



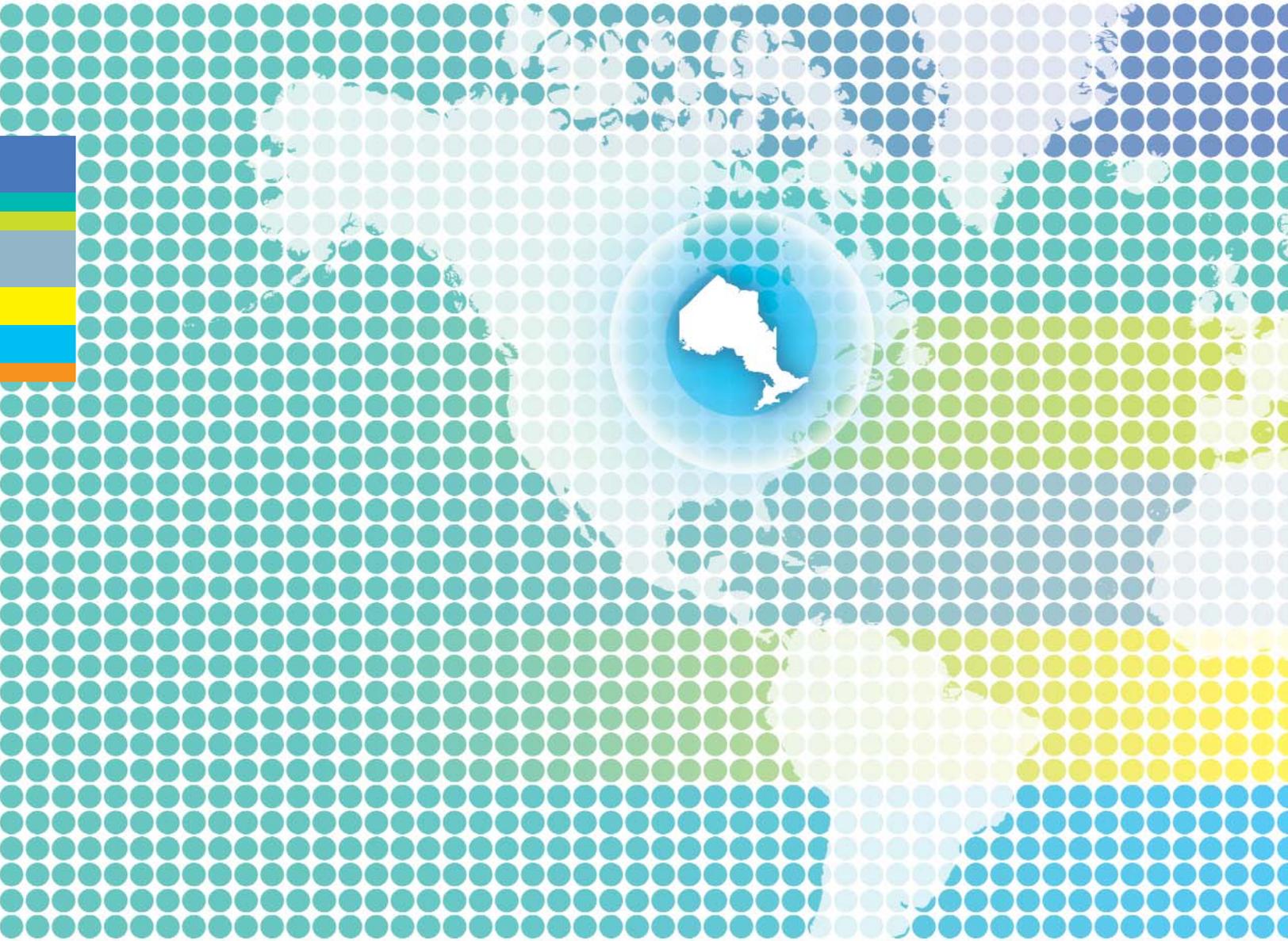
A Bright Green Future
CLEANTECH ASSET MAP

AN ANALYSIS OF THE CONVERGENCE OF TECHNOLOGY, POLICY AND CAPITAL IN ONTARIO



TABLE OF CONTENTS

- | Executive Summary [1](#) |
- | Ontario’s Evolving Cleantech Landscape [2](#) |
- | Current Strengths [14](#) |
- | Future Convergence of Innovation [22](#) |
 - | Scientist Profiles [38](#) |
- | Appendices [40](#) |



“Few global issues are more important than the environment and climate change... Dealing with these issues is the great moral, economic and social imperative of our time.”

– Ban Ki-moon, Secretary-General, United Nations, October 2007, *GEO-4* report, UNEP





EXECUTIVE SUMMARY



Climate change and the environment were once topics of marginal interest. They took a back seat to individual nations' interests in economic growth and development, and the facts related to climate change were either ignored or disputed. Today, key environmental issues, such as air quality, waste management, fresh water availability, wastewater treatment, alternative energy sources and energy management, are at the forefront of global discussions. World leaders and their governments have agreed to work together to develop environmental policies and standards of practice.

Ontario is leading the way in Canada's response to climate change. Ontario's *Green Energy Act* is the key element of the provincial government's environmental strategy. The Act will help address climate change and the environment by facilitating the development of a sustainable-energy economy. This forward-thinking legislation is supported by other initiatives, including the Feed-in Tariff (FIT) Program and the province's plan to phase out coal fired generation. By taking the lead in addressing climate change, Ontario is also building the infrastructure to grow and develop a green economy.

The province's economic landscape is changing, moving from traditional strengths in environmental and energy technologies into a field of convergence in clean technology – or cleantech. Before 2009, strong environmental and energy sectors were built using technologies from both within and outside the province, with greater involvement from international companies. Significant strength also exists in the water sector, with world-class leadership in water-treatment technologies. The growing numbers of organizations, emerging companies and research institutes involved in research and development (R&D) in the environmental, energy, water and wastewater management sectors in the province have gradually established Ontario as a cleantech hub.

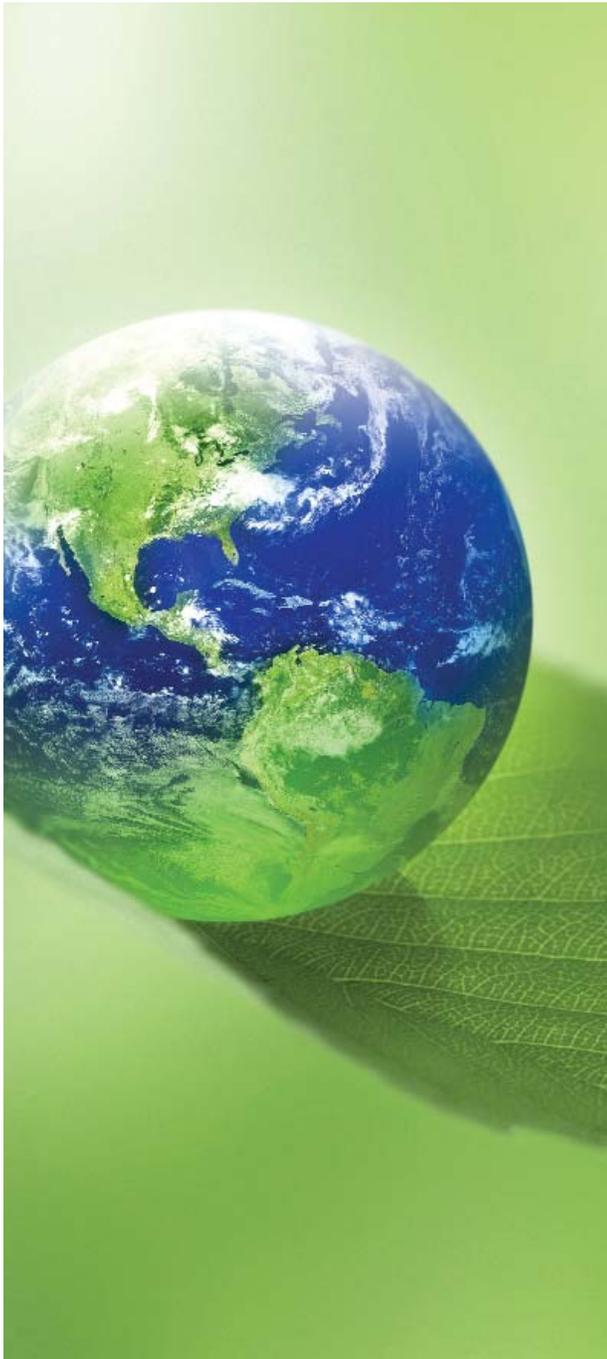
Looking ahead, Ontario will develop and commercialize more of its own green technologies. The *Green Energy Act*, the FIT Program and other legislation and initiatives will support the province's cleantech economy. Cleantech innovations are being developed and supported by university R&D and by regional and sector innovation hubs that provide the necessary commercialization support. Small and medium enterprises (SMEs) have progressively increasing access to funding options at the local, provincial and federal levels. Ontario's cultural diversity continues to provide well-diversified human resources and a sales gateway to international markets. As an established – and still growing – cleantech hub, Ontario is fostering cutting-edge research into environmental and energy-related technologies that will likely be adopted at the provincial level and ultimately gain international recognition.



ONTARIO'S EVOLVING CLEANTECH LANDSCAPE



CLIMATE CHANGE AND THE ENVIRONMENT: A GLOBAL CONCERN IN NEED OF A GRASSROOTS SOLUTION



The central message coming out of the landmark 2009 United Nations Climate Change Conference – politics and posturing aside – was that the time to act on climate change is now. The evidence is clear: food production, water quality and diminishing biodiversity are among the most pressing threats to health, societal growth and economic development on a local, regional and global scale. Evidence suggests that some environmental problems are at critical levels and may have reached the point of no return.

A variety of regulatory and economic measures have been adopted around the world, including fuel standards, recycling programs, carbon trading and various taxation policies – with varying degrees of uptake and success. Ontario is already a leader in many of these strategies, but it is the province's new *Green Energy Act* that has seized the world's attention.

Ontario and Toronto also attracted worldwide attention for their green initiatives at the Copenhagen summit. Toronto Mayor David Miller joined more than 80 city leaders at the Climate Summit of Mayors, which was held in conjunction with the UN Climate Change Conference in 2009. The Summit included demonstrations of climate change programs in action, and Toronto was one of ten cities (along with London, New York, Paris, Mexico City, São Paulo, Los Angeles, Johannesburg, Copenhagen and Jakarta) involved in a showcase of city-level climate change and low-carbon transport initiatives.

ONTARIO: GREENING OF THE GRID

“The [Ontario] green energy program is widely recognized now as the single best green energy [program] on the North American continent.”

– Former U.S. Vice-President Al Gore, Toronto, November 2009

The *Green Energy Act, 2009* “facilitates the development of a sustainable energy economy that protects the environment while streamlining the approvals process, mitigates climate change, engages communities and builds a world-class green industrial sector.” According to projections by Ontario’s Ministry of Energy and Infrastructure, the Act will also result in the creation of more than 50,000 “green-collar” jobs – from cross-sectoral R&D through to advanced manufacturing – and billions of dollars of economic activity within the first three years.

The *Green Energy Act* will help the province to eliminate dirty coal as a power source by 2014. This shift alone is expected to reduce greenhouse gas emissions by up to 30 megatonnes.

FEED-IN TARIFF (FIT) PROGRAM

Enabled by the *Green Energy Act*, Ontario’s Feed-in Tariff (FIT) Program is the first of its kind in North America. It provides a comprehensive guaranteed pricing structure for renewable electricity production and a program that promotes contracting for renewable energy generation. The FIT Program includes standardized program rules, prices and contracts for anyone who wants to develop a qualifying energy project. Prices are set to cover project costs and provide a reasonable return on investment over the term of the contract. The FIT Program is delivered under the auspices of the Ontario Power Authority (OPA).

A significant selection criterion of the FIT Program is the “domestic content requirement,” which applies to all wind and solar projects. This requirement indicates that a certain percentage of the activities associated with the project content must come from Ontario (Table 1). This includes such items as silicon used in solar panels, inverters, electrical wiring and labour.

The domestic content requirement provides additional opportunities to existing SME integrators and those in the electrical profession and enables emerging companies in this field to obtain their first customers. It also provides an opportunity for national and international companies that set up in Ontario and integrate into the value chain to bridge gaps that are not being filled by existing Ontario companies. Although this may be perceived as a challenge in the immediate future, it is an opportunity that invites international partnerships for such projects in Ontario.

One example of the interest generated by the *Green Energy Act* is the recently announced agreement between the Ontario government and a consortium led by South Korean industrial and electronics powerhouse Samsung. Samsung and its partners have committed to build 2,500 megawatts of wind- and solar-energy generation capacity in the province. The deal also calls for Samsung to establish an Ontario base of operations for the manufacture of wind- and solar-energy equipment. The Korean consortium plans to work with major partners to build four manufacturing plants in Ontario which are expected to support the creation of 16,000 jobs over the next five years.

Table 1: FEED-IN TARIFF PROGRAM AND THE DOMESTIC CONTENT REQUIREMENT

System Type/Size	Domestic Content Requirement		
	From Oct. 1, 2009	From Jan. 2, 2011	From Jan. 2, 2012
FIT Program (>10 kW)			
Wind	25%	25%	50%
Solar	50%	60%	60%
MicroFIT Program (< or = 10 kW)			
Wind	not applicable	not applicable	not applicable
Solar	40%	60%	60%

Source: Ontario Power Authority, FIT Program FAQ.



The Exhibition Place wind turbine, located in Toronto, Ontario, is the first urban wind turbine in North America.

ONTARIO'S COMMITMENT TO ALTERNATIVE ENERGY

Many projects have led the way in demonstrating the value of alternative energy generation, even before the launch of the FIT Program, while others have developed as a result:

- The Exhibition Place wind turbine (in operation since January 2003) is the first urban wind turbine in North America and the first community-owned wind power project in Ontario. Built by Toronto Renewable Energy Cooperative (TREC) in partnership with Toronto Hydro Energy Services. <http://www.windshare.ca>
- The LoyaltyOne solar rooftop project is the largest of its kind in Canada. Opened in December 2009, it is estimated that it will generate almost 160,000 kilowatt hours (kWh) per year – about enough power to run its facilities. The solar rooftop is located at LoyaltyOne's new customer care centre in Mississauga. <http://www.loyalty.com>
- The capacity of the Sarnia Solar Project is being expanded from 20 to 80 MW. This solar farm project was developed through a partnership between Enbridge Inc. and First Solar, Inc. The Sarnia Solar Project is expected to be the largest photovoltaic solar energy facility in North America by December 2010. <http://www.firstsolar.com>.
- Stone Mills, Ontario, is home to a solar farm that is a joint venture between SunEdison and SkyPower Corp. of Toronto, which began operating in October 2009. With more than 126,000 solar panels spanning 36 hectares, this farm is expected to generate more than 10 million kWh of renewable electricity in its first year – enough energy to power 1,000 households.
- Wasatch Wind is developing wind-energy projects in the Sault Ste. Marie area and is investing in Ontario's wind-energy initiatives. The Utah-based company enables utility-scale wind turbines to be economically installed and maintained in difficult-to-access locations. <http://www.wasatchwind.com>

THE EVOLVING CLEANTECH LANDSCAPE

Ontario's background and related strengths are in the following traditional and emerging areas of environmental technology:

- Water and wastewater treatment: technologies for drinking water purification and the removal of pollutants from wastewater
- Air pollution control: technologies for the removal of gaseous and particulate pollutants from air
- Waste management: technologies for the collection, disposal and treatment of wastes
- Climate change: technologies for renewable energy generation (e.g., biomass, wind, solar, energy from waste) and energy management
- Environmental monitoring systems: technologies for monitoring environmental conditions and industrial compliance

Ontario is evolving from these traditional fields of environmental and energy technologies into a field of convergence collectively known as cleantech (Figure 1).

Figure 1: ENVIRONMENTAL SECTOR DEFINITION

TRADITIONAL

- Hazardous and solid waste
- Remediation
- Water and wastewater treatment
- Air pollution control
- Engineering consulting

EXPANDING

- Composting
- Materials reuse and recycling
- Energy efficiency
- Geographic information systems (GIS)
- Environmental software
- Renewable energy
- Alternative fuels
- Pollution prevention

EMERGING

- Advanced materials
- Nanotechnology
- Information and communication
- Microelectronics
- Transportation hybrids
- Fuel cells and hydrogen
- CO₂ sequestration
- Intelligent systems
- Biotechnology

Source: Delphi Group.

WHAT IS CLEANTECH?

According to Cleantech Group LLC, a global company with offices in North America, Europe, India and China, “clean technology” – or cleantech – describes a wide range of products, services and processes designed to simultaneously achieve the following goals:

- Provide superior performance at lower cost
- Greatly reduce or eliminate negative ecological impact
- Improve the productive and responsible use of natural resources

Because cleantech involves new technology and business models, the criteria for categorizing technology innovations as cleantech are evolving. Figure 2 describes the various cleantech industry segments.

Figure 2: CLEANTECH INDUSTRY SEGMENTS



Energy generation: wind, solar, hydro/marine, biofuels, geothermal



Energy storage: fuel cells, advanced batteries, hybrid systems



Energy infrastructure: energy management and transmission



Energy efficiency: lighting, buildings, glass



Transportation: vehicles, logistics, structures, fuels



Waste and wastewater: water treatment, water conservation, wastewater treatment



Manufacturing and industrial: advanced packaging, monitoring and control, smart production



Air and environment: cleanup/safety, emission control, monitoring/compliance, trading and offsets



Agriculture: natural pesticides, land management, aquaculture



Materials: nanomaterials, biomaterials, and chemical materials



Recycling and waste: recycling, waste treatment

IDENTIFYING AND ADDRESSING THE GAPS IN ONTARIO

Ontario has a number of significant assets that serve as the foundation to attract, support and grow the cleantech industry. These assets include the following:

- Major university and college research capabilities, with strengths in hydrogen and fuel cell technologies, water treatment, nanotechnology and green chemistry
- A well-developed ecosystem in which to grow and support the innovation-based economy (e.g., MaRS, Ontario Centre for Environmental Technology Advancement, BioEnterprise, Sault Ste. Marie Innovation Centre, Ottawa Centre for Research and Innovation; a detailed list is included in the section titled “Regional and Sector Innovation Networks”)
- Incentives for clean energy development and energy-efficient retrofits
- Access to major markets in the north-eastern United States
- Access to federal assets for Ontario businesses

As depicted in Figure 3, Ontario has lagged behind other regions in cleantech investment. However, with the current legislative framework, emerging technology strengths and funding programs, the province is likely to attract more private investment in the coming years.

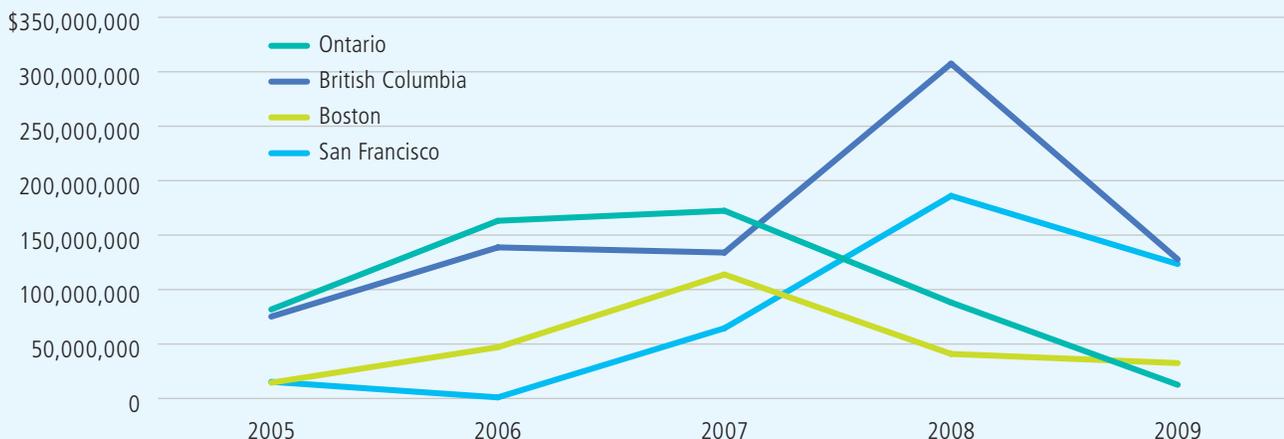
Four factors have historically hampered the growth of cleantech in Ontario:

- Limited access to needed risk and growth capital
- Not enough local demand to support globally competitive technologies
- An insufficiently attractive business environment
- A lack of resources to assist entrepreneurs in commercializing innovations

Each of these points is being addressed in a number of ways:

1. To offset the current lack of private sector investment, the province has dedicated funding to cleantech companies and projects in a variety of ways:
 - A \$250-million five-year Ontario Emerging Technologies Fund (OETF) to encourage investments in technology-based companies
 - A \$50-million boost for the Innovation Demonstration Fund (IDF), which helps companies find commercial uses for emerging technologies (preferably in biofuels and alternative energy)

Figure 3: CLEANTECH INVESTMENT, 2005 TO 2009



Source: Cleantech Group LLC – Investment database (in USD).

- A \$205-million Ontario Venture Capital Fund (OVCF) between the Ontario government and leading institutional investors to invest primarily in Ontario-focused venture capital and growth funds that support innovative, high growth companies
- The Ontario Tax Exemption for Commercialization (OTEC) Program offering a 10-year exemption from Ontario's corporate income tax and corporate minimum tax to newly established corporations operating businesses in priority areas
- \$50 million over five years to help finance research, capital and demonstration projects leading toward a "smart" electricity grid in Ontario
- \$8 million per year to encourage broader public-sector institutions, such as hospitals, colleges and universities, to serve food products grown and made in Ontario

The government is providing additional access to risk and growth capital. (For more information, refer to the Financial Support section of this report.)

2. To improve local demand and demonstrate by example, the province has dedicated \$30 million for the government to purchase emerging green technologies developed in Ontario and to showcase them for potential customers around the world.
3. The *Green Energy Act* and FIT Program will further stimulate local demand for global technologies that have been designed to show that Ontario is open for business for renewable energy projects.
4. The cleantech industry is working together (provincial programs, investors and commercialization networks) to provide vision and leadership, as well as a united voice for Ontario cleantech businesses. Organizations are working together to help SMEs tap into venture capital and other funds available to cleantech companies.
5. Government programs are improving the attractiveness of Ontario's business environment. By helping SMEs gain access to these programs, the cleantech industry will continue to grow and create stronger clusters of development.

6. Additional resources are being provided to assist entrepreneurs with commercializing innovations. Regional and sector innovation networks exist throughout the province to help mentor new entrepreneurs in the region.

There is significant evidence of strength in Ontario's cleantech industry. In 2008, Sustainable Development Technology Canada (SDTC) and the Ontario Centre for Environmental Technology Advancement (OCETA) prepared a report on Ontario's cleantech industry analysing companies (of the more than 2,600) from within the cleantech industry. To qualify as a cleantech company, the company had to meet the following criteria:

- Based in Ontario, with the majority of its executive management and R&D located in Ontario
- Primarily engaged in the development and marketing or use of its own proprietary technology to deliver products or services that reduce or eliminate negative environmental impacts, address social needs, provide competitive performance or use fewer resources than conventional products or services
- Engaged in, or about to begin, commercializing a unique product or service

Figures 4 to 7 depict the categories of the 110 cleantech companies by age, stage of development, sector and business model:

- Almost half of the companies have been in operation for more than 10 years.
- Most (75%) of the listed companies are involved in product commercialization.
- Most (85%) of the companies are focused in six sectors, with 14 or more companies involved with water and wastewater, energy infrastructure, and recycling and waste.
- More than 70% of the companies are technology product companies.

These results provide evidence that the strong, longstanding, traditional environment and energy companies (now categorized as cleantech) in Ontario are poised to tackle some of humankind's biggest challenges.

Figure 4: COMPANIES BY AGE

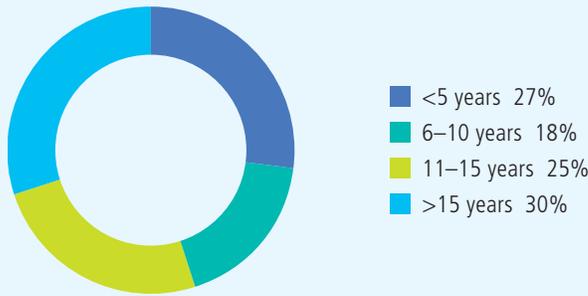


Figure 5: COMPANIES BY DEVELOPMENT STAGE



Figure 6: COMPANIES BY SECTOR*

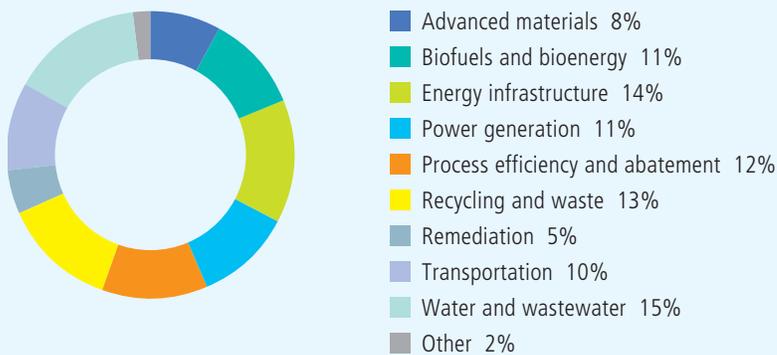
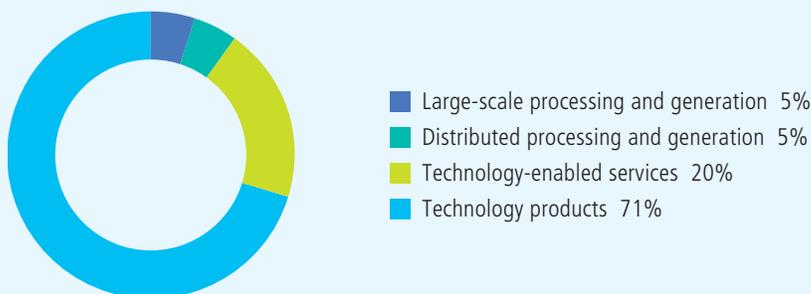


Figure 7: COMPANIES BY BUSINESS MODEL



Source: *The 2009 OCETA SDTC Cleantech Growth & Go-to-Market Report*.
 *Percentages may not add to 100% because of rounding.

ONTARIO'S EVOLUTION IN CLEANTECH

The remainder of this report showcases Ontario's past strengths and current and future convergence of technologies, policies and commercialization mechanisms that will enable the province's cleantech strengths to be widely demonstrated within the province and elsewhere. Ontario's evolution into this segment can be represented as three phases of growth (Figure 8).

Phase 1 (Pre-2009) – Ontario has always been strong in the environmental sector, but many of the technologies adopted, particularly in the energy sector, were from outside the province. However, with professionals and companies increasingly being attracted to the province, there has been an increase in technical, business and financial skill sets. Learning from the experiences of others, Ontario is progressing into the next phase by aggressively adopting cleantech, primarily in alternative energy technologies.

Phase 2 (Post-2009) – The provincial government understands the importance of an innovation-driven economy. As a result, it has put money into resources (e.g., commercialization centres, demonstration funds) that can assist with the commercialization of technologies. The *Green Energy Act* is central to Ontario's plan to invest in cleantech so that more new technologies will be created and developed in Ontario.

Phase 3 (Next 5 years) – Ontario is prepared to become a hub for cleantech research and adoption. Unique technologies in R&D and others that have been developed in the region will attract investors interested in innovation. Ontario clean technologies are positioned to meet both local and global demand.

Figure 8 : ONTARIO'S EVOLUTION IN THE CLEANTECH SECTOR

Market	Phase 1 (pre-2009) Primarily imported technologies	Phase 2 (post-2009) Imported technologies but also more from Ontario	Phase 3 (next 5 yrs) >80% Ontario-based technologies
Development	<p style="text-align: center;">→</p> <p>SMEs The number of small and medium enterprises (SMEs) is growing because of increased commercialization support, government funding, financial institutions and multicultural business connections.</p>	<p style="text-align: center;">→</p> <p>University Research Cutting-edge research will propel Ontario to the next phase of cleantech development. New technologies will be adopted at the provincial and national levels and eventually at the global level.</p>	



CURRENT STRENGTHS



AT THE MARKET LEVEL

Before 2009, Ontario was very competitive in both the green energy and water sectors, although the province relied primarily on imported technologies. The province learned from European best practices and adopted world-class technologies to develop and grow its green sector.

GREEN ENERGY SECTOR

Ontario has a number of strengths that provide it with an advantage in the green energy sector:

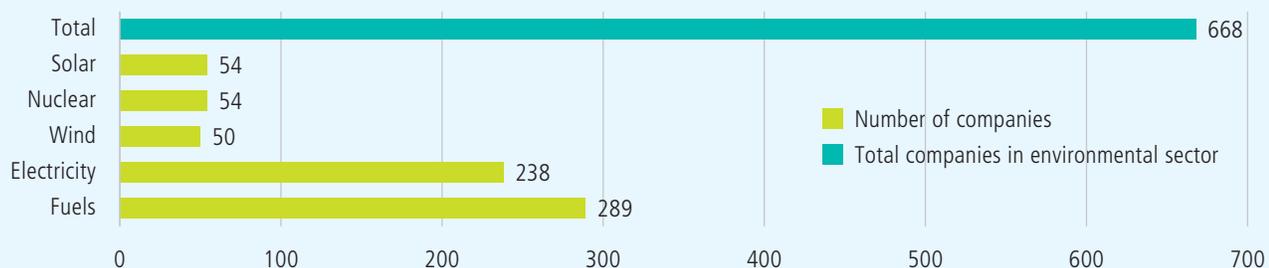
- A substantial shoreline suited for the generation of wind power
- A large supply of biomass from agriculture and forestry
- Remote, off-grid areas that offer cost-competitive niche markets for renewable energy sources
- A diverse mix of energy supply options
- Dedication of the provincial government to conservation and renewable energy
- Ontario-based, small-scale wind turbine manufacturers that are developing innovative designs for remote and agricultural applications
- Ontario-based bioenergy companies developing ethanol production and gasification technology
- Ontario-based companies developing innovative solar air- and water-heating technologies and advanced photovoltaic products
- Ontario-based development of fuel cells and hydrogen systems

Many opportunities exist to grow the cleantech industry in Ontario through the development and promotion of green energy technologies. By 2013, many renewable sources of energy are expected to compete with grid power. Some of these avenues for growth involve taking advantage of the province's energy gap and Canada's commitment to reducing greenhouse gas emissions. Ontario's green energy technology opportunities include the following:

- Increasing global photovoltaic demand (about 30% per year)
- Establishing the wind industry by developing wind farms and small wind-energy-generation technologies
- Increasing the focus on building energy efficiency
- Maintaining an urban focus on the advantages of green roof technology
- Growing the economic attractiveness of ethanol and other biofuels
- Creating interest in waste disposal options, such as gasification or anaerobic digestion
- Supporting a well-established hydrogen and fuel-cell industry
- Advocating for net metering regulations, which will promote small-scale renewables and the sale of excess electricity to the grid

According to a 2008 survey, 668 companies are involved in energy technologies in the Greater Toronto Area (GTA), which encompasses 48 cities and towns within eight sub-regions (Figure 9). Energy technologies are divided into five categories, as indicated in the figure. Most of the companies in the industry are manufacturers or suppliers, with fewer service providers and consultants.

Figure 9: COMPANIES INVOLVED IN ENERGY TECHNOLOGIES*

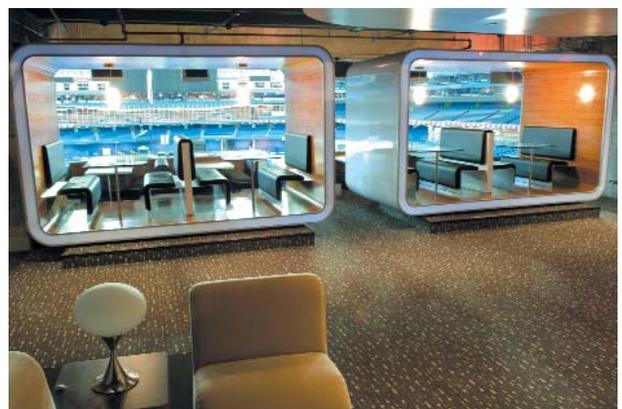


Source: *Statistical Description of Toronto Region Energy and Environment Sector Strength*, Toronto Region Research Alliance.

*Because companies may be associated with more than one sub-sector, the "Total companies in environmental sector" number is lower than the total of the "Number of companies."

RENEWABLE ENERGY AND ENERGY-MANAGEMENT TECHNOLOGIES

- ARISE Technologies Corporation (located in Waterloo) develops high-performance, cost-effective solar technology. It develops proprietary technology for the manufacture of high-efficiency photovoltaic (PV) cells and the production of low-cost silicon at 7N+ high-purity for PV cell applications. The company also creates complete turnkey PV solutions for solar farms and rooftop installations. ARISE expanded operations to Germany several years ago to set up a manufacturing facility in the early days of solar technology. <http://www.arisetech.com>
- Toronto-based CleanEnergy handles all aspects of a geothermal energy (geoexchange) project, from feasibility and conceptual analysis to design, installation and commissioning. Geoexchange offers the lowest energy consumption, lowest greenhouse gas emission and lowest operating, heating, ventilation and air conditioning (HVAC) costs. CleanEnergy received the Canadian Geoexchange Coalition's Prize for Excellence for its work on the Reid's Heritage Homes Leadership in Energy and Environmental Design (LEED) platinum home. <http://www.cleanenergydevelopments.com>
- Encelium Technologies in Richmond Hill developed the Energy Control System, an intelligent, integrated lighting-control and energy-management solution. The technology provides greater control over energy usage and costs and works with standard lighting components. In 2008, Encelium received the Frost and Sullivan Emerging Company of the Year Award. <http://www.encelium.com>
- Hydrogenics (located in Mississauga) has more than 60 years of experience designing, manufacturing and installing industrial and commercial hydrogen systems around the world. Applications of its technology include hydrogen generators, hydrogen fuel cells for electric vehicles, fuel-cell installations, and hydrogen storage and power systems for optimizing solar and wind power systems. In December 2009, Hydrogenics was awarded a contract for its HySTAT-30 electrolyzers to be used at a fuelling station in Los Angeles as part of California's "Hydrogen Highway" initiative. <http://www.hydrogenics.com>



Encelium Technologies was asked to reduce overall lighting energy consumption by 50% at the Rogers Centre in Toronto, one of the world's premier sports and entertainment centres. Energy savings ranged from 56% to 79% throughout the building, resulting in annual cost savings of approximately \$303,000. With annual energy reductions of 3,731,000 kWh, enough energy will be taken off the grid to power more than 400 homes in Toronto.

The Trojan ultraviolet disinfection water treatment system installed in the Groundwater Replenishment System in Orange County, California.



WATER SECTOR

Ontario has a number of strengths that provide it with an advantage in the water sector:

- Leadership in high-tech water-treatment technologies (e.g., membrane filtration, ultraviolet disinfection)
- Significant awareness of water and wastewater management, resulting from issues related to the Great Lakes and drinking water quality
- A high concentration of industry around the Greater Toronto Area (GTA), the Golden Horseshoe, and southwestern Ontario
- Proximity to the U.S. market, where many states face challenges with water quality and availability
- Involvement of university and government laboratories in research related to water and wastewater issues
- Policy leadership from the provincial government in regulations, standards, source water protection, watershed management and water efficiency

There are many opportunities to grow the cleantech industry in Ontario through the development and promotion of water and wastewater technologies. Some of these avenues for growth are supported by legislation designed to protect the water supply from contamination, such as the *Ontario Water Resources Act*, the *Ontario Safe Drinking Water Act* and the *Sustainable Water and Sewage Systems Act*. Other opportunities include the following:

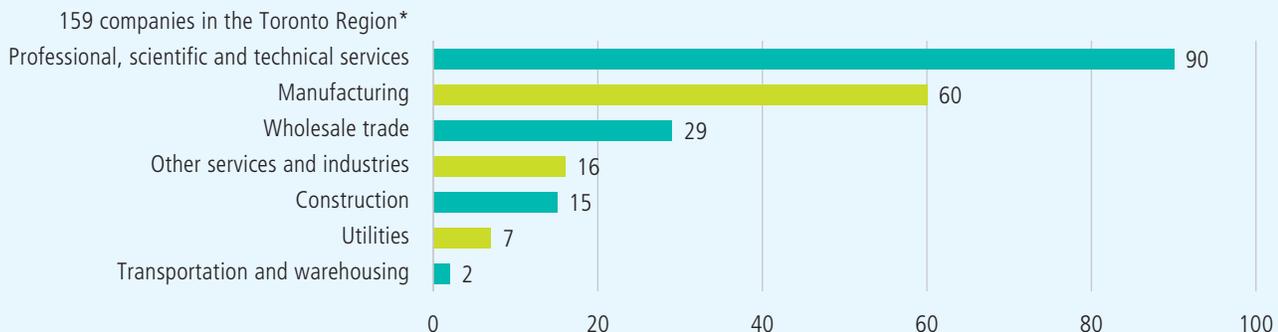
- Geographical placement of companies and research facilities to create organized technology clusters that can support further innovation and development
- The need for simple, low-maintenance wastewater solutions for small communities
- Increasing global need for water and wastewater services
- Increasing public concern about water quality and availability
- Increasing public awareness of the impact of chemical pollutants and the corresponding demand for water-treatment technologies

EXCELLENCE IN R&D LEADS TO INTERNATIONAL ACQUISITIONS IN THE WATER SECTOR

- Trojan UV in London (now under the ownership of Danaher) is a well-known international ultraviolet light (UV) disinfection company. It develops products with municipal, industrial and commercial applications for the water and wastewater markets. Trojan UV also provides clients with water-research testing and pilot facilities. <http://www.trojanuv.com>
- Oakville's ZENON Environmental, now under the ownership of GE Water & Process Technologies, is a world leader in providing advanced membrane products and services for water purification, wastewater treatment and water reuse to municipalities and industries. It has developed several water membrane technologies in use in facilities around the world. John Coburn, co-founder of ZENON, maintained his commitment to the water sector by starting XPV Capital Corporation, the first water-sector-specific venture capital firm. http://www.zenon.com/index_gewater.shtml

A 2008 Industry Canada survey indicated there were 169 water-related companies in the GTA (Figure 10). Water technologies are divided into seven general categories. The region is a global centre for water-related patent activity, especially membrane separation, filtration and flocculation technologies.

Figure 10: GREATER TORONTO AREA COMPANIES IN THE WATER SECTOR



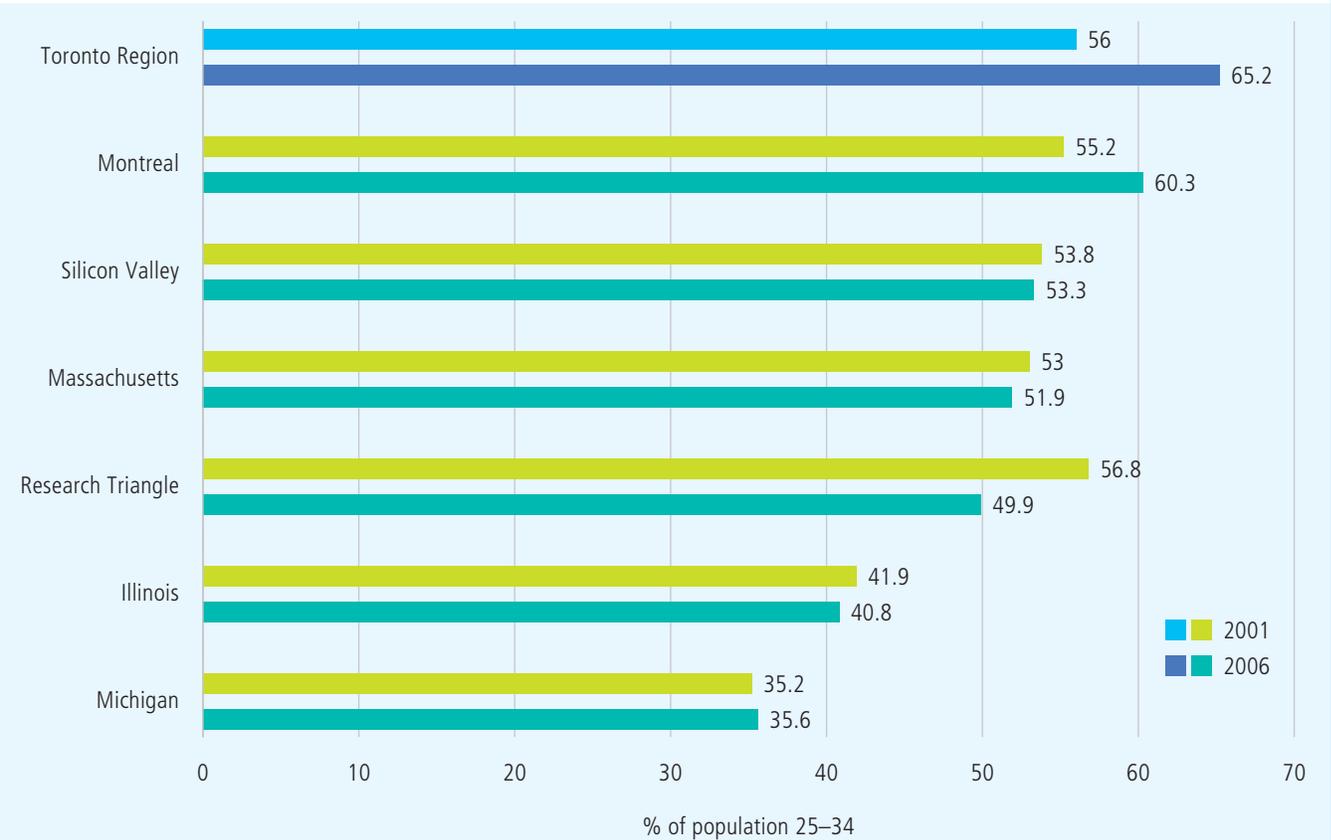
Source: Industry Canada, 2008.

* Some companies may be involved in more than one area.

AT THE DEVELOPMENT LEVEL

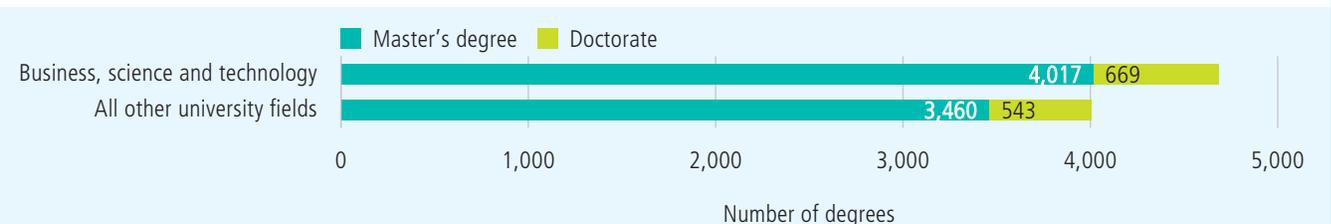
Ontario universities are world-class in many areas that directly involve the cleantech industry. The realized benefits are two-fold: the universities foster research into innovative technologies with numerous applications, and they produce a highly skilled workforce that helps to grow the burgeoning cleantech industry. For example, in comparison with other population segments, a very high percentage of the population in the GTA possesses post-secondary degrees or diplomas, and these numbers are increasing (Figure 11). The number of post-graduate degrees granted in business, science and technology are also increasing relative to those in other university fields (Figure 12).

Figure 11: PERCENTAGE OF POPULATION 25–34 YEARS OLD WITH POST-SECONDARY DEGREE OR DIPLOMA, 2001 AND 2006



Source: Statistics Canada, U.S. Census Bureau, *Annual Toronto Region Innovation Gauge*, *Toronto Region Research Alliance*.

Figure 12: POST-GRADUATE BUSINESS, SCIENCE AND TECHNOLOGY, AND OTHER EDUCATIONAL DEGREES AWARDED IN GREATER TORONTO AREA, 2006–2007



Source: Common University Data Ontario (CUDO), *Annual Toronto Region Innovation Gauge*, *Toronto Region Research Alliance*.

RESEARCH IN GREEN ENERGY SECTORS

Many leading organizations and research institutes within the green energy sector are located in Ontario, including several Centres of Excellence (e.g., Energy, and Earth and Environmental Technologies). More than 225,000 students are enrolled in Southern Ontario universities and colleges in green energy-related programs, including these:

- Centennial College: installation, repair and maintenance of solar thermal and solar PV systems
- Durham College: Renewable Energy Technician Program
- Lambton College: Alternative Energy Engineering Technology Program
- McMaster Institute for Energy Studies: Renewable Energy Program
- Seneca College: PV systems, partnership with Canadian Solar Industries Association
- St. Lawrence College: Wind Turbine Technician Program
- University of Toronto: Centre for Environment and Centre for Urban Health Initiatives
- University of Waterloo: Waterloo Institute for Sustainable Energy (WISE)

The GTA has a healthy supply of students, research establishments and international partnerships within different strata of the green energy sector. Table 2 lists statistics for 2007.

RESEARCH IN WATER SECTORS

Many leading organizations and research institutes within the water sector are located in Ontario. University and college academic departments continually upgrade their strategic research plans to ensure that their organizations remain at the forefront of water sustainability. Areas of focus include these:

- Climate change, land use and source water protection
- Watershed planning and management
- Water and energy conservation and efficiency improvements
- Infrastructure maintenance and replacement
- Water, energy and food for sustainable communities
- Bottled water usage

The Greater Toronto Area has a very strong student and research base in the water sector:

- In 2007, there were more than 8,200 university graduates of programs related to water sciences (source: Industry Canada).
- More than 150 experts conduct research and development at 19 water-related research institutes (e.g., Canadian Water Network, Drinking Water Research Group, Water Policy and Governance Group).
- From 2006 to 2007, GTA universities received 30% (\$11.4 million) of NSERC funding for research in the water sector, including drinking water, wastewater and water resource management, and aquatic ecosystems and species.
- Thirty-eight percent of NSERC Industrial Research Chairs were awarded to researchers in the GTA.

Table 2: GREATER TORONTO AREA GREEN ENERGY SECTOR STATISTICS, 2007

Hydrogen and fuel cells	<ul style="list-style-type: none"> → 26 university programs in engineering, physical, material and environmental sciences → 4,000 university graduates in hydrogen-related programs → Three Canadian Research Chairs at top-ranked universities → Centre of advanced research and development in four universities → Ranked among the top eight regions for scientific impact based on number of citations per publication
Solar energy	<ul style="list-style-type: none"> → More than 100 university programs in engineering, physical and environmental sciences → More than 3,400 university graduates in solar-related programs → Centre of advanced research and development, with 22 research institutes and 85 experts
Wind and turbine	<ul style="list-style-type: none"> → 45 university programs in environmental science, engineering and sustainable and renewable energy → More than 2,700 university graduates → Ranked seventh in North America for number of publications on the subjects of wind, turbine and green energy technologies → Centre of major academic research, with 19 wind-technology-related experts in five universities

Source: Toronto Region Research Alliance.



← Trent University's Worsfold Water Quality Centre in Peterborough – a state-of-the-art facility dedicated to developing innovative analytical techniques and applying existing techniques to emerging health and contaminant issues.

↓ Dr. Dimitre Karamanev (right) and his PhD student Victor Pupkevich (left) stand beside the Biogenerator in their Biotricity lab at the University of Western Ontario.



ONTARIO'S RESEARCH ACHIEVEMENTS WITHIN THE GREEN ENERGY SECTOR

- Biotricity (located in London), a spin-off company from the University of Western Ontario, developed the Biogenerator, the first practical biotechnology for electrical power generation. The Biogenerator will be used for stationary power generation in the range of 1 to 200 MW per unit. It is among the most efficient converters of hydrogen to electricity. One of the unique properties of the Biogenerator is that it goes beyond zero-CO₂ emission and actually consumes CO₂ from the atmosphere, converting it into highly valuable protein feedstock. The cost of electricity produced by the Biogenerator is expected to be competitive at current market prices. With appropriate funding, the Biogenerator could be a commercial reality in the next three years. Biotricity is funded by Ontario Centres of Excellence (OCE), the Natural Sciences and Engineering Research Council (NSERC), Canada Foundation for Innovation (CFI) and the University of Western Ontario. <http://www.biotricitypower.com>
- Dr. Olivera Kesler, Canada research chair in fuel cells materials and manufacturing, is investigating how to reduce the cost and improve the durability of fuel cells by using new materials and processing techniques. The goal is to produce fuel cells more quickly by using an easily scalable process for mass production. The work also involves understanding the electrochemical performance and degradation behaviour of solid oxide fuel cells (SOFCs).
- Dr. Ted Sargent is using funding from the KAUST Global Research Partnership Investigator award to create low-cost paint-on solar cells. His goal is to abolish the compromise between high efficiency and low cost in solar cells. The work involves colloidal quantum dots, which are very small semiconductor particles (measured in nanometres). The project will also involve materials other than heavy metals, rendering the quantum dots more environmentally friendly.
- In 2006, the Solar Buildings Research Network (SBRN) was launched by NSERC through its Research Network Grant Program. Twenty-four top Canadian researchers in solar energy and buildings from ten Canadian universities joined to develop solar-optimized homes and commercial buildings of the future. Three University of Toronto researchers were involved: Dr. Ted Kesik, Dr. Nazir Kherani and Dr. Stefan Zukotynski. <http://www.solarbuildings.ca>

ONTARIO'S RESEARCH ACHIEVEMENTS WITHIN THE WATER SECTOR

- Doctors Peter Abrams, Donald Jackson, Charles Minns and Brian Shuter and colleagues at the University of Guelph are collaborating with natural resources agencies in Ontario and Quebec to study the impacts of climate change on limnetic biodiversity and fisheries in both provinces. The NSERC-funded study will work toward ameliorating the effects of climate change on fish communities and fisheries in both provinces' inland lakes.
- The Drinking Water Research Group was formed in 1998 as a consortium of researchers from the University of Toronto, Dalhousie University (in Halifax) and Indiana University at Kokomo. The group addresses issues of water treatment, distribution and innovation to meet future water needs and compliance. The group benefits from the unique resources, expertise and concerns of universities in three different geographical areas.
- Dr. Grant Ferris, in collaboration with researchers at the University of Ottawa and Atomic Energy of Canada Limited (AECL), is leading a project on the biogeochemical stability of bacteriogenic iron oxides for sustainable natural remediation of metal and radionuclide contaminants in groundwater and wetland systems. The project is investigating the ability of microorganisms to precipitate minerals and other materials from water sources and is funded by the NSERC Strategic Grant program.
- Dr. Barbara Sherwood Lollar, Canada research chair in isotope geochemistry of the earth and the environment, was involved in compiling a report by the U.S. Environmental Protection Agency (EPA) on methods of monitoring and improving the success of cleanup efforts. The report outlined how cleanup can be performed by using a technique called compound specific isotope analysis, which was developed by the University of Toronto's Stable Isotope Laboratory.
- The Worsfold Water Quality Centre (WWQC) at Trent University in Peterborough is dedicated to the development and application of innovative new techniques for the analysis of organic and inorganic contaminants at the isotopic, elemental and molecular scale. The mandate of the WWQC is to produce new analytical technologies and apply existing technologies to emerging health and contaminant issues. Four major Canada Foundation for Innovation (CFI) awards since 1999 have enabled the purchase of more than a dozen different mass spectrometers, giving researchers the tools to carry out a variety of investigations and resulting in the creation of innovative new analysis capabilities. Recently, the National Network for Environmental and Water Research (NNEWWR) was established to facilitate the commercialization of the intellectual property and technologies developed in the Centre, and to provide these techniques on a commercial basis to external clients, including industrial partners and government agencies. <http://www.trent.ca/wqc>



FUTURE CONVERGENCE OF INNOVATION



AT THE MARKET LEVEL

Clusters are conducive to the development of cleantech businesses and technology. When organizations come together to create a cluster, it results in the collection of knowledge and resources and influences economic development policies. Clusters can build on the unique strengths of a region and encourage dialogue between members to develop greater understanding of the region's strengths and needs. The following sections of this report delve deeper into the existing infrastructure in Ontario—such as the legislative framework, technology transfer mechanisms, commercialization and funding support, and cultural uniqueness—that positions it as the main hub for cleantech innovation and growth in North America.

LEGISLATIVE SUPPORT AND INITIATIVES

Ontario has adopted a number of environmental and energy initiatives that will help to support and foster the growth of cleantech technologies and companies.

As stated earlier, the *Green Energy Act* provides incentives for growth in cleantech and promotes the development of a green economy. More specifically, the *Green Energy Act* facilitates the following:

- Providing certainty and clarity in the approvals process for renewable energy projects to make Ontario an easier place in which to invest
- Implementing a twenty-first-century “smart” energy grid
- Helping community groups and First Nations and Métis peoples to allow them to advance their own renewable energy projects
- Establishing domestic content requirements for renewable energy projects to ensure that job opportunities are created in Ontario
- Helping Ontario's energy consumers to invest in conservation and energy-demand-management projects
- Creating incentives to help energy consumers invest in small-scale renewable energy projects
- Providing opportunities for municipalities and local utilities to initiate new renewable-energy-generation projects (under 10 MW)
- Making resources available to municipalities to help Ontario expand the development of renewable energy sources

RENEWABLE ENERGY PROJECTS ENCOURAGED BY THE FIT PROGRAM

- The Lakewind Power Project is a 10 MW wind farm located in Bervie in the Township of Kincardine and is a project of the Toronto Renewable Energy Cooperative. It has applied for a FIT contract and intends to commission the project toward the end of 2011. <http://www.windshare.ca/lakewind>
- The Pukwis Community Wind Project is a 20 MW wind farm located on Georgina Island in Lake Simcoe. It has applied for a FIT contract and intends to commission the project toward the end of 2011. <http://www.windfallcentre.ca>
- The SolarShare Community Solar Project, a 250 kW solar PV project located in Toronto, is a project of the Toronto Renewable Energy Cooperative. It has applied for a FIT contract and intends to commission the project toward the end of 2010. <http://www.trec.on.ca/projects/solarshare.html>
- Stormfisher Biogas in Toronto is a renewable energy company that builds, owns and operates biogas plants across North America. The company works with food-processing and agricultural industries to process organic by-products and convert them into natural gas and electricity. The company's first North American project is a 2.8 MW plant in London, Ontario. <http://www.stormfisher.com>



A technician inspects Pukwis wind measurement equipment before installation on Georgina Island.

Together with the *Green Energy Act*, the FIT Program provides a comprehensive guaranteed pricing structure for renewable electricity production and promotes contracting for renewable energy generation. Qualifying renewable fuel sources include bioenergy (e.g., biogas, biomass, landfill gas), solar PV, water power and wind. The FIT Program is divided into two streams:

- FIT Program: Renewable energy projects that generate at least 10 kW of electricity
- microFIT Program: Home or small business installations that generate a maximum of 10 kW of electricity from renewable energy sources

In the water sector, Ontario has been a policy leader on regulations, standards, protection of source water, management of watersheds and water-efficiency measures. Water technology firms serve to

benefit from the administrative arrangements between the Ontario Clean Water Agency and the provincial government. Table 3 outlines the purposes of key water-focused legislation.

Several trends and demand drivers can promote the growth of cleantech technologies and companies that focus on the water sector. It is estimated that Ontario’s water systems will need an investment of \$30 billion to \$40 billion over the next 15 years to bring them up to safe standards and accommodate growth. Most of this investment will embrace water and wastewater conveyance systems. There is also great potential to improve the efficiency of treatment systems and infrastructure, as well as convergence in delivery of utility services. As such, there will be an increasing reliance on private sector sources for the financing and delivery of utility services.

Table 3: ONTARIO WATER SECTOR LEGISLATION

Legislation	Purpose
<i>Ontario Water Resources Act</i>	<ul style="list-style-type: none"> → Governs water quality and quantity → Prohibits discharge of polluting material in or near water → Regulates sewage discharge → Regulates licensing and approvals for waterworks, sewer works, removal of water and effluent discharge
<i>Ontario Safe Drinking Water Act, 2002</i>	<ul style="list-style-type: none"> → Protects human health through control and regulation of drinking water systems and testing → Creates legally binding standards for contaminants in drinking water → Licenses drinking water systems
<i>Drinking Water Systems Regulations</i>	<ul style="list-style-type: none"> → Regulates municipal and private drinking water systems
<i>Sustainable Water and Sewage Systems Act, 2002</i>	<ul style="list-style-type: none"> → Requires inventory and management plans for municipalities that provide water and sewage services → Outlines allowable sources of revenue and maximum increases for charges for water services
<i>Nutrient Management Act, 2002</i>	<ul style="list-style-type: none"> → Restricts how and where farmers can apply nutrients to land → Supports development of regulations for nutrient management on farms

Source: *Opportunities and Gap Analysis for Canada’s Environmental Technology Sector*, Appendix 1: Water and Wastewater Sector.

TECHNOLOGY TRANSFER LEADING TO SPIN-OFFS

Ontario universities are strong contributors to research and development in a number of sectors within cleantech. R&D excellence from universities is being nurtured through technology transfer offices and other provincial agencies. Figure 13 illustrates the location of some R&D influencers.

1. The Ontario Centres of Excellence (OCE) facilitate the path from research to commercialization by providing support for industrially relevant R&D and developing industry and academic relationships across Ontario’s technology transfer networks. There are six OCE: Communications and Information Technology, Earth and Environmental Technologies, Energy, Materials and Manufacturing, Photonics and Commercialization of Research. <http://www.oce-ontario.org>
2. C4 Ontario fosters innovation in Ontario by promoting technology transfer and commercialization. It is a consortium of 10 univer-

sities (including McMaster University, University of Western Ontario, University of Waterloo, Wilfrid Laurier University, University of Guelph, University of Windsor and Brock University) and research institutions that shares resources and best practices to collaborate in multi-disciplinary research. <http://www.c4ontario.ca>

3. MaRS Innovation advances commercialization through industry partnerships, licensing and company creation. It is supported by the Government of Canada, through the Networks of Centres of Excellence and 14 member institutions, including the University of Toronto and Ryerson University. <http://www.marsdd.com/marsinnovation>
 - a. The University of Toronto ranks first in the world in the field of environmental engineering and third in environmental sciences. It is involved in commercialization activity in energy and the environment through its Innovation and Partnership Office and actively collaborates with other universities and industry-sector organizations. <http://www.utoronto.ca>

Figure 13: LEADING TECHNOLOGY TRANSFER ENABLERS IN ONTARIO



- b. Ryerson University has established research in water and wastewater treatment, eco- and environmental toxicology and air quality, and environmental interfaces and biofilms. It also provides technology transfer support through the Office of Research Services. <http://www.ryerson.ca>
4. The McMaster Industry Liaison Office (MILO) supports the research of McMaster University and its affiliated hospitals. It assists researchers and industry by advancing collaborative research, helping researchers obtain funding, evaluating and protecting intellectual property (IP), licensing technologies, establishing and supporting spin-offs, and educating the research community. <http://ip.mcmaster.ca/>
5. Ontario Partners for Innovation and Commercialization (OPIC) is a virtual network of specialized technology transfer experts. Its purpose is to enhance knowledge and technology transfer capacity by sharing expertise and educational resources among the consortium's members (Brock University, Lakehead University, Laurentian University, Nipissing University, Ryerson University, Trent University and the University of Ontario Institute of Technology). <http://www.opic-ontario.ca>

CLEANTECH RESEARCH INSTITUTES

The Ontario government has funded a number of cleantech research institutes:

- In August 2007, Ontario invested \$10 million in the BioIndustrial Innovation Centre (BIC), located at the Sarnia campus of the University of Western Ontario. The Centre connects researchers and members of the petrochemical industry to create and commercialize new sources of clean fuel. BIC is expected to attract more than \$1 billion in private sector investment by 2014, support up to 1,000 jobs in research and engineering and attract new bioindustrial plants to the petrochemical industry in the area. <http://www.researchpark.ca>
- In May 2008, Ontario invested \$25 million to establish the Centre for Research and Innovation in the Bio-Economy (CRIBE) in Thunder Bay. The Centre's initial effort and resources involve the development of a pilot biorefinery initiative to test new products and processes that use wood fibre as raw material.
- In September 2009, Ontario invested \$13.6 million in GreenCentre Canada, which helps to turn green chemistry discoveries into business solutions. Founded by PARTEQ Innovations of Queen's University, GreenCentre works with academic technology transfer and industrial partners to identify research breakthroughs that can benefit the environment and produce industrial applications. The organization provides product and application development, intellectual property management, commercial development and marketing. Begun less than a year ago, GreenCentre Canada has already received close to 90 technology disclosures from chemistry researchers at universities across Canada and is now at the point of negotiating a number of license agreements and formalizing proof-of-principle funding grants. GreenCentre is also funded by the Government of Canada's Centres of Excellence for Commercialization and Research (CECR). <http://www.greencentrecanada.com>

SPIN-OFFS FROM UNIVERSITY R&D

- Agri-Therm Inc., a spin-off company from the University of Western Ontario, has developed the first mobile pyrolysis process for rapidly converting low-value bioresidue at the source into higher-value bio-oil. Bio-oil is a renewable energy resource that can be generated from almost any waste source (e.g., wood, corn stocks, manure, tires, plastics) by using pyrolysis. Agri-Therm's platform is mobile, simple to use, adaptable to different market uses and affordable. The potential market for bio-oil is \$8 billion per year. <http://www.agri-therm.com>
- EnerWorks Inc., a spin-off company from Queen's University, is a provider of solar thermal energy. The company develops and manufactures proprietary renewable energy appliances for residential, commercial and industrial markets in North America and the Caribbean. EnerWorks was created when its founders collaborated and expanded on previous work to explore and commercialize new ways to use solar energy in heating water for homes and businesses. <http://www.enerworks.com>
- Tyromer, a spin-off company from the University of Waterloo, developed a devulcanization technology for scrap tires. The process makes scrap tires useful again: they can be reformulated and used for the manufacturing of new rubber products. Tyromer's process does not use chemical solvents, uses little energy and is continuous. <http://www.tyromer.com/technology.html>
- Vive Nano, a spin-off company from the University of Toronto, has developed a disruptive nanotechnology platform to produce cost-effective nanoformulations of agricultural chemicals and industrial catalysts. The result is the production of agricultural chemicals that reduce spray water use rates and lower soil contamination. The catalysts will also decrease energy requirements for industrial production. <http://www.vivenano.com>



Left: Chemical engineer Dr. Lionel Catalan (left) and chemist Dr. Stephen Kinrade in their concrete testing lab at Lakehead University in Thunder Bay, where they have invented a special admixture for concrete that promises to reduce the amount of commonly used cement in concrete formulations, a green technology that reduces CO₂ emissions and has recently been licensed by GreenCentre Canada for further development.

Right: Scientist and co-founder Dr. Jordan Dinglasan prepares a sample of Vive Nano's patented nanomaterials.

REGIONAL AND SECTOR INNOVATION NETWORKS

Ontario offers a number of programs and tools that provide commercialization support to SMEs. These programs are delivered through regional innovation networks for the cleantech industry and are currently being aligned as the Ontario Network of Excellence (ONE) to better support researchers, entrepreneurs and businesses across the province. The organizations that run the programs, as illustrated in Figure 14, have worked with more than 800 SMEs throughout the province.

1. BioEnterprise Corporation, founded in 2003, is a not-for-profit company supported by Agriculture and Agri-Food Canada and the Ontario Ministry of Agriculture, Food and Rural Affairs. It assists with the commercialization of products and services in the agri-food, agri-life sciences and bioproduct industries. BioEnterprise also provides early-stage and emerging companies

with access to business services and networks. <http://www.bioenterprise.ca>

2. Communitech, founded in 1997, is an industry-led organization of more than 550 members and 33,000 professionals in the technology sector. It has helped to turn the Waterloo Region into a world-renowned technology hub. Communitech provides peer-to-peer networking, advocacy and promotion services, business and educational partnerships and an entrepreneurial venture support program. <http://www.communitech.ca/en>
3. The Durham Strategic Energy Alliance (DSEA) is a regional innovation network consisting of business, government and educational institutions working together to advance energy initiatives in the Durham Region. The R&D capabilities are led by the University of Ontario Institute of Technology's (UOIT) energy systems and nuclear engineering programs, which are unique in Canada. <http://www.dsea.ca>

Figure 14: NETWORK OF COMMERCIALIZATION VEHICLES IN ONTARIO

1. Bioenterprise in Guelph
2. Communitech in Waterloo
3. DSEA in Whitby
4. ELORIN in Kingston
5. GHBN in Hamilton
6. IION in North Bay
7. MaRS in Toronto
8. OCETA in Mississauga
9. OCRI in Ottawa
10. RIC Centre in Mississauga
11. SOBIN in Sarnia, Chatham and Windsor
12. SSMIC in Sault Ste. Marie
13. TechAlliance in London



4. The Eastern Lake Ontario Regional Innovation Network (ELORIN) is a regional network that supports biobusiness development. It sponsors regional educational series, seminars and conferences that promote innovation and biobusiness development. ELORIN is also involved in a number of related projects, such as a biomass processing facility and a biofibres initiative. <http://www.elorin.ca>
5. The Golden Horseshoe Biosciences Network (GHBN), founded in 2002, is a regional partnership of business leaders, entrepreneurs, researchers and economic development officers who collaborate in the biotechnology and biosciences sectors. It has developed programs for entrepreneurs, mentored university students in biosciences careers and assisted with the growth of an incubator program at McMaster University. <http://www.ghbn.org>
6. Innovation Initiatives Ontario North (IION) is a regional innovation network. Its goal is to serve as the resource for innovation and commercialization in Northern Ontario, primarily in the areas of bioscience, medicine and bioproducts. IION's mandate is to attract innovation and knowledge-based businesses to Northern Ontario and to facilitate partnerships between industry and educational institutions. <http://www.iion.ca>
7. MaRS is focused on building the next generation of global technology companies by providing research, advisory services, mentorship and capital connections to dozens of high-potential cleantech ventures. MaRS also initiated the Discovery District "Energy Island" project, designed to create and implement a district-wide energy-management plan. <http://www.marsdd.com>
8. The Ontario Centre for Environmental Technology Advancement (OCETA) is a private, not-for-profit corporation that promotes the commercialization and market adoption of cleantech and environmentally sustainable solutions. Since 1993, Ontario's environmental sector innovation network has advised and assisted more than 1,500 Canadian entrepreneurs with commercializing their innovations. <http://www.oceta.on.ca>

OCETA offers a number of services:

- SME Support: business and technical services to support entrepreneurs and start-up companies with commercialization assistance.
- ETV (Environmental Technology Verification) Canada: business and technical services to support delivery of sector-based environmental performance benchmarking projects and third-party verification of environmental performance claims.
- Toronto Region Sustainability Program: program delivery services to support small to medium-sized manufacturers located in the GTA with pollution-prevention and energy-efficiency technical assistance. This service is a prime example of an integrated solution (see the section "Community-Driven 'Green' Projects").
- aboutREMEDIATION: business and technical services to support the adoption of innovative technologies and solutions for site characterization, remediation and redevelopment of contaminated sites and brownfield properties.

OCETA, along with The Russell Mitchell Group, authored the *2009 OCETA SDTC Cleantech Growth & Go-to-Market Report*.

OCETA is also involved with the *Clean 15* Canadian clean technology competition organized by Drayton Weissenfels Inc., which connects visionary North American corporations with Canadian cleantech opportunities. In October 2009, *Clean 15* awarded the top prize to Vive Nano, a Toronto-based company that focuses on the commercialization of nanotechnology-based products and materials for crop protection and catalyst applications (e.g., wastewater treatment, fuel cells, biofuels). <http://www.oceta.on.ca>

9. The Ottawa Centre for Research and Innovation (OCRI) is a not-for-profit, member-based economic development corporation that promotes the advancement of globally competitive knowledge-based institutions and industries. It consists of 700 member companies and offers a range of services, including entrepreneurship, global marketing, investment and commercialization and life sciences programs. Through 2008, it helped with the launch of more than 3,100 new businesses. <http://www.ocri.ca>

OCRI also administers Canada's Top 10 Competition, which promotes the ten most-promising Canadian life-sciences companies (five early-stage and five emerging/late-stage) to Canadian and international investors and partners. Since 1999, winners and alumni have secured more than \$522 million in venture capital financing. <http://www.topcanadiancompanies.ca>

10. The Research Innovation Commercialization (RIC) Centre is a regional innovation network. It works with entrepreneurs and businesses in bringing ideas to market in the aerospace, advanced manufacturing, life-sciences and emerging technology sectors. RIC provides services that include marketing, mentoring, science and laboratory and strategic planning. <http://www.riccentre.com>
11. The Sault Ste. Marie Innovation Centre (SSMIC), founded in 1999, promotes growth in the information technology and knowledge-based sectors in the city and within the Algoma District. It focuses on three core areas: business incubation, SME support services and market development projects. SSMIC is involved in a number of alternative energy projects, including solar and wind farm initiatives. <http://www.ssmic.com>
12. The Southwestern Ontario Bioproducts Innovation Network (SOBIN), a regional innovation network, is dedicated to advancing new bioproducts and finding new uses for biobased feedback in manufacturing, with a focus on the automotive, chemical and energy industries. SOBIN consists of three convergence centres: the Chatham-Kent Bioprocessing/Energy Centre, the Sarnia-Lambton BioProduct Development Centre and the Windsor-Essex Bioproducts Testing Coordination Centre. <http://www.sobin.ca>
13. TechAlliance, founded in 2002, consists of more than 150 member organizations in the London and southwestern Ontario technology sector. It helps entrepreneurs launch new ventures, provides education and networking opportunities to SMEs and advocates for members in the technology, life-sciences and advanced manufacturing sectors. It has facilitated more than \$3 million in investments and launched the Emerging Leaders initiative to foster and support future business leaders. <http://www.techalliance.ca>



- ← One of the first Sun Simba HCPV modules built at Morgan Solar's new manufacturing facility in Toronto.
- ↓ EFS-plastics Inc. produces PP and LD-PE repro resin out of curbside collected mixed plastics and shopping bags.



EMERGING ENTREPRENEURS AND TECHNOLOGIES

Alternative energy

- BIOX Corporation in Hamilton designed, built, owns and operates a biodiesel production facility. It uses a proprietary and patented production process to convert a variety of feedstocks into biodiesel. <http://www.bioxcorp.com>
- Morgan Solar of Toronto has developed a new optical technology for concentrating sunlight. Its concentrated PV systems will be used in large-scale solar farms. <http://www.morgansolar.com>
- Plasco Energy Group, located in Ottawa, is a waste-conversion and energy-generation company. It builds, owns and operates the proprietary Plasco Conversion System, which converts household, commercial and institutional waste into green power and other products. <http://www.plascoenergygroup.com>
- Pond Biofuels in Markham developed a process to increase the biofuel yield from algae. It is the core of a pilot project at St. Mary's Cement, which is using algae to clean stack emissions. <http://www.pondbiofuels.com>



BIOX Corporation's biodiesel production facility in Hamilton, Ontario.

Energy management

- dx2 technologies of Toronto develops real-time energy monitoring systems. The technology enables consumers to understand their energy profiles from consumption and cost perspectives. <http://www.dx2.ca>
- Energate, located in Ottawa, provides home energy-management solutions, including smart thermometers and wireless switches that control water heaters, pool pumps and consumer energy-management portals. The company's solutions support communication between utilities and homeowners. <http://www.energateinc.com>
- Vicicog in Markham developed technology that enables more-efficient use of different energy sources. Its transmission combines leading-edge chain and computer control technology and efficient pulleys that can handle high torque, shift under load and provide excellent system-wide efficiency. <http://www.vicicog.com>

Water and environmental technologies

- EFS-plastics Inc. in Elmira is a post-consumer plastic recycling and reprocessing company. Its proprietary method of recycling consumer plastic produces high-quality pellets that can replace up to 100% of new plastic in the manufacture of consumer products. <http://www.efs-plastics.ca>
- nimTECH Inc. of Toronto developed a non-invasive sonic gauge system. The technology uses ultrasonic sensors to probe any substance through almost any type of container and provides results in real time. These real-time data fill an existing visibility gap in industrial processes by allowing factories to be "tuned" and made to function more intelligently – and with less waste. <http://www.nim-tech.com/Webfiles/competence.html>
- Real Tech Inc., located in Whitby, provides high-quality analytical and monitoring instrumentation for the water and wastewater industries. The company focuses on UV photometry and related applications. <http://www.realtech.ca>
- RefinedData Solutions, Inc. in Richmond Hill develops XML-based software applications that integrate with existing systems to provide environmental and occupational health and safety (OHS) management information. Its products deliver enterprise-grade solutions at an affordable price. <http://www.refineddata.com>

FINANCIAL SUPPORT

Small and medium enterprises (SMEs) have many different options for financial support of their cleantech projects. Listed below are just some of the options available to entrepreneurs in Ontario. They represent funding alternatives that have helped in the growth of companies' capital, enabled the hiring of qualified executives and funded initial demonstration projects.

Ontario Provincial Programs

The Aboriginal Loan Guarantee Program supports Aboriginal participation in new renewable energy infrastructure (e.g., wind, solar, hydroelectric). The program provides up to \$50 million in loan guarantees for energy-generation and electricity-transmission projects. <http://www.ofina.on.ca/algp/program/overview.htm>

The Business Mentorship and Entrepreneurship Program (BMEP), administered by MaRS, helps innovative science and technology companies bring new technologies to market. It offers entrepreneur training, business mentorship and global network access. Funded by the Ontario Ministry of Research and Innovation, the program has been able to attract more business mentorship to the province, supply hundreds of entrepreneurs with free market research services and provide business toolkits to help science and technology entrepreneurs. Many of the companies mentioned in this report receive mentorship through the BMEP program. <http://www.marsdd.com>

The Capital Pool Company (CPC) Program, created by the TSX Venture Exchange (TSXV), is a unique-to-Ontario listing mechanism that serves as an alternative to traditional initial public offerings (IPOs). CPC helps growing companies to cost-effectively access public market capital and allows them to benefit from experienced public company management. The CPC program provides at least \$100,000 in seed financing and a prospectus offering to create a corporate vehicle with public distribution of up to \$1.9 million. Since inception, the program has helped more than 2,000 companies to be listed, with some examples provided below. <http://www.tmx.com/en/pdf/CPCBrochure.pdf>

→ BioExx Specialty Proteins Ltd., headquartered in Toronto [TSXV: BXI], plans to develop, construct, own and operate a global base of oilseed-processing facilities. Its initial focus is on canola oilseed extraction, with plans to expand into rapeseed, soybean and flax seeds. <http://www.bioexx.com>

- Cleanfield Technologies (Ancaster [TSXV: AIR]) develops, markets and distributes proprietary, renewable energy products for urban applications, such as small wind turbines. The company's unique Vertical Axis Wind Turbine (VAWT or V3.5) is designed for tower and rooftop installation and can produce renewable energy for commercial and residential markets. Future product lines include a 250 kW universal inverter, larger wind turbines and nanowire solar technology. <http://www.cleanfieldenergy.com>
- ElectroVaya Inc. (Mississauga [TSX: EFL]) develops and manufactures portable power solutions with its proprietary Lithium Ion SuperPolymer battery technology. Its goal is to provide portable power solutions for the aerospace, defence and wireless sectors, and to develop alternative energy applications (e.g., uninterrupted power supply [UPS], standby power, plug-in hybrids and zero-emission vehicles). In August 2009, the Ontario government announced an investment of up to \$16.7 million to support battery research and pre-commercialization activities. <http://www.electrovaya.com>
- RuggedCom Inc. (Concord [TSX: RCM]) designs and manufactures ruggedized communications equipment for harsh electrical environments and climates. The company has pioneered a number of products and technologies in the electrical utility and industrial automation industries, including the world's first IEC 61850-3-compliant Ethernet switch suitable for use in electric utility substations. <http://www.ruggedcom.com>
- ZENN Motor Company (Toronto [TSXV: ZNN]) produces zero-emission, no-noise electric vehicles, also known as Neighbourhood Electric Vehicles (NEVs). NEVs are recharged by plugging them into a standard electrical outlet and are ready to go within four hours. The company is also a stakeholder in EESor, a Texas-based company that has patented the Electrical Energy Storage Unit (EESU), an ultracapacitor storage device. <http://www.zenncars.com>

Community Futures Development Corporations (CFDCs) are community-based, not-for-profit organizations run by local volunteers. Through FedNor/Industry Canada they provide funding, advice and support to areas in rural and Northern Ontario. <http://www.ontcfdc.com>

The Community Power Fund (CPF) is a financing organization that supports entrepreneurs and projects related to community-owned renewable energy. Its short-term goals include funding up to 15 community power projects, which will offset more than 50,000 tonnes of greenhouse gas emissions by producing 75 MW of community power, with long-term goals of producing 500 MW by 2015 and 10,000 MW by 2025. <http://www.cpfund.ca>



EnviroGrid, a REGEN Energy Inc. technology, is the first solution to provide the benefits of distributed intelligence in the energy-efficiency industry, allowing for a very short ROI in a solution that can be rolled out in a day.

The Green Schools Pilot Initiative enables cleantech companies to demonstrate the viability of technologies to Ontario's schools. Approved companies can showcase their innovative green technologies in a real-world setting and gain exposure to larger markets. <http://www.mri.gov.on.ca/english/programs/gspi/program.asp>

→ Log-One Ltd., based in Loretto, develops and manufactures intelligent, energy-efficient thermostats. The company works with North American utility companies, multi-residential property managers and school boards to develop energy-saving solutions. Log-One's technology enables clients to reduce HVAC energy costs by 25% to 45%. In November 2009, the company was given approval to install its energy-efficient thermostats in eight schools in the Upper Canada District School Board. <http://www.log-one.com>

The Innovation Demonstration Fund (IDF) is a discretionary, non-entitlement funding program operated under the Ontario Ministry of Research and Innovation. It focuses on the commercialization and demonstration of cleantech technologies, processes and products. The IDF will support pilot-stage initiatives related to environmental, alternative energy, bioproducts, hydrogen and other significant technologies. The fund will cover up to 50% of eligible costs in the commercialization process. <http://www.mri.gov.on.ca/english/programs/idf/guidelines.asp>

Vive Nano and Tyromer (two companies mentioned earlier in this report and born out of university research) have both applied for IDF funds.

- Vive Nano recently received \$4 million, which will be used for pilot plant construction.
- Tyromer received
 - \$250,000 from the Sustainable Chemistry Alliance fund (<http://www.suschemalliance.ca>), which is dedicated to the role of sustainable chemistry in the development of solutions that affect climate change, peak oil, energy security, the need for safe water and the use of scarce natural resources; and
 - \$750,000 from First Leaside Visions II Limited Partnership (<http://www.firstleaside.com>), a registered Ontario Commercialization Investment Fund (OCIF) through efforts of the Accelerator Centre in Waterloo. The Ontario government established the program to help leverage pools of seed capital for spin-off technology companies created by faculty, staff and students of Ontario-based research institutions.

The Investor Accelerator Fund (IAF) is an early-stage seed fund co-managed by MaRS Discovery District and OCE. It helps Ontario-based start-up and early-stage technology companies bring technology products and services to market. The IAF also provides access to market research and business mentoring services through its management organizations. Individual companies are eligible for up to \$500,000 in investment funding. <http://www.oce-ontario.org/Pages/Cinvest.aspx>. Below are some recent cleantech investments made by IAF.

- Echologics Engineering Inc. of Toronto develops and commercializes technology to reduce leaks in water distribution systems. Its products effectively reduce water loss through fluid delivery pipelines, resulting in monetary, environmental and health cost savings. <http://www.echologics.com>
- Energent Inc., located in Waterloo, provides energy-intensive facilities with automated, real-time energy information solutions that reduce energy costs and lower carbon emissions. These solutions enable companies to make decisions to effectively manage and reduce their energy use by up to 40%. Energent maintains the systems that collect real-time information from client sites, which is delivered to the client via the Internet. <http://www.energent.com>
- REGEN Energy Inc., in Toronto, has developed a wireless controller that automatically manages electrical peak demand levels for commercial heating and cooling applications. The technology can reduce peak energy demand and consumption by 25% to 30%. REGEN's controllers provide efficient energy-management solutions that are ideal for most buildings. <http://www.regenenergy.com>
- Skymeter Corporation of Toronto provides vehicle-use information through a combination of in-vehicle sensors and a patented data-processing system. Applications include road-use charging, parking metering, location-based marketing and pay-as-you-drive insurance. The technology can help reduce automotive emissions and traffic congestion. <http://www.skymetercorp.com/cms/index.php>



Stemergy Renewable Bio-Fiber Technologies harvests hemp near London, Ontario for conversion to use in car parts.

Hemp and flax-based composite building materials.

The Northern Ontario Heritage Fund Corporation (NOHFC) provides a number of programs to foster opportunities in Northern Ontario. These include the Enterprises North Job Creation Fund, the Emerging Technology Fund, the Infrastructure and Community Development Fund, the Northern Ontario Young Entrepreneur Fund, the Northern Ontario Youth Internship and Co-op Fund and the Northern Energy Fund. http://www.mndm.gov.on.ca/nohfc/default_e.asp

- Ellsin Environmental Ltd., located in Sault Ste. Marie, is building a 930-square-metre plant to recycle scrap tires. The facility will use a patented technology developed by Environmental Waste International to convert whole scrap tires into hydrocarbons (oil and process gas), carbon black and scrap steel by using a patented reverse polymerization process. <http://www.ellsin.com>

The Ontario BioAuto Council focuses on supporting affordable, sustainable biobased materials ventures and commercialization. Product applications include flexible biobased foams for car seats and wood fibre composites for automotive and construction applications. <http://www.bioautocouncil.com>

- GreenCore of Toronto manufactures proprietary, high-performance cellulosic-fibre-reinforced composite materials. Its products are used in automotive products, furniture, toys and other consumer and industrial products. All its products are environmentally friendly and provide more strength to the base polymer. <http://www.greencorenc.com>

The Ontario BioCar Initiative represents a partnership between the automotive industry and the public sector, including four Ontario universities. It is geared toward accelerating the use of biomass in automotive materials, as well as reducing related costs and the improvement of value. <http://www.bioproductsatguelph.ca/biocar/>

- Stemergy Renewable Bio-Fiber Technologies, located in Delaware, produces and supplies renewable biofibre material from stem fibre plants (e.g., hemp, flax), which are environmentally friendly renewable resources. The biofibres are processed and refined to accommodate a wide range of applications that traditionally use plastics, such as storage bins. <http://www.stemergy.com>

The Ontario Fuel Cell Innovation Program (OFCIP) is a discretionary funding program that focuses on the commercialization of fuel cells and related technologies. Strategic objectives include nurturing the development of SMEs involved with fuel cells and compatible technologies and increasing the performance, reliability, durability and economic viability of these technologies. <http://www.mri.gov.on.ca>

The Ontario Power Authority's Technology Development Fund provides funding for projects that promote the development and commercialization of technologies that have the capability of improving electricity supply, conservation or demand management. <http://www.powerauthority.on.ca>

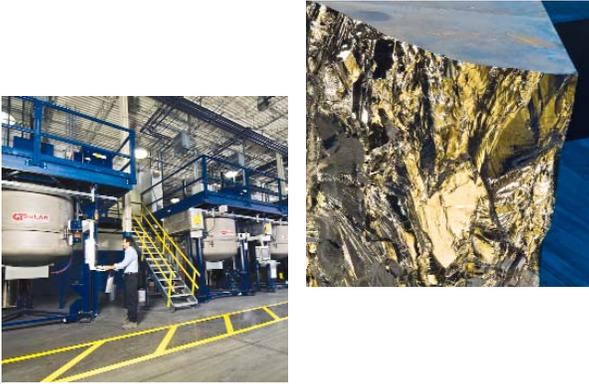
Precarn administers a number of programs that fund research, aid entrepreneurs and assist in the commercialization of innovative technologies. The Core Research Funding Program supports projects related to intelligent systems. Precarn is also teaming with the Canadian Society for Computational Intelligence to fund a contest to promote the development of intelligent systems solutions. <http://www.precarn.ca/ProgramsFunding/index.html>

- SITTM Technologies Inc. of Sault Ste. Marie develops distributed systems of small-scale energy units that work on-site at the consumer level. Their technology enables communities to contribute to energy production and shortens the energy value chain. SITTM's technology will add to the current energy balance by providing access to biodiesel production technology. <http://www.sittm.ca>

The Toronto Atmospheric Fund (TAF) supports projects that reduce local greenhouse gas emissions, as well as best practices in energy conservation and efficiency. Funds are granted under four strategic program areas: FleetWise (hybrid and electric vehicle solutions), LightSavers (low-carbon lighting), TowerWise (energy efficiency in high rises) and SolarCity (local solar generation). <http://www.toronto.ca/taf/>

- Habitat for Humanity Toronto: integrating renewable energy into general practice
- Harbourfront Centre: net-zero program development
- Toronto Community Housing Corporation: solar roofing pilot project
- Toronto Renewable Energy Cooperative: enabling solar uptake in Toronto's residential sector
- University Health Network: energy-management and engagement program
- YWCA Toronto: Elm Street affordable housing project

6N purified solar silicon: The cost-effective 6N product produces high efficiency solar cells and modules with performance equivalent to conventional semiconductor silicon.



6N solidification furnaces: These furnaces are used in the last step of 6N's silicon purification process to provide a standard PV industry product form.

Federal Programs

The following list includes sources of federal government financing for cleantech companies:

- Business Development Bank of Canada (BDC) <http://www.bdc.ca>
- Canada Foundation for Innovation <http://www.innovation.ca>
- Canadian International Development Agency (CIDA) <http://www.acdi-cida.gc.ca>
- Development Innovation Fund <http://www.idrc.ca>
- Federation of Canadian Municipalities' Green Municipal Fund (GMF) <http://www.sustainablecommunities.ca/GMF>
- Natural Resources Canada Energy Funds (and other eco-grants) <http://www.nrcan-rncan.gc.ca>
- National Research Council of Canada's Industrial Research Assistance Program (IRAP) <http://www.nrc-cnrc.gc.ca/eng/ibp/irap.html>
- Natural Sciences and Engineering Research Council of Canada (NSERC) Collaborative Research and Development Grants <http://www.nserc-crsng.gc.ca>
- Northern Ontario Development Fund http://www.ic.gc.ca/eic/site/fednor-fednor.nsf/eng/h_fn02348.html
- Program of Energy Research and Development (PERD) <http://www.nrcan-rncan.gc.ca>
 - ecoAGRICULTURE Biofuels Capital Initiative (ecoABC) <http://www.ecoaction.gc.ca>
 - ecoENERGY for Biofuels <http://www.ecoaction.gc.ca>
 - ecoENERGY for Renewable Power <http://www.ecoaction.gc.ca>
- Scientific Research and Experimental Development (SR&ED) Tax Incentive Program <http://www.cra-arc.gc.ca/sred>
- Sustainable Development Technology Canada (SDTC) <http://www.sdtec.ca>

SUSTAINABLE DEVELOPMENT TECHNOLOGY CANADA

Sustainable Development Technology Canada (SDTC) is a not-for-profit, non-share capital corporation operated under the *Canada Business Corporations Act*. It funds sustainable development projects and builds private sector partnerships to bring technologies to market. SDTC operates the SD Tech Fund (emerging clean technologies) and the NextGen BioFuels Fund (facilities for next-generation renewable fuels). It has provided funding to several Ontario cleantech companies:

- Blue-Zone Technologies Ltd., located in Concord, specializes in cost-effective prevention and reduction of greenhouse gas emissions from hospital operating rooms. Its globally innovative technology sustainably captures excess volatile anaesthetics, which are medical gases with high global-warming potency that are usually vented into the atmosphere through operating rooms' scavenging systems. <http://www.bluezone.ca>
- Duropar Technologies of Brampton takes raw materials that are difficult to recycle (e.g., asphalt, blue bin waste plastics) and processes them by using their patented technology. The resultant composite material can be moulded into different shapes and products, such as railway ties. The product is environmentally friendly, stronger than concrete and impervious to freeze-thaw cycles, salts, chemicals, gasoline and oil.
- Elementa Group in Sault Ste. Marie created an endothermic, non-combustion process for the clean conversion of carbon-based material into pure syngas. It is very clean, highly efficient and simple to construct and operate, and it supports the reduction of greenhouse gases. The process produces clean energy, hydrogen and other valuable products from garbage and industrial by-products. <http://www.elementagroup.com>
- Fifth Light Technology, located in Oakville, creates lighting solutions that provide sophisticated operating control over individual light fixtures. The company's advanced lighting management system conserves energy, reduces operating costs and improves lighting quality. <http://www.fifthlight.com>
- Xogen Technologies Inc. of Orangeville is developing an innovative technology for wastewater treatment. Their technology has the potential to reduce the footprint of treatment plants, to eliminate most conventional unit processes and the production of biosolids, and to produce a by-product (oxyhydrogen gas) for reuse as an energy source. <http://www.xogentechnologies.ca>
- 6N Silicon, located in Vaughan, has developed cost-effective metal-processing techniques to develop solar-grade silicon for use in PV cells. Its technology addresses the cost and supply of silicon. The company's efforts were supported by Sustainable Development Technology Canada (SDTC) as part of the EOS Project. <http://www.6nsilicon.com>

COMMUNITY-DRIVEN “GREEN” PROJECTS

The success of many of the previously mentioned companies is determined not only by the commercialization and funding support provided by the community but also by the desire that exists in communities to make the shift to “green.” A few examples of community-driven green projects in Ontario are listed below.

- The Better Buildings Partnership (BBP) is a Toronto-based city-to-business program that provides expertise, resources and financial assistance to building owners, managers and developers. Its goal is to assist with the implementation of energy-efficiency measures and newer, energy-efficient technologies for existing buildings and new constructions. <http://www.bbptoronto.ca>
- The Town of East Gwillimbury has launched the Thinking Green! Initiative, a comprehensive sustainability program that is designed to protect the environment, enhance economic prosperity and improve the community’s health and lifestyle. The initiative includes energy-efficient standards for new homes and buildings, an energy retrofit program and an energy-generation and conservation strategy. <http://www.eastgwillimbury.ca>
- The Enwave Deep Lake Water Cooling (DLWC) system in Toronto is a private district heating and cooling system. It draws cold water from Lake Ontario to provide cooling for more than 140 buildings in the downtown core. It is the world’s largest lake-source cooling system and a source of renewable, green energy. <http://www.enwave.com/dlwc.php>
- The City of Guelph has a comprehensive community energy plan developed by a consortium and implemented through several initiatives led by various stakeholder groups. Initiatives include generating electricity from landfill gas and sourcing locally created renewable resources. <http://www.guelph.ca>
- The London EnerGuide Partnership is a municipal resource designed to augment the use of energy-saving and renewable technologies in residential construction. It promotes the implementation of energy-efficient options for new homes and educates homebuyers on the true costs of energy-efficient choices. <http://www.energuide.london.ca>
- Quality Urban Energy Systems of Tomorrow (QUEST) is an Ottawa-based coalition of members from industry, the environmental movement, government, academia and the consultant community. Its mission is to foster a community-based, integrated approach to land use, energy, transportation, waste and wastewater, and to reduce greenhouse gases, air pollution and waste. <http://www.questcanada.org>.
- The Toronto Region Sustainability Program delivered by OCETA provides small to medium-sized manufacturers in the GTA with one-stop shopping for greening their business bottom lines through pollution-prevention and energy-efficiency technical assistance. The program presents businesses with opportunities to reduce their environmental footprint and achieve integrated sustainable solutions while addressing their environmental priorities. <http://www.oceta.on.ca/TORSUS/index.htm>.

CULTURAL DIVERSITY: A GATEWAY TO INTERNATIONAL MARKETS

Ontario can be described as a mosaic of different cultures from around the world. This cultural diversity provides for access to valuable human resources, an educated workforce, international business acumen and connections to world markets.

Ontario has always been a destination for immigrants with education and experience (source: Statistics Canada):

- The growth rate of the Greater Toronto Area (GTA) was 1.92% from 1996 to 2007.
- Annual net migration was 80,000 from 2000 to 2006.
- Since 1961, more than one quarter (26.8%) of Ontario’s population has been born outside Canada (30% in all city regions and 43.4% in Toronto).
- In 2000, 26% of immigrants had university degrees.
- By 2006, more than half (51.1%) of all working immigrants to Canada joined Ontario’s labour market.
- Between 2001 and 2006, 45% of new immigrants to Canada settled in the GTA.

UV Pure Technologies' Hallett 30 water purification systems installed in the municipal potable water treatment system in Baltimore, Ontario.



DOING BUSINESS IN CHINA

UV Pure Technologies develops and manufactures technically advanced, world-leading UV water purification systems. More than 9000 systems are installed in residential, commercial and municipal applications of up to 1 MGD flow rates for drinking water and wastewater treatment. The company developed the Hallett with Crossfire Technology, which offers easy lamp changes and visual quartz inspection, is self-cleaning and smart and boasts multiple sensors and on-board diagnostics. All systems provide a minimum dose of 40 mJ/cm². During a business forum in Beijing, the Chinese Ministry of Water Resources recommended the product for use in China's domestic water industry. UV Pure announced a Chinese distribution agreement with Omazo Ventures to sell its water-treatment products in China. <http://www.uvpure.com>

A high rate of immigration is an indicator of economic growth and stability. The influx of well-educated immigrants to the GTA increases the strength of the labour force through the addition of international skills, training and life experiences. Another benefit of immigration is "knowledge spillover," which involves the learning and transfer of knowledge between individuals and companies that constitutes an essential element of the innovation process.

A number of programs and initiatives encourage immigration of skilled and educated workers to Ontario and help companies to take full advantage of these valuable human resources.

- The Toronto Region Immigrant Employment Council (TRIEC) implements local solutions to assist immigrants who are looking for employment opportunities. It consists of all three levels of government, as well as employers, labour groups, occupational regulatory bodies, educational institutions, assessment service providers and community organizations. <http://www.triec.ca>
- Ontario has an uncapped number of work permits available to foreign workers.
- Ontario's Provincial Nominee Program enables employers to permanently recruit research staff and other workers within specific occupations. <http://www.ontarioimmigration.ca>
- The Federal Credential Recognition Program provides orientation sessions for potential immigrants. <http://www.hrsdc.gc.ca>

Highlighted below are examples of prominent cleantech activities in Ontario that are connected to two of the largest growing world markets: China and India. This trade activity is facilitated by immigrants from these countries who have formed business communities in Ontario.

The Canada China Environmental Forum (CCEF) discusses the opportunities for Canadian cleantech companies to meet China's environmental concerns. Canada and China have a history of environmental cooperation, which includes the *Canada-China Framework Statement for Co-operation on Environment into the 21st Century* (signed in November 1998). Canadian firms can take advantage of this relationship by providing Chinese businesses with innovative environmental solutions, such as water treatment, clean energy options and environmental-management technologies. <http://www.canadachinagreen.com>

There are many opportunities for Canadian cleantech companies to grow their business in China:

- Getting involved with Canadian organizations and associations that have business relationships and resources in China (e.g., Canada China Business Council, The Hong Kong Canada Business Association, Asia Pacific Foundation of Canada)
- Joining an organized trade mission to China to develop business relationships
- Developing an understanding of the Chinese market and how Chinese companies do business
- Seeking out value-added collaborations and cooperative alliances with other companies
- Building upon existing support networks with other companies outside of the cleantech sector

After China, the second-largest market in the world is India, which is also a key target market for Ontario entrepreneurs (as underscored by Premier Dalton McGuinty's mission to India in December 2009). Many Indian business-centric organizations exist in Ontario and work closely with the Ontario government in various capacities, such as making introductions to business partners and connecting them to national and state-level decision makers in India. Some of these organizations include TiE (The Indus Entrepreneurs), Canada India Foundation (CIF) and Process Research ORTECH Inc. (PRO).

PRO explores, develops and commercializes innovative solutions in cleantech and renewable energy for Ontario's process industries. It also provides technology transfer, skills development and training, engineering assistance and market evaluation. PRO was a sponsor of the Canada India Energy Forum held in April 2009 and organized by the CIF. The forum's goals were to provide a platform for the exchange of energy-sector knowledge and information, highlight developments in the Canadian and Indian energy sectors and promote mutual business opportunities between energy companies in both countries. Conference topics included renewable energy sources, biofuels, technology transfer, infrastructure and investment. Such forums set the stage for trade relations between Ontario and India to flourish in the cleantech sector. <http://www.processortech.com>

DOING BUSINESS IN INDIA

In December 2009, Premier Dalton McGuinty led the Clean Technology Mission to Mumbai. The result was several hundred million dollars in agreements between Indian partners and Ontario cleantech companies. The following announcements were made during the mission:

- Canasia Power Corp. (located in Toronto) and Chem Process Systems Pvt. Ltd. signed a Memorandum of Understanding to produce and develop heat-transfer technologies, which will be energized and powered by Canasia-designed solar power systems. <http://www.canasiapower.com>
- PCI Geomatics, located in Toronto, announced an agreement with Rolta Inc. to provide world-leading environmental monitoring and market-access technology. <http://www.pcigeomatics.com>
- R.V. Anderson Associates Limited of Toronto, Mott MacDonald Limited and PHE Consultants have been working together since 2007 on the design and implementation of the Mumbai Sewage Priority Works Projects, which includes improvements to Mumbai's wastewater system. The project was secured during the 2007 Trade Mission to India and has now expanded significantly. <http://www.rvanderson.com>

AT THE DEVELOPMENT LEVEL

Scientist Profiles

Cutting-edge research into environmental and energy-related technologies will propel Ontario through Phase 3 of cleantech growth and development. Many researchers are involved in leading-edge scientific developments that may be commercialized and then either licensed or spun off into new companies. These cleantech innovations will not only be adopted within the province but will also have a global impact. The profiles below introduce just a few of the researchers who are well recognized in their community.



Luc Duchesne

LUC DUCHESNE is an entrepreneur and a scientist engaged in the bioeconomy. He has a BSc in forestry from Laval University, an MSc from the University of Toronto and a PhD from the University of Guelph. Dr. Duchesne is widely published in a broad range of disciplines, including forest economics, bioenergy, biotechnology, molecular biology, entomology, pathology, microbiology, old-growth forests, fire ecology and non-timber forest products. He is also the principal in Biocarbon Systems International, a new, publicly listed northern Ontario venture, which uses R-MAP (remote mapping and photography) technology. This technology was originally developed for forest inventory of biomass stocks in all forest types but is also well suited for assessing and monitoring carbon stocks in compliance with the requirements of voluntary and regulated carbon-sequestration projects in forest and agricultural ecosystems.



Cynthia Goh

CYNTHIA GOH, professor of chemistry and associate director of the Institute for Optical Sciences at the University of Toronto, earned her PhD from the University of California in Los Angeles. Dr. Goh is a co-developer of Vive Nano's technology. She is also an experienced entrepreneur, having founded Axela Inc. (named one of the top-ten biotechnology firms in Canada in 2005) and Dalenyi BioSurfaces. She has independently launched a number of commercialization initiatives, including Entrepreneurship 101 – an annual course that currently runs at MaRS Discovery District and which introduces entrepreneurship to experienced scientists and engineers. Dr. Goh has extensive experience in milestone-driven research and has worked with many industrial partners.



Stephen Harrison

STEPHEN HARRISON has many years of experience in the development and evaluation of solar-energy equipment. He is the director of the Solar Calorimetry Laboratory at Queen's University. His experience includes eight years as a research officer at the National Research Council of Canada, where he was involved in the development of national and international standards for solar heating equipment. In 1999, he co-founded Enerworks Inc., a manufacturer of solar thermal products. In 2005, he became the theme leader for solar heating and cooling within the Canadian Solar Buildings Research Network, which includes the participation of researchers at 11 universities across Canada.



Rafael Kleiman

RAFAEL KLEIMAN earned his SB (bachelor of science) degree from MIT, and MSc and PhD degrees from Cornell. He holds the Canada research chair in microelectromechanical systems (MEMS) and is a renowned expert in MEMS devices. He led a successful application to the Canada Foundation for Innovation and the Ontario Research Fund that together will provide \$10.2 million for advanced photovoltaic research, with a focus on the supply of clean, sustainable solar energy.



Mohini Sain

MOHINI SAIN received his PhD in chemical engineering from the Technical University, Bratislava. He is the director of the Centre for Biocomposites and Biomaterials Processing, a professor in the faculty of forestry and cross-appointed to the department of chemical engineering and applied chemistry at the University of Toronto. He is the lead inventor of GreenCore's technology and the founding president of GreenCore Composites Inc. His research areas include nano-biocomposite processing, industrial bioplastics synthesis, reinforced-natural-fibre-composite manufacturing processes and the development of cost-effective technology to use renewable raw materials in industrial product manufacturing. Dr. Sain also works on isolation and surface science of pulp, microfibres and nanofibres and their applications in papermaking, biopackaging, transportation and related areas. He is the leader of the AUTO21 Renewable Materials project and leads a research team on the BioCar Initiative in collaboration with the University of Guelph.



Ted Sargent

TED SARGENT received a BScEng (engineering physics) from Queen's University and a PhD in electrical and computer engineering (photonics) from the University of Toronto. He holds the rank of professor in the Edward S. Rogers Sr. department of electrical and computer engineering at the University of Toronto, where he is also the Canada research chair in nanotechnology. He won one of 12 inaugural Global Research Partnership grants from King Abdullah University of Science and Technology in Saudi Arabia. These prestigious \$10-million five-year grants support research on topics relevant to the global society. His book *The Dance of Molecules: How Nanotechnology Is Changing Our Lives* (Penguin) was published in Canada and the United States in 2005 and has been translated into five languages.



Stephen Tullis

STEPHEN TULLIS received a BSc and an MSc from Queen's University and a PhD from Cambridge University. His main interests are turbulence and combustion. In his work, direct numerical simulation (DNS) is used to understand the underlying physics involved in the interaction between turbulence and flame dynamics in premixed combustion. The results of these large and computationally expensive simulations can be used in the development of improved subgrid scale models for large eddy simulations (LES) of turbulent reacting flows. LES of the flows in gas turbine combustors (and other flows of engineering interest, where turbulence plays a crucial role in performance) is one of the ultimate outcomes of this work. Dr. Tullis is an assistant professor at McMaster University.



APPENDICES



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PHOTO CREDITS AND COURTESIES

Sir Adam Beck I Hydroelectric Power Station [page 14–15]:
Energy Control System at the Rogers Centre, Toronto [page 17]:
Trojan UV Water Treatment System [page 18]:
Worsfold Water Quality Centre [page 21]:
Photo, Dimitre Karamanev & Victor Pupkevich [page 21]:
Pukwis Community Wind Project [page 24]:
Photo, Lionel Catalan & Stephen Kinrade [page 27]:
Photo, Jordan Dinglasan [page 27]:
Sun Simba HCPV Module [page 30]:
Recycled Plastic Pellets [page 30]:
BIOX Biodiesel Production Facility [page 30]:
EnviroGrid Energy Controller [page 32]:
Hemp Harvesting / Hemp Lumber Composites [page 33]:
6N Silicon Furnaces / Purified Solar Silicon [page 34]:
Hallett 30 Water Purification System [page 36]:
Photo, Luc Duchesne [page 38]:
Photo, Cynthia Goh [page 38]:
Photo, Stephen Harrison [page 38]:
Photo, Rafael Kleiman [page 39]:
Photo, Mohini Sain [page 39]:
Photo, Ted Sargent [page 39]:
Photo, Stephen Tullis [page 39]:

Ontario Power Generation
Encelium Technologies Inc.
Trojan Technologies
Worsfold Water Quality Centre (WWQC) / Trent University
Biotricity / University of Western Ontario
Windfall Ecology Centre
GreenCentre Canada / Lakehead University
Vive Nano Inc.
Morgan Solar Inc.
EFS-plastics Inc.
BIOX Corporation
REGEN Energy Inc.
Stemergy Renewable Bio-Fiber Technologies
6N Silicon Inc. / Lloyd Sutton
UV Pure Technologies Inc.
Luc Duchesne
Cynthia Goh
Stephen Harrison
Rafael Kleiman
Mohini Sain
Ted Sargent
Stephen Tullis

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