every aspect of our day-to-day lives. Social networks like Facebook, Twitter and LinkedIn, big data analytics, cloud computing, and even our daily use of Smartphones, require scalable infrastructure—data centres—to keep pace with the rising demand for fast, reliable, power-efficient and cost-effective connectivity. Global data centre traffic is expected to triple by 2019 (to 10.4 billion terabytes from 3.4 billion terabytes in 2014) and currently draws more than two per cent of the world's electric energy, accounting for nearly three per cent of the global carbon footprint. Incumbent technology is unable to keep pace with this growing demand effectively and power efficiently. Internal connectivity is limited by the capacity of the optical transceiver modules linking servers; external connectivity is limited by the cost and power consumption of existing technologies.

## Project Overview

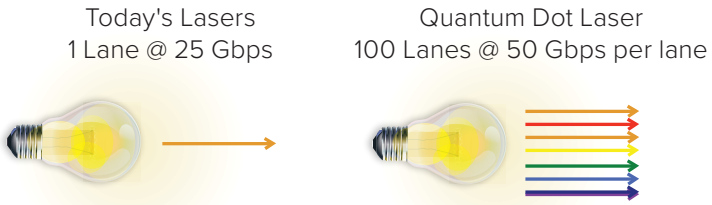
Ranovus has developed a high capacity, optical-interconnect platform technology for internal and external data centre connectivity applications. It consists of a multi-wavelength laser, a set of silicon-photonics modulators, and the associated high-speed drivers and amplifiers. The use of a single laser to provide the light for multiple data streams and the integration of the modulators on a single chip are the keys to reducing cost and power consumption of the interconnect module. The modules that Ranovus has developed cost one-sixth that of existing modules and use just 15 per cent of the energy consumed by currently available options.

### The Laser and Silicon Photonics

Central to the Ranovus technology is a multi-wavelength quantum dot laser (MWQDL) developed in partnership with the National Research Council of Canada and silicon photonics designed and optimized in partnership with McMaster University.

The MWQDL can replace up to 100 conventional lasers, saving on cost, power consumption and size. Ranovus has been working with the NRC since early 2012 to develop a differentiated design that would increase both electrical bandwidth (how fast data can be transmitted) from 3 Gbps to 12 Gbps and optical bandwidth (how many channels can be used simultaneously) from 20 to 30 wavelengths. After several iterations and a result of its continued efforts, Ranovus is currently delivering, in a single package, a 200 Gbps transceiver module supporting a 4.8 terabit/second (Tbps) optical system over a single pair of optical fibres.

THE RANOVUS MULTI-WAVELENGTH QUANTUM DOT LASER



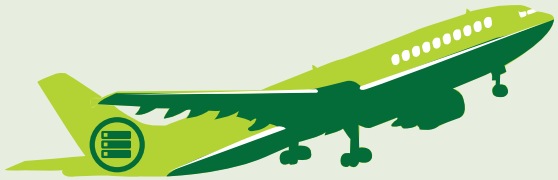

Beta testing is underway now in two of the top five global-data-centre original equipment manufacturers (OEMs) and Ranovus hopes to deploy the technology for field trials by the fourth quarter of 2016. Purchase orders are now being accepted for deployment of the technology in 2017, at which time additional capitalization, beyond SDTC, will be tapped to scale up manufacturing capabilities.

### The Potential

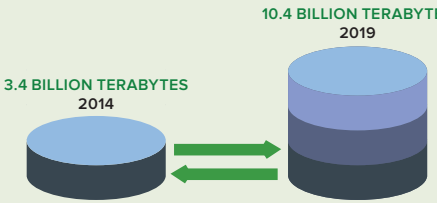
Initially, Ranovus intends to focus its marketing efforts on large data centres operated by companies like Google, Amazon, Facebook and Microsoft. Once that is achieved, the next-stage goal is for the technology to be sold to vendors that support other Tier 1 data centres and OEMs that can deploy the technology to customers and applications beyond data centres.

The market for linking data centres is estimated at $12 billion, while improving connectivity within data centres is estimated at another $12 billion (where higher capacity is demanded at lower prices). Combined, the global connectivity market is estimated at $24 billion, with about 60 per cent of that total related to various optical components like the Ranovus multi-wavelength platform.

## KEY FACTS



Data centres account for
**3%**
**OF THE GLOBAL CARBON FOOTPRINT,**
on par with the global airline industry.




Global data centre traffic is expected to
**TRIPLE**
from 3.4 billion terabytes in 2014 to
**10.4 BILLION TERABYTES**
by 2019.

The 200 gigabits/second (Gbps) optical module Ranovus has developed for connecting data centres costs
**$2,000**
**AND CONSUMES 12 WATTS OF POWER;**
existing modules cost $12,000 and consume 80 watts of power.

EXISTING OPTICAL MODULE
**$12,000**
**80 WATTS OF POWER**

RANOVUS OPTICAL MODULE
**$2,000**
**12 WATTS OF POWER**



Funded by the Government of Canada | Canada


INDUSTRY
ENERGY UTILIZATION

PRIMARY BENEFIT
CLIMATE CHANGE

CO-BENEFITS
CLEAN AIR

CLEAN WATER

COMPANY NAME:
**CARBONCURE TECHNOLOGIES**

PROJECT NAME:
**$CO_2$ UTILIZATION IN CONCRETE**

CARBONCURE™

**Key Products/Services:** $CO_2$ utilization technology for the concrete sector

**Operating Since:** 2007

**SDTC Support:** 2010 to 2015

**Vision:** Re-thinking carbon dioxide in concrete for a lower carbon future.

**Consortium Partners:**
- Air Liquide
- Brampton Brick (formerly Atlas Block Co. Ltd.)
- The Shaw Group Ltd.
- Basalite Concrete Products

**SDTC Funding:** $1,192,000

**Leveraged Funding:** $2,090,283

**Total Project Value:** $3,282,283

**For more information:** carboncure.com

*"SDTC's contribution has been instrumental in bringing CarbonCure's technology to market. With SDTC's support we have been able to successfully launch our technology and continue rolling it out to market, maximizing the environmental benefits for North Americans."*

***Rob Niven***
*CEO and Founder*
*CarbonCure*

CARBONCURE $CO_2$ UTILIZATION TECHNOLOGY:

## At a Glance

CarbonCure Technologies manufactures a retrofit carbon dioxide recycling technology for existing masonry and ready-mixed concrete plants. CarbonCure's technology recycles $CO_2$, reducing the carbon footprint of the concrete industry by creating affordable, greener and stronger concrete products. Using CarbonCure's technology, concrete manufacturers are able to permanently store $CO_2$ in their concrete as solid limestone. The addition of $CO_2$ also potentially reduces the need for some energy-intensive components in the concrete, further reducing greenhouse gas emissions.

## The Opportunity

The cement and concrete industry produces approximately 5 per cent of global GHGs. Environmental concerns and the opportunity to recycle $CO_2$ in the concrete industry led Halifax-based CarbonCure to consider $CO_2$ as an asset rather than a liability. They saw the potential to recycle $CO_2$ in the concrete industry to make greener, stronger building materials while creating significant environmental benefits.

## Project Overview

The initial SDTC-funded project aimed to refine and commercialize CarbonCure's $CO_2$-utilization technology in the concrete sector. The performance of the technology was validated through two full-scale industrial demonstrations—with the Shaw Group and Atlas Block (now Brampton Brick), respectively—for concrete masonry units. The demonstrations allowed CarbonCure to take its technology out of the lab and test it at an industrial scale in multiple full-scale production facilities.

Based on the demonstrations, CarbonCure was able to refine and optimize its technology for masonry products, as well as evolve it even further to include ready-mixed concrete applications. $CO_2$ injection methods were also improved, becoming increasingly more effective and efficient; the resulting technology is not only cost competitive but the end product can be even stronger than traditional concrete. Together with the overarching environmental benefits of the technology, CarbonCure has a very attractive product that has garnered considerable global interest.

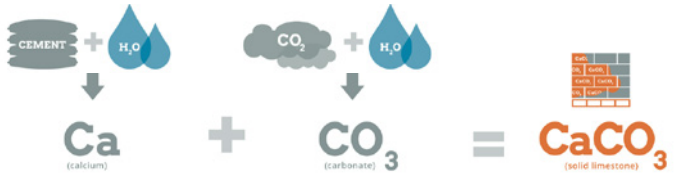

*Left: Using CarbonCure's technology, $CO_2$ is sourced from industrial emitters and injected into the concrete mix at a plant. Upon injection, the $CO_2$ is converted into calcium carbonate and permanently embedded in the concrete.*

### The Technology

CarbonCure's technology is an affordable retrofit to existing concrete plants that allows producers to recycle waste carbon dioxide ($CO_2$) and in the process, create more environmentally friendly concrete. Carbon dioxide is sourced from local industrial gas suppliers—who collect emissions from the smokestacks of nearby industrial facilities such as oil refineries, coal plants and fertilizer plants—and stored onsite within pressurized vessels that match the plant production requirements. Once collected and purified, the $CO_2$ is injected into the mixer and permanently converted into a very fine solid mineral that is locked away within the concrete.

### The Reaction

The primary reaction involved in CarbonCure's technology involves carbon dioxide and cement. When $CO_2$ is added to concrete during mixing, the $CO_2$ reacts with water to form carbonate ions. The carbonate then quickly reacts with calcium ions released from the cement to rapidly form a limestone-like material. This mineral is created in the form of nanomaterials dispersed throughout the concrete mix. The conversion of $CO_2$ into solid carbonate minerals permanently binds it within the concrete and as such, it cannot be released back into the atmosphere. The resulting concrete has a lower carbon footprint.

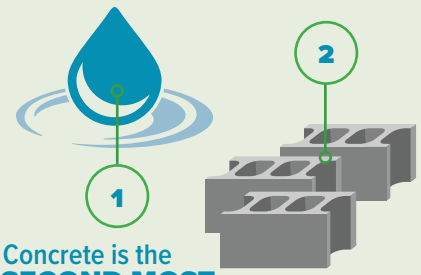



### Global Interest in Greener Concrete

CarbonCure's technology is operational in more than 25 concrete plants across North America. Utilized initially in masonry products (e.g., concrete blocks), CarbonCure has devoted considerable time in research and development to expand the technology's reach to include ready-mixed (i.e., poured-concrete) applications. The ready-mixed concrete market represents a large economic opportunity for CarbonCure, but also has huge global environmental benefits since there are many more opportunities to sequester $CO_2$ into poured concrete.

CarbonCure is seeing considerable overseas interest for its technology, in places such as China—a country that produces more concrete than the rest of the world combined—India and the Middle East. Before taking its technology elsewhere, however, the CarbonCure team is first intent on bringing broad market coverage to North America, servicing not only concrete producers, but the increasing number of builders and architects looking for innovative green-building solutions. Whereas many companies are working in this space, CarbonCure has a substantial first-mover advantage as the only company with a market-ready, cost-effective, and proven, operational $CO_2$-utilization technology.

## KEY FACTS

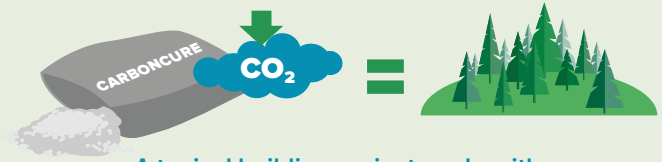



Concrete is the **SECOND MOST ABUNDANT** material on earth overall (after water).

Concrete is the world's most abundant manmade material. There is more concrete manufactured globally than any other material.

**THE CEMENT INDUSTRY PRODUCES**

**5%** of global greenhouse gas emissions.




A typical building project made with CarbonCure concrete products may **REDUCE AS MUCH $CO_2$** as an acre of forest will sequester over the course of a year.



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INDUSTRY
**POWER GENERATION**

PRIMARY BENEFIT
**CLIMATE CHANGE**

CO-BENEFIT
**CLEAN AIR**

COMPANY NAME:
## GENERAL FUSION INC.

PROJECT NAME:
## ACOUSTICALLY DRIVEN MAGNETIZED TARGET FUSION

generalfusion

**Key Products/Services:**
Magnetized Target Fusion (MTF)

**Operating Since:** 2002

**SDTC Support:** 2009 to 2015

**Mission:** To develop a fast, practical and cost-competitive approach to fusion energy.

**Consortium Partner:**
• Los Alamos National Laboratory

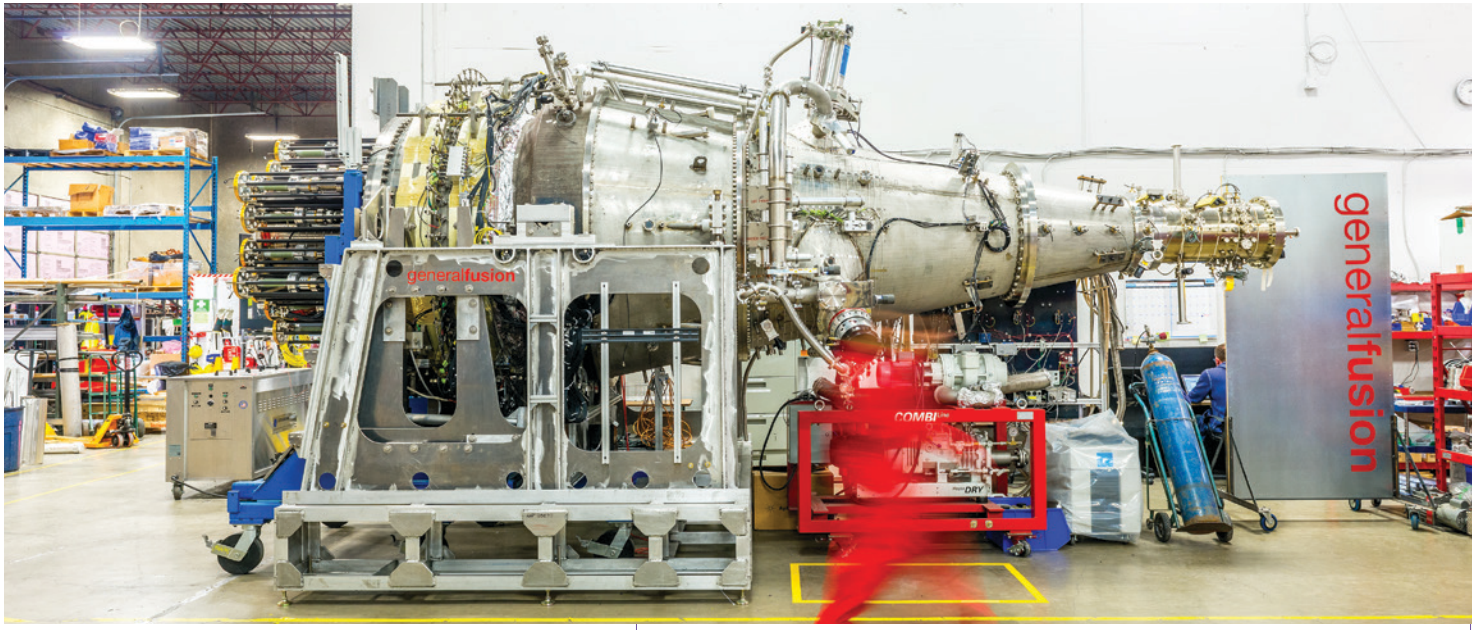
**Associated Project:** Demonstration of fusion energy technology

**SDTC Funding:** $13,897,455

**Leveraged Funding:** $44,240,136

**Total Project Value:** $58,137,591

**For more information:**
**generalfusion.com**




*"SDTC funding catalyzed significant support for General Fusion, which has enabled us to rapidly grow a world-class science and engineering team, and leading fusion-research facility. Our MTF technology has the potential to transform the world's energy supply and we're proud to have SDTC supporting a disruptive industry that is creating high tech jobs while building Canada's capacity to meet our clean-energy-generation commitments."*

***Nathan Gilliland***
*CEO*
*General Fusion*

GENERAL FUSION'S MAGNETIZED TARGET FUSION PROJECT:

# At a Glance

Energy supply is the number one challenge of the 21st century, with population growth expected to drive global energy demand up by 34 per cent in the next 20 years. Fusion energy is a clean, safe, and cost-competitive option for meeting this demand. General Fusion is developing the world's first full-scale demonstration fusion power plant based on commercially viable technology. In this project, General Fusion aimed to verify the technical and economic viability of their Magnetized Target Fusion (MTF) technology, and constructed the core components of a full-scale power plant. This power plant will safely produce reliable baseload electricity with zero greenhouse gas emissions at prices competitive with fossil fuels, making it a powerful tool to tackle climate change.

## The Opportunity

Fusion is a clean, safe and abundant energy source that, if harnessed and replicated on the earth, could replace fossil fuels and provide a nearly unlimited source of power with zero $CO_2$ emissions. Fusion occurs when atoms (normally hydrogen isotopes) are heated to very high temperatures, allowing them to collide and fuse. As the sun's sole energy source, fusion is created through extreme pressure and heat. The challenge for fusion science here on Earth is to create sun-like conditions on our own planet.

Fusion can generate its power from virtually limitless seawater and is a safe form of energy, without the meltdown risk or radioactive waste associated with conventional nuclear fission. Not yet commercially available, fusion represents a trillion-dollar opportunity to supply the majority of future global-energy demand.

### Project Genesis

General Fusion was founded in 2002 by Dr. Michel Laberge as he sought to develop an approach to fusion energy that could address the world's urgent need for carbon-free sources of energy. Drawing on more than 50 years of research from universities and national laboratories around the world, Dr. Laberge identified an approach that, given modern advances in electronics and plasma physics, could provide a feasible path to a fusion power plant. Called Magnetized Target Fusion, General Fusion is focused on making this technology a reality.

## Project Overview

Research into fusion technology has generally involved two approaches. Magnetic Confinement Fusion attempts to confine plasma at fusion temperatures for long periods of time (minutes) and at very low density using strong magnetic fields. At one trillion times higher density, Inertial Confinement Fusion attempts to compress fuel to fusion conditions for a nanosecond. In the middle is General Fusion's approach—Magnetized Target Fusion (MTF)—that uses aspects of both magnetic confinement and compression to achieve fusion conditions for a few microseconds, at intermediate densities.

The MTF system uses a sphere, filled with molten lead-lithium that is pumped to form a vortex. With each pulse, magnetically confined plasma is injected into the vortex. Surrounding the sphere, an array of pistons impact and drive a pressure wave into the centre of the sphere, compressing the plasma to fusion conditions. The resulting energy is converted to steam to spin a turbine, producing electricity.

This system overcomes a number of key challenges in the creation of a commercial power plant, while utilizing existing industrial technologies such as pistons instead of large lasers or exotic magnets.

Through the SDTC program, General Fusion constructed several iterations of the core sub-systems of a full-scale fusion prototype, demonstrating that many key technical challenges could be overcome. The company's team of 65 world-leading engineers and physicists continue to conduct a milestone-driven simulation and experimentation campaign, moving toward development of a demonstration power plant.

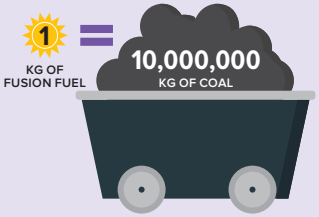
*Photo: Construction of sub-systems that will eventually comprise a demonstration power plant is underway at General Fusion's facility in Burnaby, BC.*

### Next Steps

General Fusion is in the process of developing and optimizing the sub-systems that will comprise a demonstration power plant. To reduce technical risk during this phase, each component is subject to its own experimental and prototyping program. Leveraging SDTC funding to attract over $100 million in venture capital, the company is on track to achieve performance milestones, which will lead to design and construction of a demonstration power plant.

## KEY FACTS

**FUSION**
is what **POWERS THE SUN AND THE STARS** and occurs at extremely high temperatures (over 100 million degrees Celsius).




1 kilogram of **FUSION FUEL** holds the **EQUIVALENT ENERGY** of 10 million kilograms of coal.

**2.8%** of the world's energy supply is **PROVIDED BY RENEWABLES**, with the rest supplied by fossil fuels, hydro or nuclear.

**FUSION** is a game-changing technology set to **DISPLACE THE USE OF NATURAL GAS AND COAL** that combined, contribute to 45% of the world's GHG emissions.



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INDUSTRY
**POWER GENERATION**

PRIMARY BENEFIT
**CLEAN AIR**

CO-BENEFIT
**CLIMATE CHANGE**

COMPANY NAME:
## MORGAN SOLAR

PROJECT NAME:
## SUN SIMBA™ GEN 4.0 COMMERCIALIZATION PROJECT

morgansolar

**Key Products/Services:** Solar Photovoltaic and Illumination Technologies

**Operating Since:** 2007

**SDTC Support:** 2014 to 2016

**Mission:** To make solar energy the most widely used and affordable power source in the world.

**Consortium Partners:**
- Iberdrola S.A.
- Enbridge Inc.

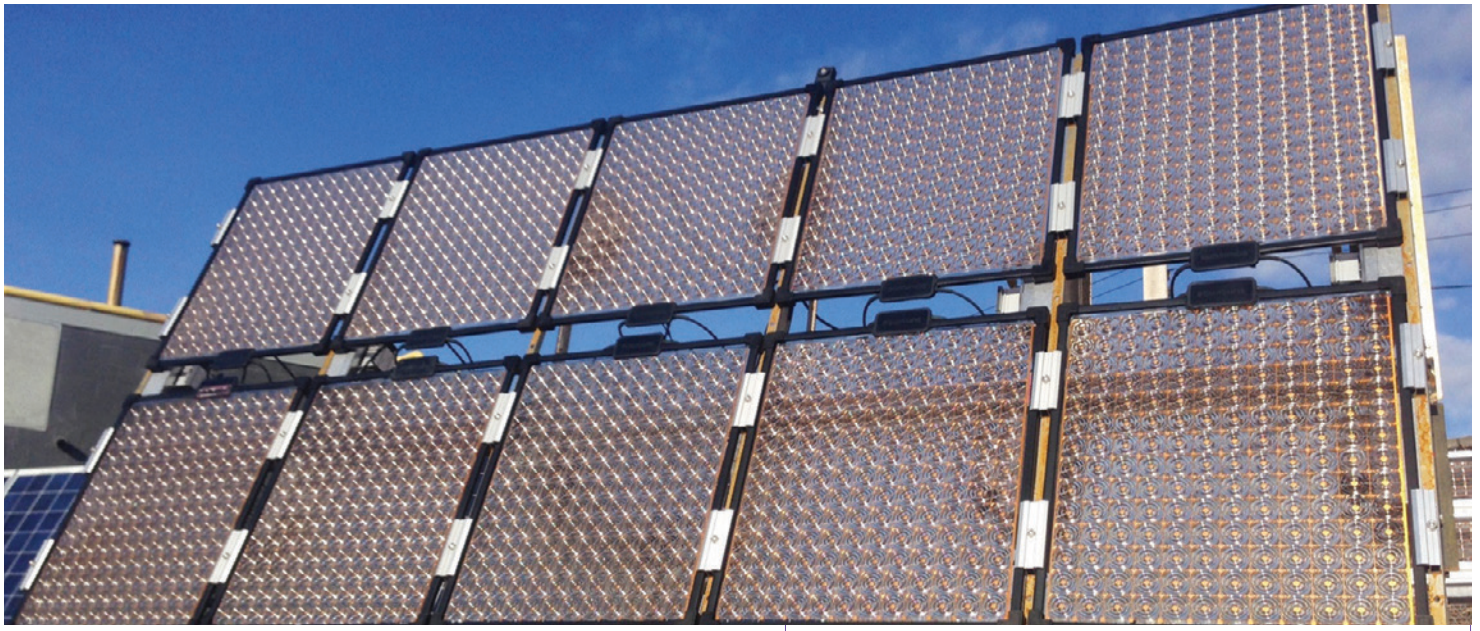
**Associated Project:** Concentrated Photovoltaic Systems

**SDTC Funding:** $2,067,778

**Leveraged Funding:** $4,450,494

**Total Project Value:** $6,518,272

**For more information:** morgansolar.com



*"Morgan Solar has benefited greatly from its engagement with SDTC. Several important technology demonstrations (with strategic customers and third-party laboratories seeking to test and validate the performance and reliability of the technology) were made economically feasible as a direct result of the SDTC-funded Sun Simba project. The results from the demonstrations will play a crucial role in unlocking sales and exports in the future. The team at SDTC has been supportive of our efforts, provided guidance at critical junctures, and facilitated introductions to other industry players."*

***Hugo Navarro***
*Vice President, Project Development and Operations*
*Morgan Solar*

MORGAN SOLAR'S SUN SIMBA™ COMMERCIALIZATION PROJECT:

# At a Glance

Morgan Solar's cutting-edge Concentrated Photovoltaic (CPV) panel is twice as efficient as conventional silicon PV panels and can be manufactured at a fraction of the cost. The Sun Simba project (and resulting technology) not only lowers the number of parts needed to produce a solar panel but also uses a lower-cost material for those parts, creating a double cost advantage. Initially designed for utility scale projects—large ground-mounted solar farms—the light-weight and small form factor of the Sun Simba Gen 4.0 has rooftop, small-scale and off-grid applications.

## The Opportunity

With the global market for photovoltaics experiencing exponential growth that's expected to continue into the foreseeable future, real opportunities exist for companies who provide forward-thinking, low-cost solutions for the solar power industry. Solar PV is growing all across the world—especially in China, Japan, the U.S. and India—and becoming increasingly competitive very quickly. In a growing number of places, solar power is the best and most affordable option for homeowners, businesses, governments, and societies.

Morgan Solar was founded in 2007 with the goal of making unsubsidized solar energy competitive with traditional sources of generation. The company has pioneered a new approach to the design and manufacture of solar modules; their products lead the industry in efficiency, durability, and low cost.

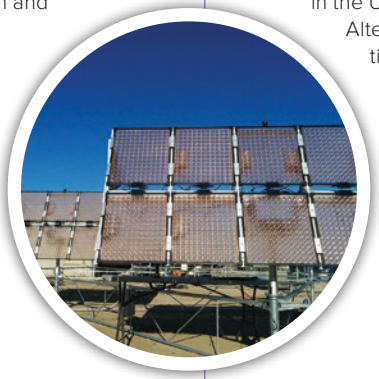


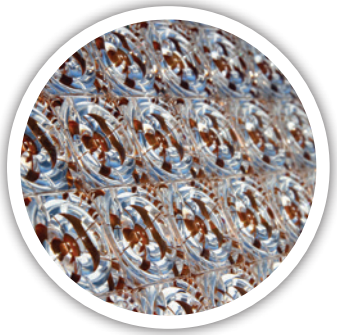
*Photo: Sun Simba CPV module installation.*

## Project Overview

The Morgan Solar Inc. (MSI) Sun Simba Commercialization Project aims to develop and refine the company's technologies in order to help build out their pilot line of modules. The proprietary solar CPV technologies are presently being deployed for validation purposes in a variety of settings in order to showcase their benefits and compelling economics. While some of the panels are deployed on Morgan Solar's own sites, other demonstrations are for the purposes of third-party validation with key stakeholders. SDTC support has made these demonstrations feasible, helping open up new markets and international opportunities for MSI.

MSI is currently working on three deployments of the Sun Simba technology that will be put into the hands of arms-length partners: University of Ottawa Sun Lab in Canada, Electric Power Research Institute (EPRI) in the U.S. and the Commissariat aux Énergies Alternatives (CEA) in France, respectively, will all be testing MSI's Sun Simba technology. Each of the three deployments will evaluate the strengths and weaknesses of the technology, demonstrating how the MSI panels perform in a variety of conditions. From collection to degradation, the panels will be evaluated on their performance, reliability and economics in real-life conditions.

*Photo: Close-up view of an MSI solar panel.*



### The Technology

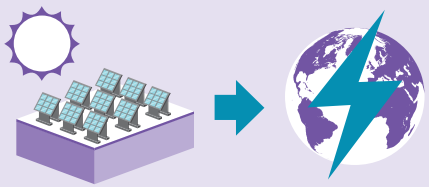
The Sun Simba™ Concentrated Photovoltaic (CPV) module fundamentally changes the economics of solar power. The next-generation technology is the first of its kind to concentrate sunlight in a planar direction, generating industry-leading energy yields at unprecedented low costs. Sun Simba replaces the silicon solar cells of conventional solar panels with advanced optics for capturing sunlight and extremely efficient, multi-junction solar cells for converting that sunlight to electricity. Two-axis track technology allows MSI's panels to move up and down, and side to side to collect the sun's energy; it is a revolutionary approach.

Unlike other CPV technologies that come in big-box structures with big-ticket pricing associated with infrastructure and installation costs, Sun Simba is only an inch thick and is the same length as a traditional solar panel, bearing the same current and voltage. MSI's CPV panels slip easily into existing solar paradigms with two key differences: Sun Simba is twice as efficient and half the size of existing panels, meaning twice as many panels can reside in a given area, doubling the power potential of a given installation. The technology also reduces the technical complexity of solar installations—resulting in an easier process—and comes at a fraction of the cost of conventional solar panels.

### Proving Up a Radical Idea

Morgan Solar continues to do demonstrations with various partners in a number of settings across the globe—from Nevada to Alberta to France—to prove up their Sun Simba technology across relevant jurisdictions with considerable sun intensity and prevalence. With months of accumulated data documenting the installations, Morgan Solar is effectively demonstrating the performance, reliability and durability of their products across the globe. Sun Simba is patented in Canada, the U.S., China and Europe.

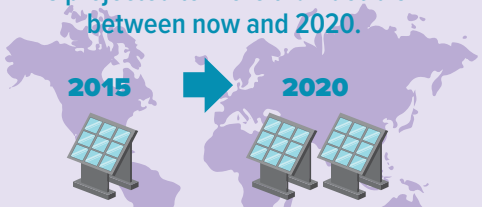
## KEY FACTS



**1% OF GLOBAL ELECTRICITY DEMAND**

In 2014, cumulative photovoltaic capacity reached 178 GW—an amount sufficient to supply 1% of global electricity demand.

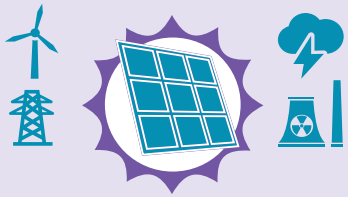
Worldwide deployment of about 55 GW is being forecasted for 2015, and installed PV capacity is projected to more than double between now and 2020.



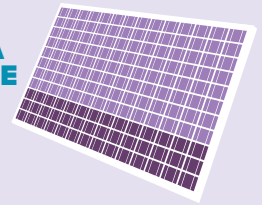

**55 GW 110 GW**

By 2050, solar power is anticipated to become the world's

**LARGEST SOURCE OF ELECTRICITY.**



**SUN SIMBA PANELS ARE 28% EFFICIENT**



At 28% efficient (and rising), Sun Simba panels are approximately twice as efficient as conventional silicon-PV solar panels (~15%-16% efficient) or thin-film solar panels (~11%-13% efficient).



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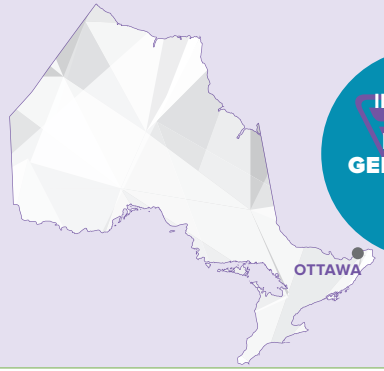



INDUSTRY
**POWER GENERATION**

PRIMARY BENEFIT
**CLEAN AIR**

CO-BENEFIT
**CLIMATE CHANGE**

COMPANY NAME:
## SOLANTRO SEMICONDUCTOR CORP.

PROJECT NAME:
## NANO-INVERTER CHIPSET DEVELOPMENT AND DEMONSTRATION OF AC-BIPV ARCHITECTURE

**Project scope changed in 2013 to the development of digital power processing chipsets for PV applications.**

solantro™ SEMICONDUCTOR CORP.

**Key Products/Services:** Dedicated digital power processing chipsets and reference platforms for power conversion applications

**SDTC Support:** 2010 to 2015

**About:** Solantro™ is a fabless semiconductor company, with core expertise in semiconductor-based, system-on-chip architectures for distributed and scalable renewable power systems.

**Operating Since:** 2009

**Consortium Partners:**
- Solantro Semiconductor Corp.
- BIPV Inc.
- nv Wienerberger sa
- System Photonics S.p.A.
- Tecta Solar
- Solarcentury Holdings Ltd.
- Bosch Solar CISTech Gmb
- Captelia SAS
- Aliavis S.r.l

**Associated Project:** Self-Forming Dynamically Scalable Renewable Energy NanoGrids

**SDTC Funding:** $2,049,234

**Leveraged Funding:** $5,057,430

**Total Project Value:** $7,106,664

**For more information:** **solantro.com**

*"SDTC really did their homework. On their advice, we made changes to the statement of work and ultimately delivered a successful product."*

***Antoine Paquin***
*Founder, President and CEO*
*Solantro Semiconductor Corp.*

SOLANTRO'S DIGITAL POWER PROCESSING CHIPSETS:

## At a Glance

When this project was initiated, Building Integrated Photovoltaic (BIPV) was a rapidly growing segment of the global solar energy market. With the subsequent rapid and significant cost reduction in PV systems, however, the market quickly shifted towards PV solutions for residential and commercial installations. Solantro's chipset, initially developed for BIPV systems, readily found applicability in PV architecture, providing a compelling and cost-effective solution for PV applications.

## The Opportunity

Much of the cost of renewable power systems is labour and equipment related. The thesis behind Building Integrated PV is that if building materials themselves are made to be plug-and-play, then the cost of PV is somewhat absorbed by the cost of the building material. Therefore, it follows that new construction would embed BIPV technology for fundamental economic reasons.

Solantro investigated BIPV practices and found that the standard practice for building a BIPV system is to arrange the individual modules in series of connected strings and to use a central inverter to convert the DC (direct current) power to grid-compatible AC (alternating current) power. However, the series-string configuration has a number of drawbacks: the power output from the string is disproportionately degraded if one or more of its modules are partially shaded; a breakdown in any one BIPV module cuts off the power flow from the entire string; and the central inverter is a single point of failure for the whole system.

Solantro's original proposal implemented the nano-inverter design with integrated circuits. The objectIve was to produce AC-BIPV systems with performance comparable to conventional DC-BIPV systems. Additonally, this performance needed to be present in different geographical locations with unique grid-tie requirements. If successful, the approach would increase solar energy harvest by up to 30%, reduce the cost and time of installation by 50%, enhance safety, and overcome certain restrictions on site suitability.

## Project Overview

### Market Factors Result in Change of Project Scope

Solantro's original concept of using AC-BIPV architecture together with its nano-converter was based on a business case where the cost per watt of non-integrated PV architecture (as a competitor to BIPV) was considerably higher than that of a potential BIPV solution. What Solantro did not anticipate was that rapid technological improvements and market factors would lead to a dramatic drop in the cost of PV for solar applications—between 2009 and 2012, costs fell by approximately 75 to 80 per cent. The cost of available hardware and electronics (PV solutions) was now so low that it compromised the business case for building-integrated solutions. With PV solutions suddenly rendered much more economic on a cost per watt basis, Solantro had to change the scope of its original project.

The good news for Solantro—and for the market—was that the chipset they had developed worked for both BIPV and PV architecture and brought a unique and compelling value proposition to PV solutions. The dramatic decrease in cost of PV solutions (and commensurate increase in market appetite for PV goods) created a new opportunity for Solantro to mass manufacture its chipsets and exponentially scale up its production at a very low cost. With the switch to a PV product, Solantro had to eliminate the use of a nano-inverter, opting instead for a more appropriate micro-inverter chipset solution.

A progressive and technologically advanced Asian market quickly saw the potential in Solantro's technology and eagerly embraced the new product; Solantro's micro-inverter chipset is now in production and being delivered to customers in Asia, Europe and North America.

### Solantro Chipsets


Unlike existing integrated circuits with a general purpose of processing information, Solantro's chips are designed and built specifically to measure, process and drive complex power architectures from distributed energy resources.

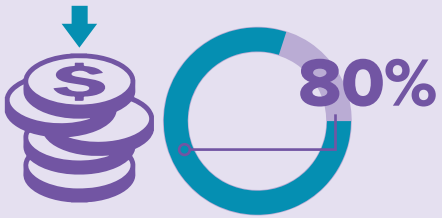
Solantro is the only power semiconductor company that delivers a dedicated digital power processing (dP2) chipset for renewable and distributed energy. The dP2 chipset provides the critical functionality required for innovative, high-performance, power conversion systems.

Solantro's chipsets are used for DC applications and for grid-tied AC applications. By mixing and matching, customers are able to utilize chipsets in different ways, creating a variety of products (e.g., inverters, battery chargers), all with compelling economics. Solantro's development platforms showcase how the chipsets can enable intelligent power conversion applications, acting as valuable blueprints for interested manufacturers.

### Mass Manufacturing

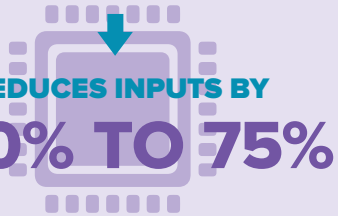
Solantro's dP2 chipsets have attracted interest from the largest power and electronic manufacturers in the world. Solantro is now scaling production for mass volumes to meet impending demand. By establishing relationships with very large wafer fabrication and assembly/test foundries, Solantro has the ability to quickly scale production to readily and easily deliver millions of units of chipsets. While they are currently shipping volumes in the tens of thousands, the market demand is in the millions of chipsets.

## KEY FACTS




Solantro's chipset reduces the cost of distributed power electronics by 80% (from $0.40/W to $0.08/W).

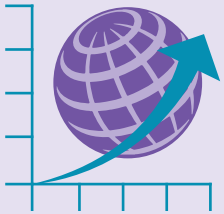
Solantro's chipset replaces costly and multiple electronic components with state-of-the-art chips reducing the number of components in a micro-inverter by more than 50%.



**REDUCES INPUTS BY**
**50% TO 75%**

**GLOBAL CUSTOMER BASE**
Solantro has customers in Asia, Europe and North America.

Global market demand for Solantro's chipsets has the potential to be
**MILLONS**
**OF UNITS.**





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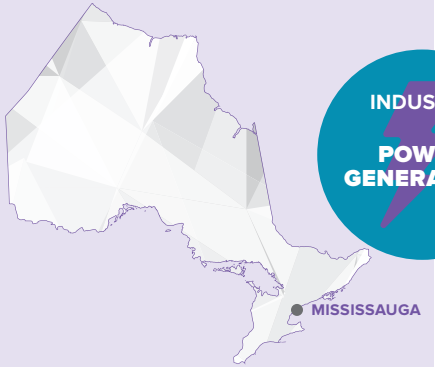



INDUSTRY
**POWER GENERATION**

PRIMARY BENEFIT
**CLIMATE CHANGE**

CO-BENEFIT
**CLEAN AIR**

COMPANY NAME:
## TEMPORAL POWER LTD.

PROJECT NAME:
## DISTRIBUTED GRID-SCALE ENERGY STORAGE

temporal
high-performance energy storage

**Key Products/Services:** Flywheels and flywheel modules for distributed energy storage solutions;
turn-key energy storage plants

**Operating Since:** 2010

**SDTC Support:** 2010 to 2016

**Mission:** Provision of energy storage solutions through the implementation of high-performance flywheel technology.

**Consortium Partners:**
- Hydro One Networks Ltd.
- NRStor

**SDTC Funding:** $4,123,572

**Leveraged Funding**: $7,898,506

**Total Project Value:** $12,022,078

**For more information:**
**temporalpower.com**

*"The potential for our flywheel technology in energy-storage and distribution applications is significant in three key ways: 1) it is ideal for frequency response, displacing the use of non-renewables for grid stability; 2) it can maximize the renewable power delivered to the grid; and 3) it offers a highly stable, micro-grid power solution for isolated communities that previously relied on diesel—an environmentally damaging and costly fuel source, in terms of both delivery and usage—for power-generation requirements."*

***Eric Murray***
*CEO*
*Temporal Power*

TEMPORAL POWER'S DISTRIBUTED GRID-SCALE ENERGY STORAGE PROJECT:

# At a Glance

Temporal Power worked with a large utility to demonstrate how an innovative, Canadian, electricity-storage technology can improve the way wind power is connected to the electricity grid. The flywheel-based storage solution reduces reliance on non-renewable fuels and mitigates the challenges caused by the intermittent output of power from wind farms while maintaining grid stability. In this project, Temporal Power and NRStor, a Canadian storage developer, demonstrated how flywheel storage systems provide frequency stability across the grid, reducing reliance on fossil-based generation. By implementing flywheel energy-storage solutions in a variety of network applications, Temporal Power's flywheel technology is expected to significantly reduce global GHG emissions by 2020.

## The Opportunity

One of the current challenges facing power-system operators is how to efficiently and effectively integrate renewable energy sources—like solar and wind power—into existing operations. In the case of renewable generation, quick changes in weather can result in dramatic changes in output, resulting in significant voltage spikes and sags to power delivered to the grid. These rapid fluctuations can lead to considerable challenges regulating voltage and power quality to homes and businesses. The incumbent solutions use brute force, consuming excessive water or fuel to maintain grid stability. An opportunity existed to improve grid stability using new technologies.

Temporal Power's (Temporal's) flywheel technology helps to effectively manage the weather-induced challenges that complicate power delivery from renewable sources, balancing out short-term intermittency by absorbing or inserting power, as required, to smooth out power flows.

## Project Overview

With the help of SDTC-funding, Temporal engaged in two projects in Southern Ontario—Minto and Clear Creek—to validate the performance of its flywheel technology. Using the same technology in different ways, both of the projects have resulted in enhanced grid stability while allowing for more renewable energy delivered to the power grid.

*Photo: Ten 250 kW flywheels are stored in a vault at Temporal's Minto, Ontario, installation.*

### The Technology

Flywheels are not a new invention; they have been widely used since the industrial revolution to smooth out the erratic nature of rotating equipment. Temporal's all-steel flywheels are approximately ten feet tall and four feet in diameter. Used in groups, they are placed in vaults in the ground as part of energy-storage installations. Acting as a kinetic battery, a flywheel system stores electrical energy by accelerating a rotating mass to a high speed and using the resulting momentum to generate electricity when needed. In doing so, the system can cost-effectively maintain a constant frequency of power delivery to the grid. Previously, non-renewable sources—such as gas-fired generation—were used to smooth out power delivery, with renewable energy seen as less consistent and predictable. Conversely, Temporal's flywheels enable the deployment of renewable energy with the reliability of non-renewable sources .

### The Installations

**Minto – Grid Balancing**

Ontario's increased use of renewables in its power mix, coupled with the more dynamic consumption of a new generation of users, has resulted in higher-than-before power fluctuations in both supply and demand, leading to noticeable grid instability. The grid was in desperate need of balancing; Temporal's flywheel-enabled storage technology was used to balance the load of the regional facility, creating the first-in-kind, IESO-operated, energy-storage system in Ontario.

The new facility houses ten 250 kW flywheels in a modular deployment, providing network regulation services in a 4 MW range (+/-2 MW) to keep the alternating current at the required 60 Hz. The facility is easily scalable, has a small footprint and is less capital intensive than conventional, non-renewable technology. Temporal's Minto installation has been operational since 2013, effectively powering the grid and demonstrating full depth of discharge, with more than 5,200 such cycles (i.e., from fully charged to fully discharged) completed in its first year of operation.

**Clear Creek – Renewable Integration**

In Temporal's Clear Creek project, the company is continuing its work to effectively integrate wind renewable generation onto the grid, neutralizing the impact of the variability of that wind on the rest of the grid. When completed, Temporal's solution will demonstrate both storage and distribution capabilities, creating the desired steady state of power delivery. Temporal's Clear Creek facility houses ten 500 kW flywheels in a modular deployment and provides 10 MW of range (+/-5 MW) delivering automatically dispatched response ramping. Phase 1 (reactive power validation) and Phase 2 of the project (engaging its flywheels and ensuring power quality) are complete; Phase 3 (commissioning of the plant) is scheduled for the end of 2016.

## KEY FACTS

### TEMPORAL'S TECHNOLOGY IS USED FOR:

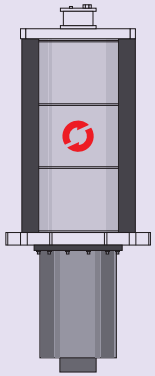

Grid balancing


Renewables integration


Isolated grids

End-user markets

Temporal flywheels are **10-FEET TALL, 4-FEET IN DIAMETER,** and capable of delivering grid stability while displacing non-renewable resources.



On the island of Aruba, Temporal's flywheels will be used to help make the island **100%-RENEWABLE-POWERED BY 2020.**



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INDUSTRY
TRANSPORTATION

PRIMARY BENEFIT
CLEAN AIR

CO-BENEFIT
CLIMATE CHANGE

COMPANY NAME:
**CORVUS ENERGY**

PROJECT NAME:
**DEMONSTRATION OF BATTERY-HYBRID ELECTRIC FERRY**

corvus energy

**Key Products/Services:** Lithium-ion energy storage systems

**Operating Since:** 2009

**SDTC Support:** 2011 to 2016

**Mission:** Energy provides purpose-built engineered energy storage solutions for marine, oil and gas, and port applications.

**Consortium Partner:**
• Wärtsilä Norway AS

**SDTC Funding:** $582,467

**Leveraged Funding:** $1,182,585

**Total Project Value:** $1,765,052

**For more information:**
**Corvusenergy.com**


*"SDTC played a crucial role in launching both Corvus and the entire maritime market for lithium-ion battery energy storage solutions. The credibility and funding that SDTC provided established the commercial viability and value proposition of our Canadian-based, advanced technology and manufacturing. We were able to execute as a true global player and integrate our solutions with locally developed technology to power the Folgefonn—one of the greenest, commercial maritime vessels operating today."*

***Andrew Morden***
*President and CEO*
*Corvus Energy*

CORVUS ENERGY'S BATTERY-HYBRID ELECTRIC FERRY DEMONSTRATION:

## At a Glance

Corvus Energy (Corvus) and Wärtsilä Norway AS (Wärtsilä) proposed to retrofit an operating coastal ferry in Norway with a Corvus battery system coupled with a Wärtsilä energy management system and electric-motor drive train. The fully electric ferry will increase safety and reliability over incumbent technology while reducing maintenance costs of existing systems and generators. In addition, a reduction of 700,000 litres of marine diesel fuel per year will generate considerable environmental benefits.

## The Opportunity

Battery-hybrid propulsion in marine vessels increases the energy efficiency of ships by optimizing the operation of their engines. Operating the engines at relatively constant and optimal power levels (i.e., load-levelling) allows for significant fuel savings and emissions reductions. While energy savings benefit all vessels, ships with frequently changing power loads and operational speeds have the most to gain through the adoption of hybrid technology.

Workboats—such as short-haul ferries or tugboats—spend a significant portion of their duty cycle maneuvering into position (relative to time spent operating at full power). Rather than sizing a diesel engine for peak power, hybrid systems allow for smaller, more economic engines. When full power is required, stored energy from batteries is used to provide additional power to the engines.

The use of hybrid systems in marine vessels addresses new emission regulations in Northern Europe and North America, reduces the need for fuel—lowering operating costs for operators—and correspondingly decreases GHG emissions and particulate matter. Moreover, changing consumer preferences for clean tech products are causing marine vessel operators to adopt cleaner and greener fuel alternatives. Corvus is filling a critical gap with the development of innovative hybrid and electric marine propulsion systems for large energy and power applications.

## Project Overview

The Corvus electric ferry project sought to retrofit an operating coastal ferry into a fully electric vessel and demonstrate its performance under normal operating conditions for six months. Together with a Wärtsilä energy management system and electric-motor drive train, Corvus has successfully retrofitted an operational ferry in Norway—the Folgefonn—with a one-megawatt lithium-ion battery pack that replaces the main drive engines.

Corvus will demonstrate zero-emission technology for coastal vessels using renewable power (i.e., hydro and wind) to charge an on-shore battery system that will in turn charge the onboard battery array, which will power the propulsion system and vessel house loads. The electric ferry will save 700,000 litres of marine diesel fuel per year reducing emissions by ~ 40 tons of NOx, 2,700 tons of CO2 and 1.2 tons of SOx yearly over incumbent technology; 2.7 tons of particulate matter emissions per year will also be nullified. The electric ferry is currently in operation for sea trials, data acquisition, and design validation.

### Energy Storage Systems

Corvus lithium-polymer energy storage systems (ESSs) are capable of large amounts of sustained power output—comparable to a diesel engine. The ESSs provide a number of benefits over the incumbent diesel-fueled engines, including load-levelling of power, blackout prevention, maintenance-cost savings, and a significant reduction of greenhouse gases and other harmful emissions. The Corvus ESS improves safety and reliability of the entire vessel, and provides a rapid return on investment for operators—the system pays for itself in less than five years.

Corvus ESSs are easily scalable, and custom sized to fit on any number of large marine vessels. For onboard installations, batteries are stacked, racked and fitted with cooling and control systems to ensure proper voltage, current, temperature and communications links.

### First-mover Advantage

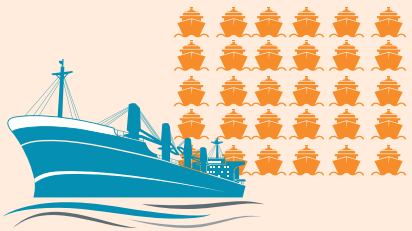
With humble beginnings in Richmond, BC, Corvus has effectively created a new market for next-generation, battery-hybrid systems for large marine vessels. Corvus systems are operational in 33 vessels, ranging across the whole spectrum of workboats, including tug boats, offshore supply vessels for oil rigs, ferries and fully electric fishing boats. Corvus has even made the leap into adjacent markets, creating hybrid cranes for port operations (i.e., moving containers); Corvus has 21 crane installations in the Port of Shanghai—the largest installations of hybrid-electric port equipment in the world. Corvus technology is continuing to grow and expand—all from the same roots as the initial SDTC project.

*Top Photo: AT6700 High Performance Energy Storage Module*

*Bottom Photo: Corvus Energy Storage System (ESS)*

## KEY FACTS

More than **TWO-THIRDS** of large commercial hybrid vessels utilize a Corvus ESS.



Corvus ESSs have been installed on more than 30 vessels and in over **50 MARINE PROJECTS WORLDWIDE.**

The MF Prinsesse Benedikte—a Danish ferry with a Corvus ESS— saved over **1M LITRES OF FUEL** as a hybrid vessel in its first year of operation. This equates to taking 800 medium-sized cars off the road for a year.


Corvus ESSs are now being used in Canada. Canadian ferry operator Seaspan will operate five battery-hybrid LNG cargo ferries on its routes, including passage between Vancouver and Vancouver Island.



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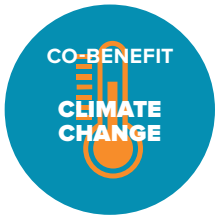



COMPANY NAME:
**WESTPORT INNOVATIONS INC.**

PROJECT NAME:
**NATURAL GAS LOCOMOTIVE**

Westport™
INNOVATIONS INC.

**Key Products/Services:**
Natural Gas Engines, Automotive Alternative Fuel Solutions, Fuel Storage and Delivery, Fuel System Components, Engineering Services

**Operating Since:** 1995

**SDTC Support:** 2011 to 2014

**Vision:** Creating a better world through innovative energy solutions.

**Consortium Partners:**
- Gaz Metro Solutions Transport S.E.C.
- Canadian National Railway Company Corp.
- Electro-Motive Diesel Inc.

**Associated Project:** Demonstration of use of Liquefied Natural Gas (LNG) and Westport fuel-injector technology in heavy-duty trucks

**SDTC Funding:** $2,302,834

**Leveraged Funding:** $16,450,810

**Total Project Value:** $18,753,644

**For more information:** Westport.com


*"We are extremely thankful to have received the funding from SDTC that allowed us to initiate the development of an HPDI fuel system that utilized natural gas as a replacement for diesel fuel for locomotives. As a direct result of this project, we also had the subsequent opportunity to add our HPDI systems to large mining trucks. Without SDTC's support, Westport may have missed out on both of these opportunities to develop economically sound and environmentally beneficial technologies."*

***Thom Rippon***
*Executive Vice President, Global Engineering*
*Westport*

WESTPORT'S NATURAL GAS LOCOMOTIVE PROJECT:

## At a Glance

Westport's natural gas locomotive project proposes to significantly improve the cost structure of rail operations while delivering positive environmental impacts. Through the development of High Pressure Direct Injection (HPDI) natural gas locomotives, Westport and its consortia partners are providing the rail industry with an alternative product that utilizes low-carbon fuel, complies with criteria-air-contaminants emissions regulations, and reduces greenhouse gas (GHG) emissions by approximately 20 per cent. With liquefied natural gas (LNG) typically delivered at a cost lower than that of diesel fuel, operators utilizing the natural gas locomotive can expect material fuel cost savings.

## The Opportunity

When looking at fuel usage, the highest fuel consumption occurs in high-horse-power vehicles—those operating in the mining, marine and rail industries, respectively. Approximately one fifth of Canada's energy-related GHG emissions result from industrial freight transportation with emissions from this sector predicted to increase by 13 per cent per year. Moreover, the rail industry was seeing the gap between the price of diesel and that of natural gas increase steadily year after year.

For Westport three key factors influenced their decision to pursue the opportunity for a natural-gas-fueled locomotive:

1) A strong demand for cheaper, cleaner, natural gas for high-horsepower applications;
2) an expressed interest in the project from Canadian National Railway Company (CN Rail);
3) and previously developed and proven HPDI technology in the heavy-duty trucking sector.

## Project Overview

Together with CN Rail, Electro-Motive Diesel (EMD) and Gaz Metro, Westport started work on a project that would deliver an LNG fuel system for locomotives. (While Westport developed the fuel system, EMD performed locomotive engineering, CN provided customer input and assisted wtih locomotives and tenders, and Gaz Metro was responsible for LNG fuel provision.) More than just a demonstration project, the HPDI natural gas engine would need to be proven in a cell before installation in a locomotive; it would need to match diesel power, torque and efficiency. There were also environmental targets: the engine would have to meet U.S. Tier 3 emissions or better (Tier 4 emissions were mandated in 2015) and reduce GHGs by at least 20 per cent as compared to diesel.

In developing the product, Westport had to design and develop an on-engine fuel system, which included injectors, a fuel-conditioning module, controls, fuel rails and an adaption of a diesel pump. In order to maximize system development, Westport built a custom rig capable of simulating a large engine, which allowed for testing to be performed at Westport facilities while running the engine in the test cell at EMD.

The demonstration was successful. The EMD engine is now operating on HPDI, and full power has been achieved in the test cell. The engine met Tier 3 regulations, fuel-efficiency and GHG-emissions targets. Further product testing will continue before the locomotive is brought to rail—tens of thousands of test hours will go into testing components and making improvements to create a robust and reliable end product.

### The Technology

While other technology choices for locomotives (e.g., spark-ignited, dual-fuel, port-injected micro pilot) were being examined by rail operators seeking improvements over the incumbent diesel engines, they all had their drawbacks vis-a-vis HPDI natural gas. Direct injection of high-pressure natural gas solved many of the issues seen in competing technologies—it could act as an excellent substitute fuel for diesel, able to maintain engine efficiency while reducing GHG emissions.

### The Tender

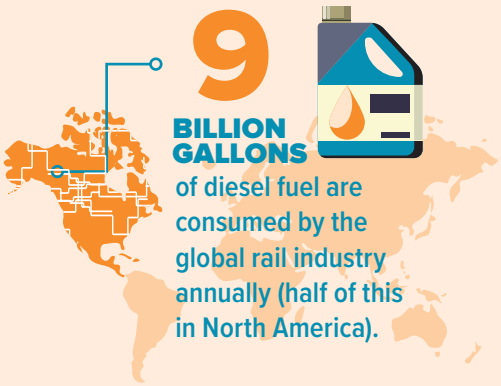
In parallel to locomotive development, Westport also initiated the development of a cryogenic off-engine system for use on the tender that would provide pressurized gas to the locomotive. While the natural gas locomotive engine was successfully demonstrated, the high-pressure tender that is needed to supply an HPDI natural gas locomotive with fuel is still under development. With further regulatory discussions and approvals required, Westport has temporarily switched gears and is developing dual-fuel tenders that are the accepted and approved bridging technology of the day. To date, Westport has delivered its first low-pressure tender (for dual-fuel applications) to CN Rail.

### Successful Partnerships

Expanding the application of HPDI technology in the high-horsepower sector, in June 2012, Westport announced a partnership with Caterpillar Inc. (CAT) to develop HPDI natural gas off-road equipment. Locomotives and mine haul trucks fitted with Westport-derived technology are currently being developed into commercial products.

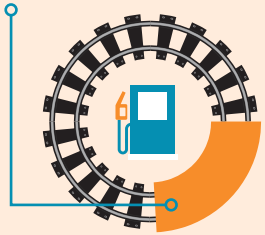

*Photo: Westport and EMD team members pose at the EMD facility in Lagrange, Illinois.*

## KEY FACTS



**9 BILLION GALLONS** of diesel fuel are consumed by the global rail industry annually (half of this in North America).

Fuel represents approximately **24% OF U.S. RAILROAD OPERATING COSTS.**



**20% LESS GHGs**

LNG vs DIESEL

Usage of HPDI LNG engines vs. diesel engines in the rail industry would lead to GHG reductions of approximately 20%.

Every HPDI natural gas locomotive that displaces a diesel locomotive will deliver GHG reductions of up to 500 tonnes per year.

**GHG REDUCTION OF 500 TONNES PER YEAR**



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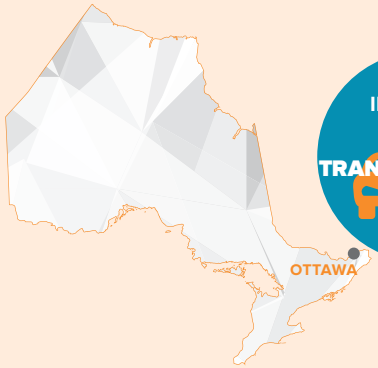
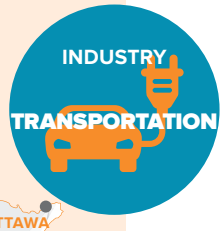
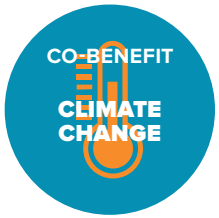







COMPANY NAME:
**GAN SYSTEMS INC.**

PROJECT NAME:
**LOW-COST GALLIUM NITRIDE POWER DEVICES FOR HIGH EFFICIENCY INDUSTRIAL BATTERY CHARGERS**

GaN Systems

**Key Products/Services:** Gallium nitride high-power transistors

**Operating Since:** 2008

**SDTC Support:** 2015 to present

**Vision:** GaN is the technology that will allow the implementation of essential future clean tech innovations where efficiency is a key requirement.

**Consortium Partner:**
• Delta-Q

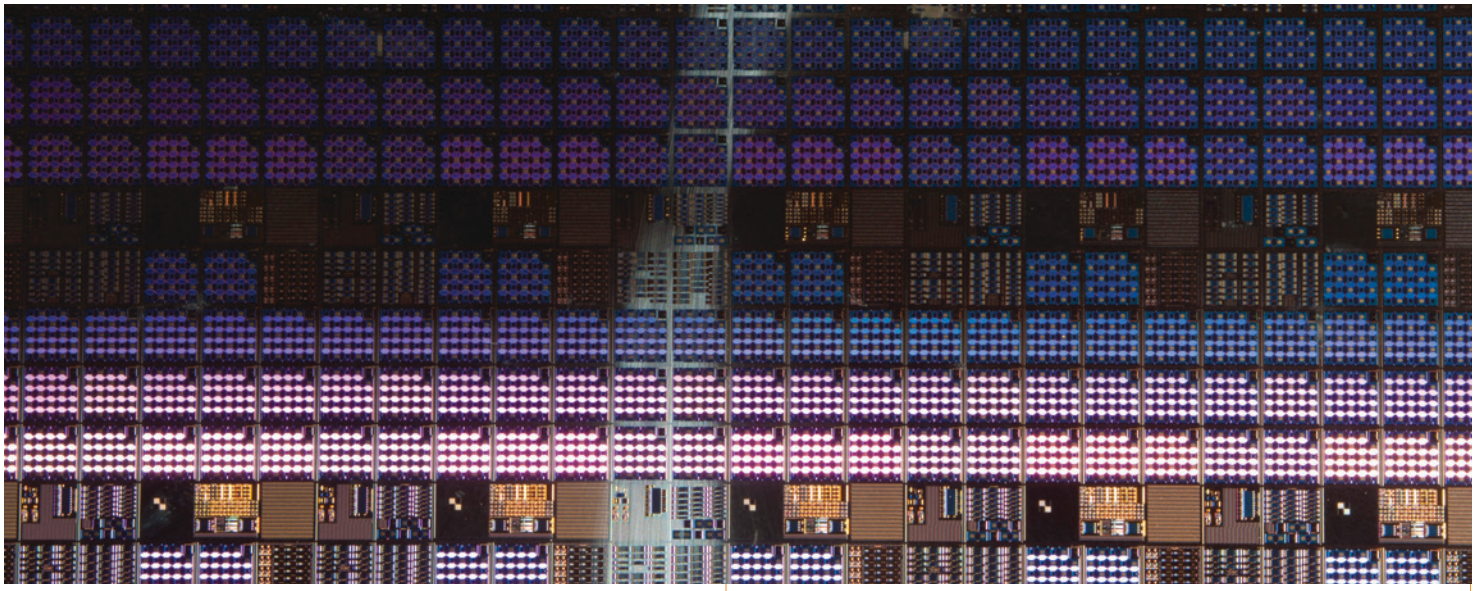
**Associated Project:** High efficiency GaN systems for transportation

**SDTC Funding:** $2,187,971

**Leveraged Funding:** $4,442,251

**Total Project Value:** $6,630,222

**For more information:**
**www.gansystems.com**



*"We are delighted with the announcement of our $2.2-million in funding from the Government of Canada and SDTC in support of the further application of our gallium nitride power transistors. In conjunction with Delta-Q, we will develop real-world solutions for electric drivetrains with immediate applicability to a wide range of energy-saving transportation. SDTC support is incomparable; beyond its funding, the disciplines and credibility that SDTC brings to our internal processes is invaluable. The mark of approval that comes with an SDTC grant and the associated due diligence process, are readily noted and appreciated by sophisticated investors."*

***Girvan Patterson***
*President*
*GaN Systems Inc.*

GAN SYSTEM'S LOW-COST GALLIUM NITRIDE POWER DEVICES FOR HIGH EFFICIENCY INDUSTRIAL BATTERY CHARGERS:

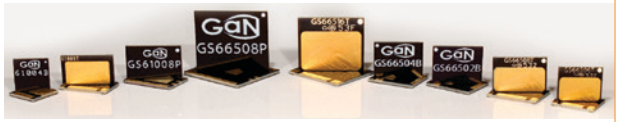
## At a Glance

Each electric vehicle utilizes a charger in order to connect its battery to a power source. This project demonstrates a new technology that improves the efficiency of the charger and reduces the vehicle's weight (if installed on-board), thereby maximizing the range of the vehicle while lowering its operating costs. GaN Systems and Delta-Q Technologies are working on a battery charger for industrial electric vehicles that uses a breakthrough material, gallium nitride, for the purposes of power conversion. Compared to silicon, gallium nitride operates at a higher frequency and more efficiently, significantly reducing wasted heat generated during the power-conversion process.

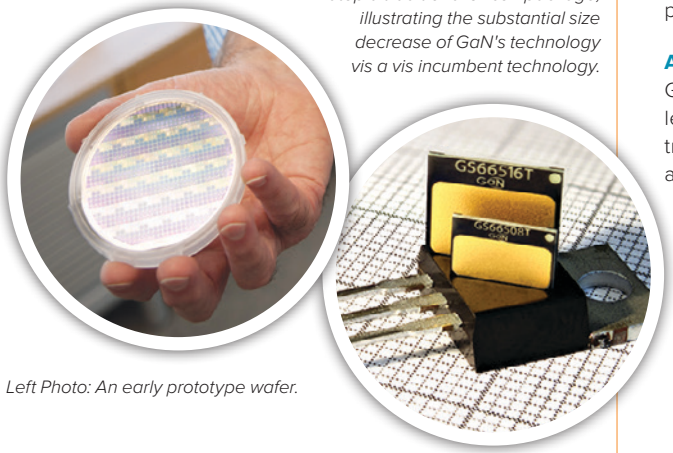
## The Opportunity

Whenever power has to flow from its source to destination, some form of conversion system is necessary. As new sources of energy are explored—wind, tides, bio-fuels—the need increasingly arises for ever more efficient conversion to link the power into power grids for distribution to the user. Gallium nitride (GaN), with its higher power and temperature capabilities, and hence efficiency, creates the next generation of power control systems that will make these new sources viable.

*Photo: GaN transistor family.*




*Right Photo: GaN's devices are posed atop a traditional silicon package, illustrating the substantial size decrease of GaN's technology vis a vis incumbent technology.*




*Left Photo: An early prototype wafer.*

## Project Overview

GaN Systems has developed power transistor designs that utilize gallium nitride on a silicon substrate. The resultant technology is much more efficient than the incumbent silicon-on-silicon transistors and semiconductors—the industry standard for the past quarter-century.

In speed, temperature and power handling, gallium nitride is set to take over as silicon power devices reach their limits, enabling the implementation of essential future clean tech innovations where electrical efficiency is a key requirement. By incorporating GaN-based transistors in mobile battery charging units—for scooters, golf carts, forklift trucks and the like—GaN Systems hopes to develop a charging unit that can be carried on board the vehicle. This would allow the unit to be charged anywhere, and not necessitate the connection to a dedicated external charger, as is the case today.

Currently, GaN-on-silicon carbide transistors are expensive to manufacture, and can't be easily mass-produced. GaN Systems has already proven that gallium nitride transistors can be built on a substrate of silicon far less expensively than on silicon carbide substrates, at a cost of $20 per wafer versus $5,000 per wafer. To advance commercialization, GaN Systems must now prove that a vehicle charger—in this case, for a golf cart—can be produced using GaN-on-silicon semiconductors; that it can be more efficient than a silicon-on-silicon charger; wcan be light enough to mount directly on the vehicle, rather than as part of an external charging station to which the vehicle must be returned for charging; and ultimately, that the technology can be scaled up sufficiently to be incorporated into electric cars.

GaN Systems has teamed up with Vancouver-based Delta-Q Technologies—a leading global supplier of industrial battery chargers—for a side-by-side comparison of the charging efficiency of a GaN-on-silicon charger versus a charger, which incorporates conventional silicon power conversion technology. The testing program is expected to launch soon in Wyoming.

### Applications

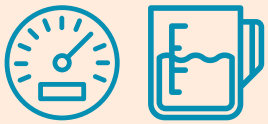
GaN-based transistors are increasingly positioned to disrupt the $15-billion power transistor market, and GaN Systems is one of the clear leaders in realising this potential. The company's innovative Island Technology® results in devices that are smaller and more efficient than traditional silicon design approaches. Its products enable previously unseen switching efficiencies that lead to more sustainable energy use and increased power efficiency, while reducing costs and environmental impacts of some of the world's fastest growing industries.

GaN Systems' breakthrough power electronics transistors can be used for a wide range of applications, from more efficient data centers and solar inverters; to thinner TVs and smaller, more powerful motors; to longer-range electric vehicles; and to a multitude of other consumer, enterprise, industrial and transportation applications.

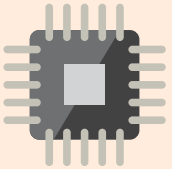
## KEY FACTS

GaN-based power conversion is rated at **99% EFFICIENCY**, compared to 90% to 95% efficiency for silicon-based conversion.

GaN's technology can **CUT POWER LOSSES INCURRED** during the charging of a battery by **50%**.



GaN's technology promises an **80% REDUCTION** in system volume and weight.



Compared to silicon, GaN offers **10X HIGHER ELECTRICAL BREAKDOWN CHARACTERISTICS**, **3X THE BANDGAP**, and exceptional carrier mobility.



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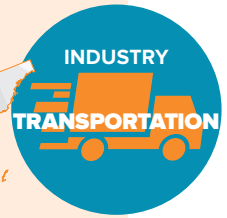
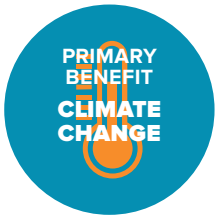




COMPANY NAME:
**EFFENCO HYBRID SOLUTIONS**

PROJECT NAME:
**LARGE SCALE DEMONSTRATION OF AN ENGINE-OFF HYBRID SYSTEM FOR HEAVY-DUTY UTILITY TRUCKS**

effenco HYBRID SOLUTIONS

**Key Products/Services:** Design, manufacture and market energy-management systems for heavy (greater than 15 tons) vocational vehicles

**Operating Since:** 2006

**SDTC Support:** 2012 to 2014

**Mission:** Effenco develops the world's most flexible and efficient heavy vehicle hybrid solutions to reduce fleet fuel costs and GHG emissions.

**Consortium Partners:**
- Waste Management Inc.
- Grundon Waste Management Limited
- Refuse Vehicle Solution Ltd.
- Department of Sanitation of New York City
- Waste Industries LLC
- Panda Waste Management Solutions
- BFI Canada inc.
- City of Edmonton
- Biffa Municipal Limited

**Associated Project:** Hybrid Refuse Truck

**SDTC Funding:** $1,780,188

**Leveraged Funding:** $4,049,276

**Total Project Value:** $5,829,464

**For more information:** effenco.com


*"We love SDTC. They are a key player in the clean technology development ecosystem and their contribution allows SMEs like Effenco to innovate at the pace required meet the technical and commercial expectations of the market. We can be daring and innovate as fast as we can; it is a considerable competitive advantage."*

*Colin Ryan*
*CEO*
*Effenco Hybrid Solutions*

EFFENCO'S ACTIVE STOP-START™ TECHNOLOGY:

## At a Glance

Effenco's Active Stop-Start technology automatically shuts down the engine of a heavy-duty truck or bus when immobile and restarts it on demand. Electrical energy is thereby stored and then dispatched to power the vehicle's equipment when the engine is turned off. Vehicles equipped with the Effenco system, therefore, don't burn fuel when the vehicle is immobile—resulting in considerable fuel savings; nor do they produce any emissions—resulting in the reduction of harmful GHGs.

## The Opportunity

Vocational vehicles are some of the least efficient vehicles on the road today. Garbage trucks spend 50 to 60 per cent of their time immobile, during which time they use only two to five per cent of the engine's rated power to operate the hydraulic systems necessary to lift bins and compact waste. Because engines are sized according to their needs for propulsion, in the case of heavy vocational vehicles, they are grossly oversized for auxiliary loads (i.e., lifting and compacting).

It's no secret that internal combustion engines lack efficiency and contribute significantly to the world's GHG emissions. Effenco's principals saw the opportunity to utilize the engine only when needed to propel the vehicle. Using Effenco's technology, auxiliary loads are powered with stored electrical energy recovered from braking (or borrowed from the engine when the vehicle is in motion). In this fashion, parasitic energy wasted from engine and transmission friction is eliminated, improving the efficiency of heavy vocational vehicles while creating tremendous environmental upside.

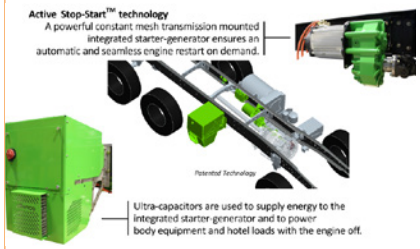
## Project Overview

Effenco's development of a Stop-Start platform evolved from the analysis of several terabytes of data—the company collected information from 120 vehicles in North America and Europe, representing more than two million kilometres of urban-driving data. Effenco approached 11 fleets in four countries to participate in the SDTC-funded demonstration of the technology.

Armed with the resulting analytics, Effenco was able to create and then optimize their Stop-Start platform. Effenco collected data over a period of three years; the length of the project allowed for several upgrades and refinements to the original technology, continually bettering the system. What started out as a bulky, not particularly elegant Stop-Start system was upgraded several times throughout the length of the project and is now smaller, lighter and less expensive—a well-adapted, well-engineered package that fits readily and handily on a variety of vehicles.

### The Technology

Effenco's Active Stop-Start technology is now operationally optimized, packaged and integrated. It is a commercially viable, state-of-the-art technology with proven results in the vocational vehicle business. The Stop-Start unit fits seamlessly on the rail of a truck and readily interfaces with the truck's own operating systems.




### Global Customer Base

With customers in Canada, the U.S., England and Ireland, Effenco is bringing its hybrid system to fleet operators in both private and public sectors. Often spurred by environmental incentives and government grants for cleaner operations, fleet operators are becoming increasingly convinced by Effenco's environmentally and economically compelling technology.

As the leading technology in the market, Effenco has the first mover advantage. SDTC funding has allowed Effenco to quickly move from technology development to deployment to commercialization. Furthermore, the company has been able to win one of the world's most important technology contests in heavy duty vehicle efficiency; Effenco's technology as selected as the most suitable for New York City's fleet of 2,230 refuse collection vehicles. Deliveries will start in the spring of 2016 with seven vehicles planned for dispatch throughout the city. In Europe, Effenco has negotiated its first OEM agreement with British custom vehicle manufacturer Dennis Eagle—Effenco's Active Stop-Start platform will soon be available as a factory-installed option across 14 different European countries.

### Moving Beyond Refuse Vehicles

Terminal tractors are another key market segment for Effenco's technology. These vehicles move containers around ports and run 24/7. As shift vehicles, they present a very compelling proposition for manufacturers as they have a much faster rate of return on capital outlays for technologies such as Effenco's Stop-Start system. With a simple supply chain—80 per cent of terminal tractors are produced by five manufacturers—the market has proved easy for Effenco to broach. An early trial with Sobey's proved highly effective and orders for terminal tractor kits are growing at four times the rate of those for garbage fleets. With early adopters such as Purolator and Cascades, it is a market that offers the potential for exponential growth.

## KEY FACTS

Effenco's Active Stop-Start technology is estimated to reduce a garbage truck's annual $CO_2e$ emissions

**BY 19 TO 28 TONS.**

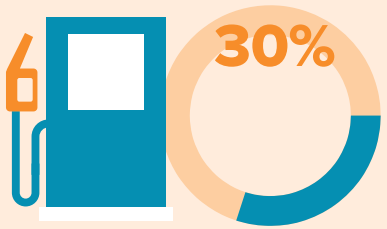
**REDUCTION IN GHG EMISSIONS**

By the end of 2020, the yearly cumulative GHG emissions reduction could reach 25 kt $CO_2e$ in Canada and 250,000 kt $CO_2e$ in the rest of North America and Europe.

**$NO_x$ AND $PM_{2.5}$ ↓ 25%**

The use of Effenco's technology contributes to improved air quality by reducing emissions of $NO_x$ and $PM_{2.5}$ by 25%.

Effenco's Stop-Start units reduce energy losses related to idling, resulting in estimated fuel savings of as much as 30%.



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INDUSTRY
WASTE MANAGEMENT

PRIMARY BENEFITS
CLEAN AIR

CO-BENEFIT
CLIMATE CHANGE

CLEAN WATER

CLEAN SOIL

COMPANY NAME:
**MINESENSE TECHNOLOGIES LTD.**

PROJECT NAME:
**SCALABLE NICKEL/COPPER WASTE-RECLAMATION SOLUTION**

minesense

**Key Products/Services:** Mineral-sensing platforms for belt- and shovel-based systems used in mining operations

**Operating Since:** 2009

**SDTC Support:** 2011 to 2014

**Mission:** Enhancing the sustainability of mining by improving the ore extraction and metal recovery process.

**Consortium Partners:**
- Canadian Arrow Mines Ltd.
- Lions Gate Metals Inc.
- BHP Billiton

**SDTC Funding:** $4,435,794

**Leveraged Funding:** $9,006,006

**Total Project Value:** $13,441,800

**For more information:** **minesense.com**

*"In a way, SDTC was our first real investor. The grant money we received from SDTC to fund the pre-commercial gap in our sensor technology was instrumental in helping us close our first round of external venture financing."*

***Andrew Bamber***
*Founder and CTO*
*MineSense*

MINESENSE TECHNOLOGY:

## At a Glance

MineSense is a technology development and marketing company specializing in sensor-based bulk mineral sensing and sorting solutions. The company's High-Frequency Electromagnetic Spectrometry (HFEMS) and High Speed XRF sensing technology measure the amount of a given mineral at the point of extraction, allowing for better sorting of the rock (based on mineral content) prior to processing, thus saving costs and requiring less energy for the process. Environmental benefits are realized through the prevention of ground and groundwater contamination via acid-generating ores left in the mining waste stream.

## The Opportunity

The mining industry is a key, but often underserved, sector for cleantech development. Mines are both capital and energy intensive, and produce enormous amounts of waste rock every day. In order to get at the "pay" rock or "ore", a mining operation must move and dispose of a large amount of waste rock. Using conventional processes, the extracted ore can still contain significant amounts of waste dilution. Further, waste rock can also often contain sufficient levels of minerals that when left in waste piles not only represent a missed economic opportunity for mine operators but also have negative environmental impacts—soil contamination and leaching can occur as acid-generating minerals acidify over time, potentially releasing metals into the groundwater.

The MineSense technology proposes to tackle both the economic and environmental pitfalls of traditional mining extraction methods. Using MineSense technology in their operations, mining companies can recover lost ore in waste, as well as remove residual waste in ore at source, reducing both dilution and losses. Mines benefit from increased metal recovery, longer life of mines and decreased environmental impact. The technology could increase the total value of a mining operation by as much as 50 per cent, as well as revive mines considered to be at "end of life" with a more accurate assessment and classification of mined mineral content.

## Project Overview

The initial MineSense project sought to use sensor technology—that was able to detect nickel and copper with extreme sensitivity, precision and accuracy—to recover remnant ore from post-closure or active-mine waste dumps. In the process of reclaiming the value of the residual metal, MineSense was also reducing the environmental impact and liability of the dumps by significantly lessening the potential for soil contamination and metal leaching from unrecovered ores. Further, new feeds for the mines were created—via the reclaimed ore from waste material—that could now be recovered at lower intensities than freshly mined material.

### The Technology

Whereas the initial MineSense technology was belt-based, scanning waste to recover high-metal content rock and rejecting the rest, MineSense has since developed a game-changing, shovel-based sensing and sorting system: ShovelSense™. This first-of-its-kind technology is able to make relevant measurements and decisions for mined material (e.g., "accept or reject") during loading, providing four distinct benefits to mining operations.

The shovel-based technology:

1) provides measurement of ore quality at point of extraction;
2) uses that measurement to support a sorting stage of valuable vs. non-valuable materials at a throughput that's relevant to base-metal and ferrous mines;
3) reduces waste content in mill-feed material at source thereby providing energy and cost saving benefits;
4) and reduces ore losses to waste, creating value from ore that would have previously been left in situ or gone to waste.

### Shovels and Sensors: a Tricky Mix

Sensors are delicate and fragile while shovels are big, rough and tough. Pairing the two posed distinct challenges. MineSense focused and refined their sensing technology in order to more easily adhere to loading assets such as shovels. In doing so, they had to consider fundamental product features such as shock resistance (to the order of ±50g), temperature (±40˚C), and moisture resistance relevant to shovel buckets. Measurement range and speed capabilities were also factored; the MineSense technology can measure and report ore quality in buckets at a range of a metre or more in real time.

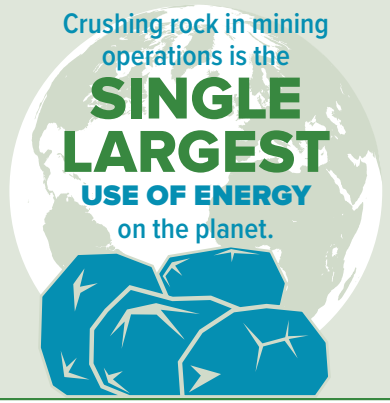
### Applications

The technology has undergone rigorous testing in lab and at partner facilities. With the support of SDTC, the technology is also undergoing commercial trials at a British Columbian copper mine. With another phase of testing planned, MineSense hopes to roll out its technology commercially to copper, copper/gold, nickel and ferrous metal mines in Canada, the U.S., Australia, Chile and South Africa. With a massive market in Canada and an even larger export market, the technology stands to deliver double economic benefit to Canada and Canadians.

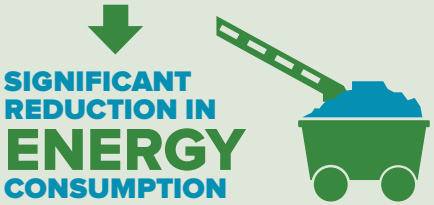
*Left Photo:*
*Loading of iron ore*

*Right Photo:*
*Rock crusher in surface mine*

## KEY FACTS




The mining industry moved
**SIX BILLION**
**TONS OF ROCK**
in 2015.

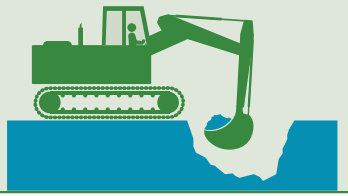


**SIGNIFICANT REDUCTION IN ENERGY CONSUMPTION**

The MineSense technology removes waste that would cost between 16 to 20 KW/h per ton of material to grind, significantly reducing the energy used in mining operations.

Shovel-based sensing could save a typical base-metal operation mining 10,000 tons of ore per day as much as

**15 GWH/YR OR 8.16 MT $CO_2$E/YR.**





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INDUSTRY
WASTE MANAGEMENT

PRIMARY BENEFITS
CLEAN AIR

CO-BENEFIT
CLIMATE CHANGE

CLEAN WATER

CLEAN SOIL

COMPANY NAME:
**OSTARA**

PROJECT NAME:
**NUTRIENT RECOVERY COMMERCIAL DEMONSTRATION PROJECT**

OSTARA

**Key Products/Services:**
Nutrient Recovery Process, Root-Activated™ Fertilizer

**Operating Since:** 2005

**SDTC Support:** 2005 to 2007

**Mission:** Ostara helps protect precious water resources by changing the way cities around the world manage excess nutrients in water streams and by producing a fertilizer that significantly reduces the risk of leaching and runoff, further protecting adjacent waterways.

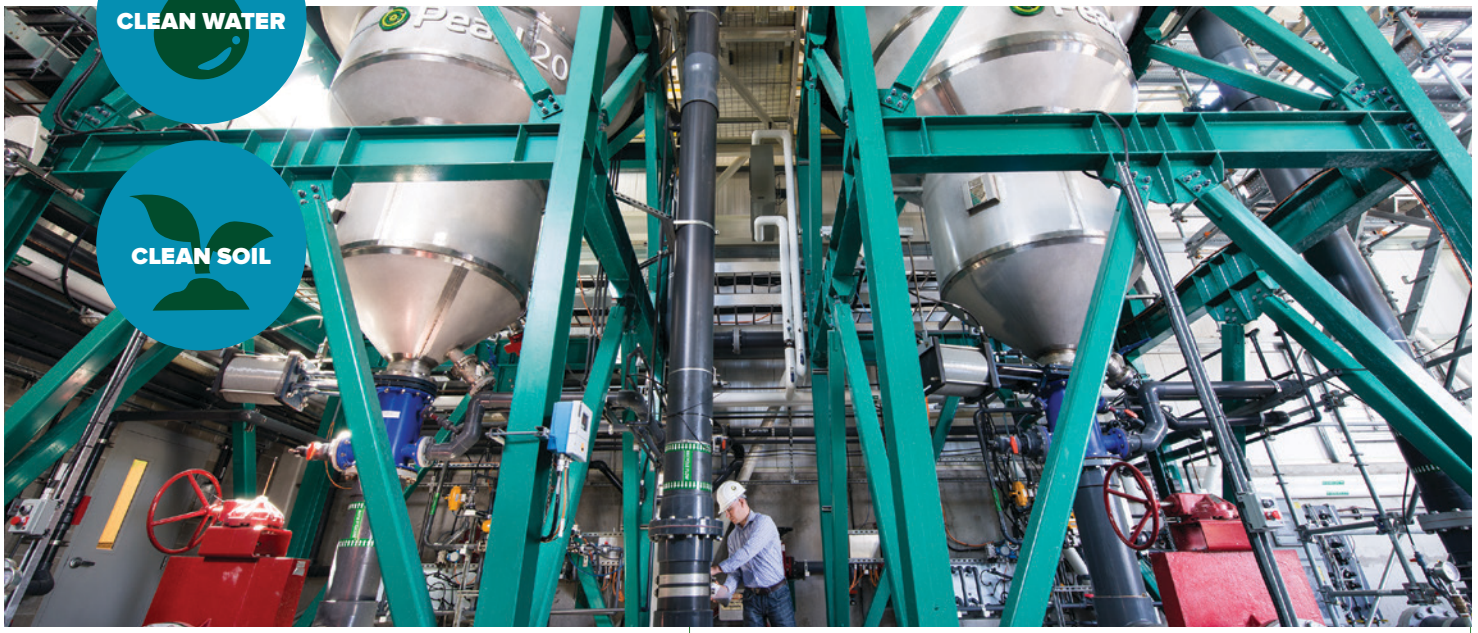
**Consortium Partners**:
- British Columbia Ministry of Environment (BC - MOE)
- City of Edmonton
- NORAM Engineering

**SDTC Funding:** $375,760

**Leveraged Funding:** $1,401,868

**Total Project Value:** $1,777,628

**For more information:** **ostara.com**



*"It's hard to convince a conservative customer base, like municipalities, to buy something new if it's only at laboratory scale. Getting that project [nutrient recovery demonstration facility] together was very beneficial for us, as we were able to scale up the technology from lab to commercial scale by a factor of 100 in only two years. SDTC's support came at the right time."*

***Philip Abrary***
*CEO, President and Co-founder*
*Ostara*

OSTARA'S NUTRIENT RECOVERY SYSTEM:

## At a Glance

Ostara has successfully developed and commercialized a technology that recovers nutrients from wastewater streams and transforms them into an environmentally safe, continuous-release fertilizer. In addition to sustainably recovering otherwise polluting nutrients, the fertilizer produced from the process releases in response to plant demand, reducing the risk of leaching and runoff, further protecting waterways. Ostara's nutrient recovery technology is both economically feasible and environmentally sound, providing a win-win solution for wastewater treatment plants.

## The Opportunity

Wastewater treatment plants (WWTPs) have long been on the front line of defense against nutrient pollution. As point sources of easily and readily measured nutrient discharge, the opportunity existed to improve plant performance in such a manner as to positively impact the environment. Turning WWTPs into resource recovery centers—where water, energy and nutrients are recovered and recycled—dynamically changes the face of a sector previously seen as one that contributed to the pollution of water, air and land.

Ostara's nutrient recovery technology seeks to improve the performance and operation of WWTPs. Designed to recover phosphorus—a non-renewable resource needed to feed the planet—the technology solves a significant environmental issue while solving a common nuisance problem (the build-up of struvite in pipes) in municipal WWTPs; traditional methods of removal and dumping of nutrients are costly, and neither elegant nor environmentally sound.

Ostara's solution, where excess nutrients are not viewed as waste but as a useful byproduct, presented a lucrative business model for the company. Ostara is able to sell both the innovative technology to solve WWTPs' operational and environmental problems and also benefit from a second revenue stream created through the sale of the process byproduct. Ostara buys back the fertilizer from the WWTPs and sells it through their marketing and distribution network within the agricultural, turf and ornamental industries, providing a share of the revenue to the municipality or WWTP operator.

## Project Overview

SDTC provided early support to Ostara, helping the company demonstrate its nutrient recovery technology, previously only seen in pilot form at the Greater Vancouver Regional District's Lulu Island wastewater treatment plant and at the City of Penticton's advanced wastewater treatment plant. Scaling up the technology by a factor of 100, in 2007, Ostara launched a demonstration facility at the City of Edmonton's Gold Bar Wastewater Treatment Facility. The project not only proved the successful scale-up of the company's nutrient recovery technology to commercial scale but also demonstrated the production of a highly pure byproduct of the process, a Root-Activated™ phosphorus fertilizer.

### The Technology

Ostara's proprietary technology recovers phosphorus and nitrogen from treated wastewater streams by providing a controlled setting within a fluidized bed reactor in which the nutrients crystalize and grow into highly pure fertilizer granules. Once they reach the desired size, they are harvested, dried, bagged and distributed under the brand name Crystal Green®.

### Crystal Green®

Unlike conventional phosphate fertilizers, which release nutrients upon watering or irrigation, Crystal Green is virtually water insoluble and releases phosphorus in response to organic acids produced by growing roots, fertilizing plants on demand. Ostara is now producing Crystal Green, marketing and distributing the fertilizer to large-scale agricultural producers, golf courses and turf/sod producers.

### Successful Demonstration leads to Fast Commercialization

Due to the successful demonstration of its nutrient recovery technology in Edmonton in 2007, Ostara was able to attract clients throughout North America and Europe. Within one year of demonstration, Ostara signed its first commercial contract with the City of Tigard, Oregon. The client, Clean Water Services, is one of the most progressive and highly rated utilities in the USA. The forward-thinking facility was an early adopter of the technology and successful operations there led to other opportunities for Ostara. To date, the company has commercially launched seven facilities in North America, one in Europe, and is preparing to bring six more on line in 2016, including the world's largest nutrient recovery facility in Chicago. Coming full circle, Ostara will also launch a full-scale plant in Edmonton that will be 20 times the size of the original demonstration facility when it opens in Spring 2016.

## KEY FACTS

PEARL

Ostara's Pearl® Process resolves issues and provides a comprehensive approach to nutrient management.

**85% LESS PHOSPHORUS**

**40% LESS NITROGEN**

The Pearl process removes up to 85% of the phosphorus and 40% of the nitrogen that would otherwise cycle back to a WWTP.

**INCREASED NUTRIENT PRODUCTION**

Granules of the recovered nutrients are produced by the Pearl process and grow in diameter from 0.9 mm to 3.0 mm before they are dried, "harvested", bagged and sold to agricultural, golf course, and turf consumers as a fertilizer called Crystal Green®.

**14 FACILITIES WORLDWIDE**

Ostara has 14 commercial facilities in operation around the globe.



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INDUSTRY
WASTE MANAGEMENT

PRIMARY BENEFIT
CLEAN WATER

CO-BENEFITS
CLEAN AIR

CLIMATE CHANGE

COMPANY NAME:
**SALTWORKS TECHNOLOGIES INC.**

PROJECT NAME:
**LOW-ENERGY, LOW-COST DESALINATION: OIL SANDS DEMONSTRATION WITH GLOBAL APPLICATIONS**

Saltworks

**Key Products/Services:**
ElectroChem High Recovery Desalination System and SaltMaker True Zero Liquid Discharge System

**Operating Since:** 2008

**SDTC Support:** 2009 to 2016 (over two projects)

**Mission:** To be the world's best water technology company, treating the world's most highly impaired waters.

**Consortium Partner:**
• EPCOR Utilities Inc.

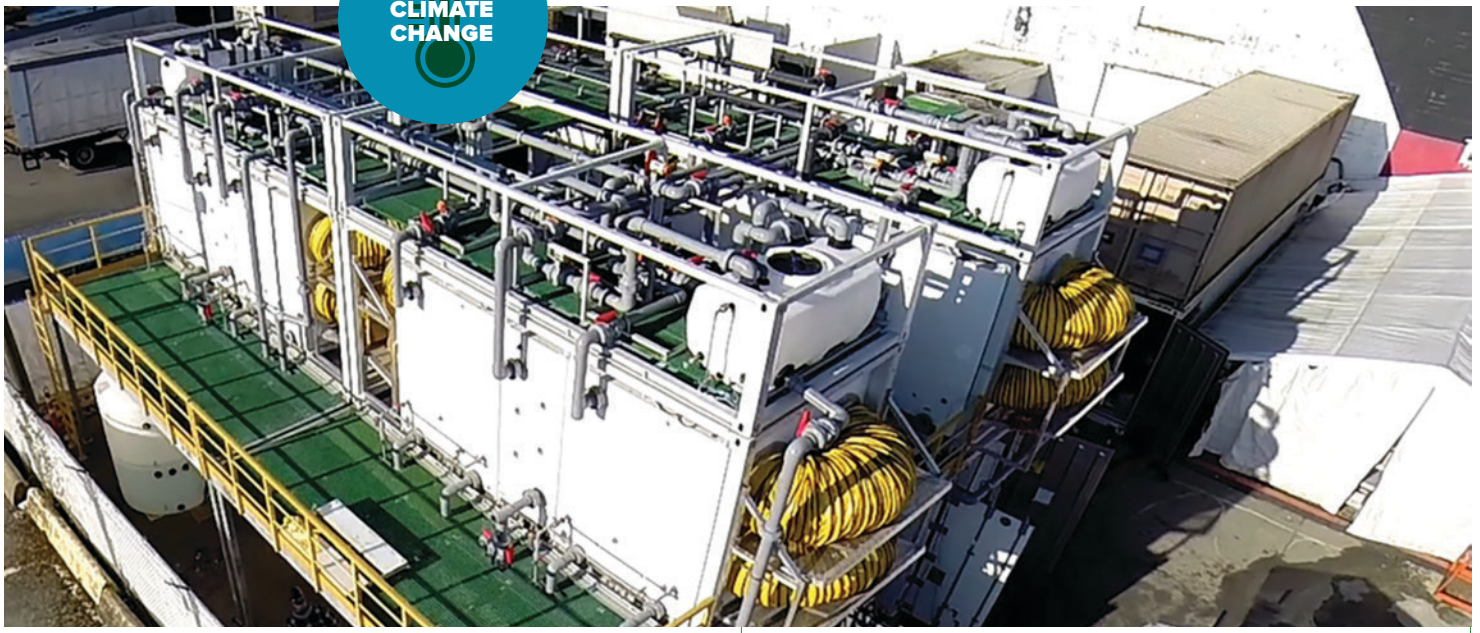
**Associated Project:** Low-energy desalination demonstration

**SDTC Funding:** $2,500,000 ($5,112,638 for two projects)

**Leveraged Funding:** $5,000,000 ($10,451,384 for two projects)

**Total Project Value:** $7,500,000 ($15,564,022 for two projects)

**For more information:**
**www.saltworkstech.com**



*"SDTC support has helped Saltworks develop and commercialize advanced water-treatment solutions much needed by industry. Our SaltMaker and ElectroChem technologies treat wastewaters to produce freshwater for a range of applications while reducing waste, energy requirements, and emissions. Saltworks is proud to have SDTC behind these green and more cost effective technologies, which are creating high tech jobs while helping Canadian industry improve competitiveness and lower environmental impact. With SDTC's support, Saltworks and Canada can become world leaders in water treatment."*

***Joshua Zoshi***
*President and Founder*
*Saltworks Technologies Inc.*

SALTWORKS' ELECTROCHEM AND SALTMAKER SYSTEMS:

## At a Glance

Steam-assisted gravity drainage (SAGD) uses steam to soften underground oil sands, separating oil and sand in a process that is both energy and water intensive. Saltworks has worked with industry to develop the ElectroChem ion exchange membrane system, a low-energy and chemical-free softening process that eliminates some minerals from brackish water to increase freshwater recovery, and the SaltMaker, which harnesses waste heat to separate water normally discarded as part of the SAGD process ("blowdown") into freshwater and solid salt. The technologies were developed with, and piloted by, oil sands partners and are now being exported internationally to treat landfill leachate, smelter discharges and shale gas waters.

## The Opportunity

Water use in industrial applications is becoming an increasing concern from a number of perspectives. Disposal of produced water, flowback, blowdown and contaminated process water is expensive and removes vast volumes of scarce water from the hydrology cycle. Many purification and recycling technologies currently being used are also expensive and yield a large environmental footprint. Saltworks' advanced desalination technologies—making fresh water from some of the world's toughest salt waters—offer inexpensive solutions to reuse water and protect the environment from a wide variety of industrial waste waters generated by the mining and oil and gas industries.

*Left Photo: SaltMaker Evaporator Crystallizer operating at a landfill in the USA treating landfill leachate.*

*Right Photo: Operation of a SaltMaker Evaporator Crystallizer wastewater treatment pilot plant.*

## Project Overview

SDTC has been working with Saltworks since 2009, when it helped the company develop a low energy seawater desalination pilot plant at Port Metro Vancouver. The technology used dry air and low-grade thermal energy—commonly found in abundance in seaside areas—to turn salt water into fresh water.

After developing and piloting the thermo-ionic system, Saltworks worked with industry to adapt the innovation for industrial use, which resulted in the original desalination process being split into two parts: an electrochemical membrane system to change water chemistry, called ElectroChem, and the SaltMaker. The electrochemical process uses specialized membranes to change water chemistry and removes about 95 per cent of the salt or other contaminants from water. The SaltMaker squeezes the remaining five per cent of salt—or other contaminants—from the water and leaves behind fresh water and a solid that can be landfilled or, depending on its properties, used in other industrial processes.

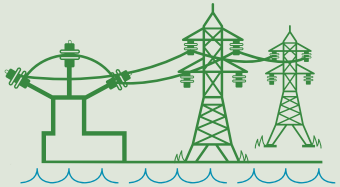
### The Uptake

As Saltworks refined its thermal-ionic desalination process, industry began to pay attention. The oil and gas industry was interested in using Saltworks' technology to treat a wide range of contaminated water produced during SAGD operations while mining companies wanted to use the technology to treat mining runoff waters. Teck Resources was an early investor in Saltworks, utilizing the technologies in its mining operations. On the oil and gas side, Suncor Energy showed early interest, and subsequent investments have come from Cenovus Energy, BP and ConocoPhillips.

Using methodical, steady scale-up from initial bench tests to a series of increasingly larger demonstration units, Saltworks eventually developed a pilot plant for use in SAGD operations, only to see crude oil prices collapse. Lessons learned in the oil sands have been translated to other industrial sectors, specifically the landfill and smelting industries, and the technology is now being marketed in the United States and Mexico, with China also on the radar. When crude prices recover, the technology will come home to Canada and be marketed as a key component of future SAGD and oil sands mining operations.

*Photo: Build completion of two SaltMaker S100s at Saltworks' facilities.*

## KEY FACTS

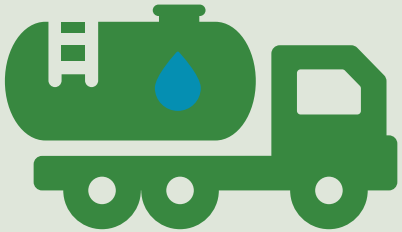


Thermo-ionic desalination produces fresh water from saline water using

**UP TO 80% LESS ELECTRICITY.**

Saltworks currently holds

**40 PATENTS.**



Offsite disposal of wastewater can typically cost as much as $120/ton while onsite treatment

**USING SALTWORKS TECHNOLOGY COSTS ABOUT $20/TON.**

Saltworks' Vancouver harbour pilot plant produces

**1,000 LITRES/DAY**

of fresh water from sea water.



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INDUSTRY
WASTE MANAGEMENT

PRIMARY BENEFIT
CLEAN AIR

CO-BENEFIT
CLIMATE CHANGE

COMPANY NAME:
**ENERKEM ALBERTA BIOFUELS LP**

PROJECT NAME:
**ENERKEM ALBERTA BIOFUELS PROJECT**

Enerkem
Alberta Biofuels

**Key Products/Services:** Waste-derived fuels and chemicals

**Operating Since:** 2000

**SDTC Support:** 2014 to present

**Mission:** Enerkem creates high quality green jobs while reducing oil dependence and waste volumes.

**Consortium Partner:**
• Enerkem Inc.

**Associated Project:** Valorization of Municipal Solid Residues via Sorting, Gasification and Conversion to Energy Products

**SDTC Funding:** $63,600,000

**Total Project Value:** $174,500,000

**For more information:** **enerkem.com**


*"We have been working with SDTC since 2003 and were able to see first-hand their instrumental role in the development and commercial deployment of clean technologies in Canada. The team has built a strong knowledge of the sector, both technical and commercial, which is recognized not only in Canada but also abroad. In light of our country's ambitious targets in GHG emissions reductions, we believe that SDTC's contribution will become increasingly important in the next few years."*

***Vincent Chornet***
*President and CEO*
*Enerkem Inc.*

ENERKEM'S ALBERTA BIOFUELS PROJECT:

## At a Glance

Enerkem Alberta Biofuels LP, a subsidiary of Montreal-based Enerkem Inc., has built the world's first commercial-scale biorefinery dedicated to the production of renewable chemicals and advanced biofuels using non-recyclable municipal solid waste as feedstock. The next-generation cellulosic ethanol plant is capable of converting 100,000 Bone Dry Metric Tons (BDMT) of sorted municipal solid waste (MSW) into 38 million litres of cellulosic ethanol. The project utilizes thermo-chemical gasification process technology developed by Enerkem and is sited adjacent to the City of Edmonton Integrated Waste Management Centre (EWMC).

## The Opportunity

An estimated 1.3 billion tonnes of municipal solid waste is generated globally every year, and about two-thirds of it finds its way into bulging municipal landfills. Development of new landfills has become a hot-button topic of controversy in many cities, with many residents rejecting them as eyesores and environmental permits becoming increasingly difficult to obtain. For years, cities around the world have been searching for ways to divert municipal waste from landfills and incinerators, but one of the major barriers has been tipping fees—non-landfill options often cost significantly more per tonne than landfilling.

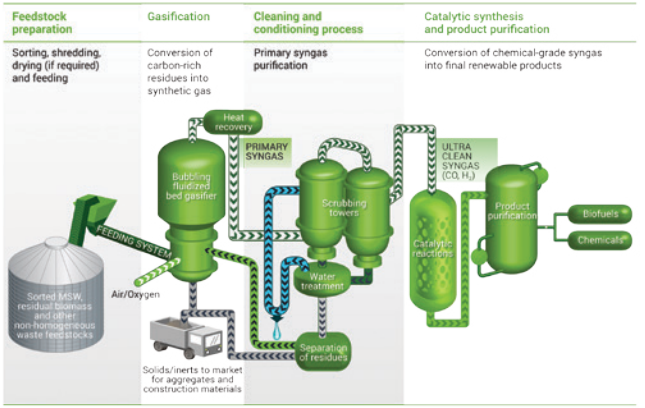
In Canada, one of the most innovative cities when it comes to finding sustainable waste-management solutions has been Edmonton. In 2004, the city launched a global search for alternatives to its landfill, which was quickly nearing capacity. More than 100 companies and corresponding technologies bid on the project and were evaluated by the city with Enerkem selected to provide a sustainable waste-management solution.

## Project Overview

In 2014, Enerkem Alberta Biofuels began commissioning its first commercial facility built adjacent to the Edmonton Waste Management Centre. When operating at full capacity, this facility will help the City of Edmonton increase its waste diversion rate to nearly 90 per cent using Enerkem's patented thermo-chemical technology that converts non-recyclable waste into renewable fuels and chemicals.

The synthetic gas produced by the advanced gasification process is cleaned and put through a catalytic process to produce methanol and then ethanol. At full capacity, the first-of-kind Enerkem plant will convert 100,000 dry metric tonnes per year of municipal solid waste into 38 million litres of biofuels, which are then sold as a chemical intermediates or clean burning fuel to refiners, blenders and petrochemical producers. By using non-recyclable municipal solid waste as a feedstock, Enerkem provides a sustainable alternative to the challenges associated with waste disposal and conventional biofuels. It equally answers the question of how to dispose of rapidly accumulating non-recyclable and non-compostable garbage, while avoiding methane emissions from waste decomposition in landfills and creating value-added products from otherwise useless waste.

**Enerkem's Thermo-Chemical Technology**




* Municipal solid waste

### Additional Sustainable Fuels

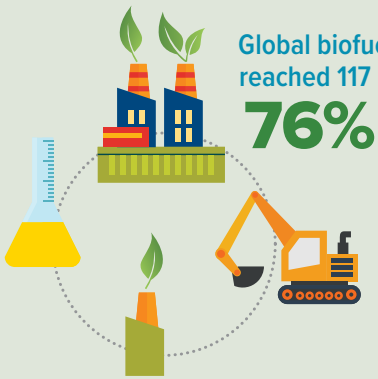
As commissioning of the Edmonton plant commenced, the company began to prepare for the addition of an ethanol module to the plant that will convert the biomethanol to ethanol via a catalytic process. This product expansion will allow Enerkem to access the renewable fuels market in North America and Europe—where ethanol is widely blended into the gasoline supply to reduce greenhouse gas emissions and improve fuel performance. The new ethanol module is expected to be commissioned in 2017.

### Global Opportunities

With lessons learned at Enerkem Alberta Biofuels, Enerkem is developing a similar facility in Varennes, Quebec that will be co-located alongside an existing, first-generation ethanol plant. The facility will produce cellulosic ethanol from non-recyclable institutional, commercial and industrial waste construction, and demolition debris.

Enerkem is also working with partners in China to jointly build municipal solid-waste-to-biofuels facilities and in 2014 signed an agreement with AkzoNobel, a leading global paints and coatings company and a major producer of specialty chemicals, to develop a project partnership to explore waste-to-chemical and biofuels opportunities throughout Europe. All of these initiatives are targeted at a global market that could yield 160 billion litres of sustainable fuels and chemicals from more than 420 million tonnes of non-recyclable, non-compostable municipal solid waste.

## KEY FACTS



Global biofuel production reached 117 billion litres in 2013, **76% OF WHICH WAS ETHANOL.**

Enerkem Alberta Biofuels will allow the City of Edmonton to **INCREASE ITS WASTE DIVERSION RATE TO 90%** of its municipal solid waste from landfills.


Enerkem's waste conversion process is **TWO TIMES MORE CAPITAL EFFICIENT** than incineration.

Globally, Enerkem's technology could convert 420 million tonnes of municipal solid waste into **160 BILLION LITRES OF SUSTAINABLE FUELS AND CHEMICALS.**



Funded by the Government of Canada | Canada

## ABOUT

Sustainable Development Technology Canada (SDTC) is a non-profit foundation created, and primarily funded, by the Government of Canada. As an organization, we work to advance the development and demonstration of new cleantech projects in Canada. Since its creation in 2001, SDTC has allocated $950 million to 330 projects that are transforming clean technology ideas into new products that are delivering significant environmental benefits to Canada—in the areas of climate change mitigation, clean air, clean water, and clean soil.

SDTC is accountable to Parliament for the funds it receives through Innovation, Science, and Economic Development Canada (ISED). SDTC has a shared governance model with the majority of the Board of Directors chosen by its Member Council and the remainder by the federal cabinet.

## MISSION

Our mission is to act as a catalyst and convenor for the cleantech ecosystem in Canada.

## OUR PHILOSOPHY

Our four-pronged Nurture, Build, Launch, Grow philosophy guides us to take appropriate actions to develop entrepreneurs, grow companies, and improve cleantech innovation in Canada.

## FUNDING HIGHLIGHTS

Funding per project: $250K to $15M

Average duration of project: Five years

Type of funding: Non-repayable contribution

SUSTAINABLE DEVELOPMENT TECHNOLOGY CANADA

# FAST FACTS

**NAME:** Sustainable Development Technology Canada (SDTC)
**FOUNDED:** 2001
**PRESIDENT AND CEO:** Leah Lawrence
**BOARD CHAIRMAN:** Jim Balsillie
**HEAD OFFICE:** Ottawa, Ontario
**STAFF:** <50

NURTURE BUILD LAUNCH GROW

## OUR FUNDS

**SD Tech Fund** is SDTC's main funding vehicle. The SD Tech Fund invests in the development and pre-commercial demonstration of clean technology innovations.

**NextGen Biofuels Fund** supports the establishment of first-of-kind, large-scale demonstration facilities for the production of next-generation renewable fuels and co-products. This fund is no longer accepting applications.

## FIND US AT

**Online:** sdtc.ca
**Twitter:** @SDTC_TDDC
**Facebook:** Sustainable Development Technology Canada
**Contact:** info@sdtc.ca or 613.234.6313


SDTC is an arm's-length foundation created by the Government of Canada to promote sustainable development and support projects that develop and demonstrate new technologies to address issues related to climate change, air quality, and clean water and soil. SDTC invests in Canadian companies that, through their innovative technologies, contribute positively to Canada by creating quality jobs, driving economic growth and protecting the environment.

**sdtc.ca**