

Solar Energy in the Toronto Region

December 2009



Outline

- Key regional facts
- Solar potential and opportunities in Ontario
- Ontario Green Energy Act (GEA)
- Global status in solar research publications and patents
- State of the solar industry
 - Highlighting recent developments and innovative companies
 - Companies and labour force
- Overview of regional assets
 - Research institutes and scientific expertise
- Government programs and incentives

Solar Energy: An emerging R&D cluster in the Toronto Region



Key Regional Facts

- Ontario has a long history of clean energy development (hydropower and nuclear energy)
 - Early closure (by 2014) of four coal plants will open up capacity on the grid (~2,000 MW)
- Strategic North American location
 - Located in the heart of 25 million acres of farmland with a high annual south-facing photovoltaic potential
 - Located on the shores of the Great Lakes - the world's largest fresh water source
- Political leadership committed to sustainability and large-scale infrastructure spending and widespread public support
 - Green Energy Act (GEA) provides strong incentives for investment in renewable energy projects

Key facts continued

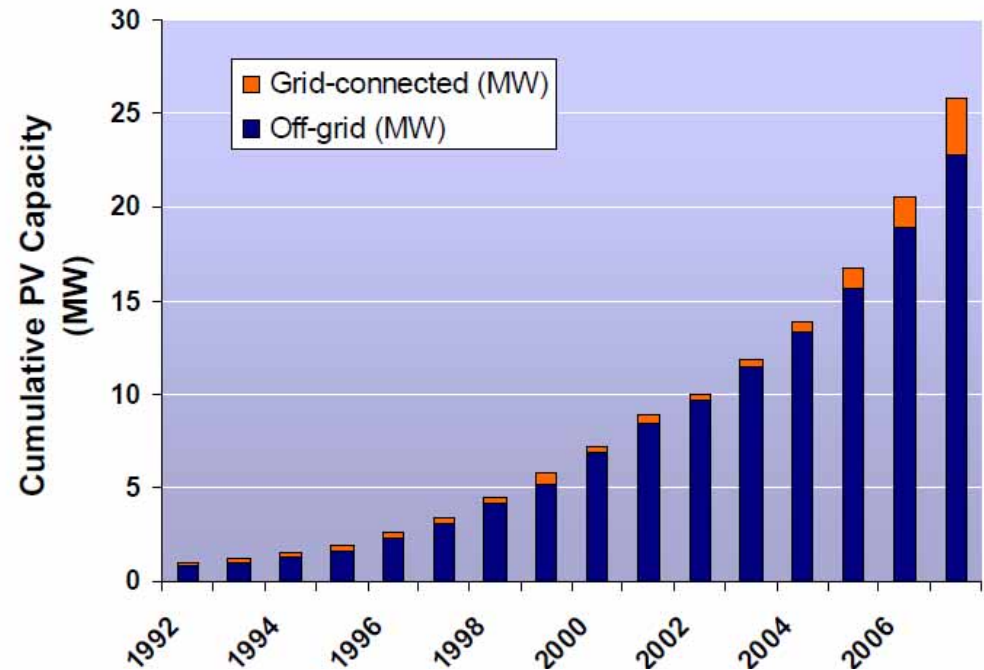
- Part of a sophisticated electricity infrastructure and growing demand for clean, reliable electricity generation
 - Investments in new renewable energy projects already in place or under construction in Ontario total \$4 billion

- Dynamic energy and environment hub
 - 210 companies that design and install PV products for public and commercial needs
 - 1,700+ companies provide products and services across variety of sub-sectors, including air/gasses, biomass, electricity, fuels, hydrogen, nuclear, solar, water, wind and waste

Significant opportunities in Canada

- The photovoltaic market has been averaging a growth of 25% annually since 1993 with 26 MW installed in 2007
- ~93% of Canada's PV applications are stand-alone systems (road signals, navigational buoys, industrial sensing, monitoring and controlling, remote homes...)
- Incentives offered for the on-grid market through GEA

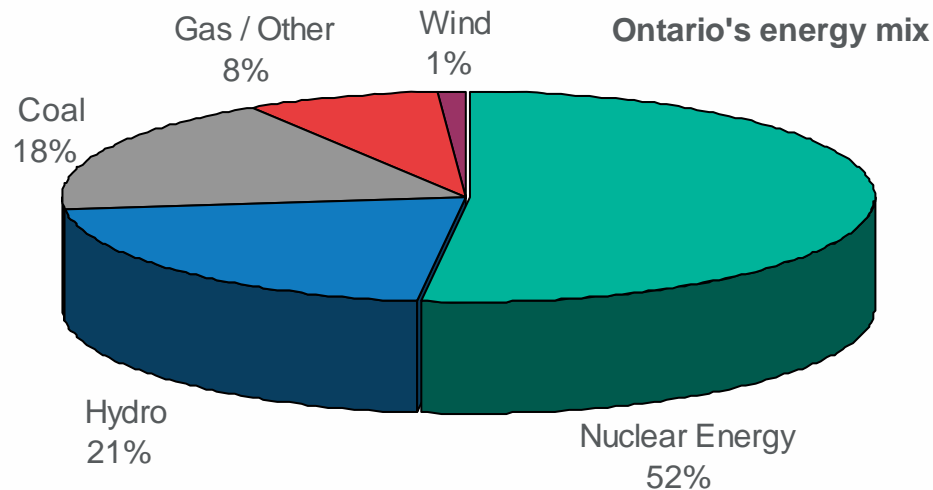
**Cumulative PV Capacity installed in Canada
from 1992 - 2007**



Source: CanmetENERGY, Natural Resources Canada

“Ontario is at an energy crossroads”

- By 2020, the province will have a peak demand of > 30,000 MW of power but only 10,000 MW of generating capacity
- Ontario’s electricity system is currently supplied by large, outdated and expensive coal and nuclear plants

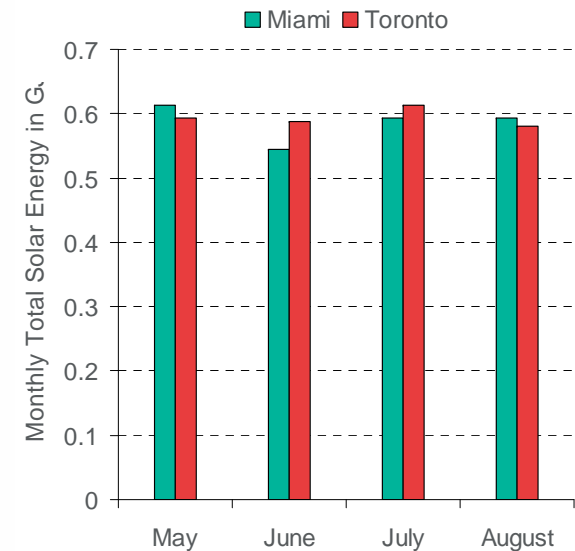
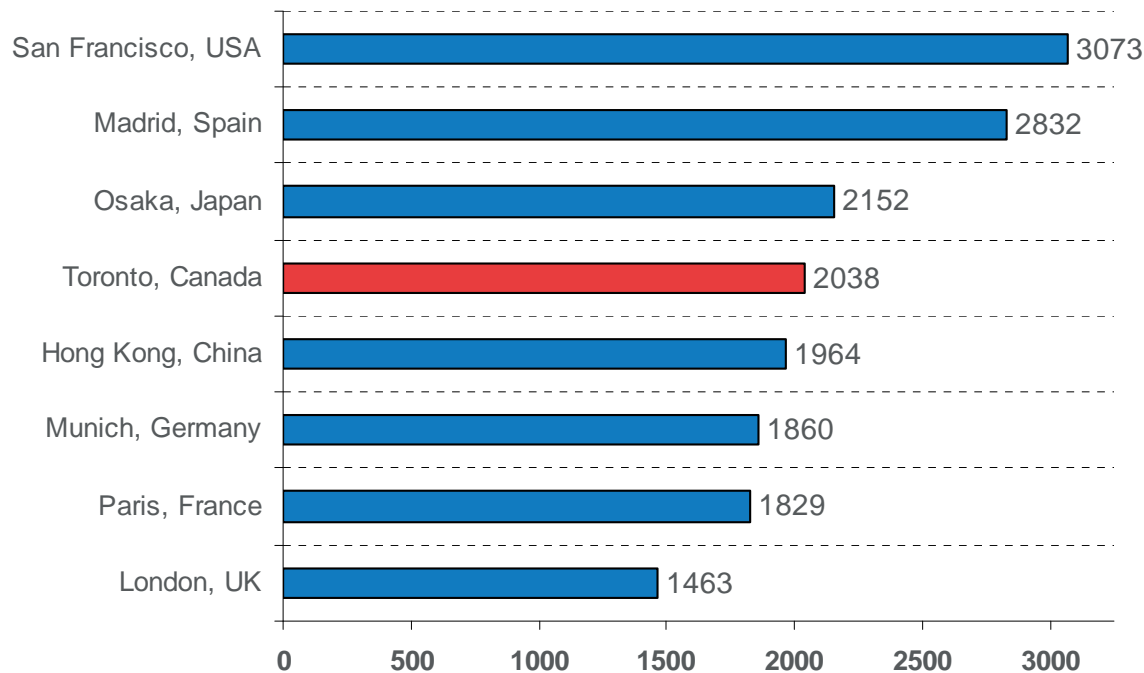


Source: David Suzuki Foundation 2004, Ministry of Energy and Environment, Invest Ontario

Ontario's solar potential

- Southern Ontario has a greater solar potential than leading regions in Germany, France and China and even a better summer solar resource than Miami, Florida

Sunshine Hours per year of Competitive Cities



Source: Yahoo Travel Guide, <http://www.climatetemp.info/>, Environment Canada, David Suzuki Foundation 2004

Market potential in Ontario

Solar Thermal

- Given strong policy measures, by 2025 the province could install:
 - 800,000 solar domestic hot water systems
 - 120,000 solar pool heaters
 - Solar passive design in 420,000 new homes
 - 2,000,000 m³ of commercial and institutional solar hot water systems
 - 825,000 m³ solar air ventilation systems
- The public supports solar development - even on agricultural land
 - About 80% of the Ontario-wide population and residents in rural areas believe in giving farmers choice over solar panel installations

Photovoltaic

- 47% of current Ontario homes have the technical capacity to install a 3-kW solar PV array (typical size for a residential system)
- 50% of Ontario's existing commercial/institutional buildings can support PV

Source: David Suzuki Foundation 2004 and *CanSIA News Release July 23, 2009*

Ontario Green Energy Act (GEA)

“Ontario’s Green Energy Act represents North America’s most ambitious and far reaching enabling legislation and will place Ontario as a world leader in renewable energy development, industrial innovation and climate protection.”

Dr. Hermann Scheer, General Chair of the World Council for Renewable Energy, Member of the German Bundestag

- Aggressive target of 10,000 MW of new installed renewable energy by 2015 in Ontario
- Ambitious goal to see 100,000 solar rooftop systems deployed across Ontario

GEA continued

Key components

- “Feed-in Tariff” (FIT) guarantees rates for energy generation for 20 years
- Up to 80.2 ¢/kWh for solar compared to 11-19 ¢/kWh for other forms of green power
- 100% inflation protection
- No cap on project size, program size or voltage
- Streamlined approvals process
- Priority grid access and ‘right to connect’ to the electricity grid for renewable energy projects
- Domestic content requirements (50% to come from Ontario goods and labour for large installations)
- “Smart” power grid system

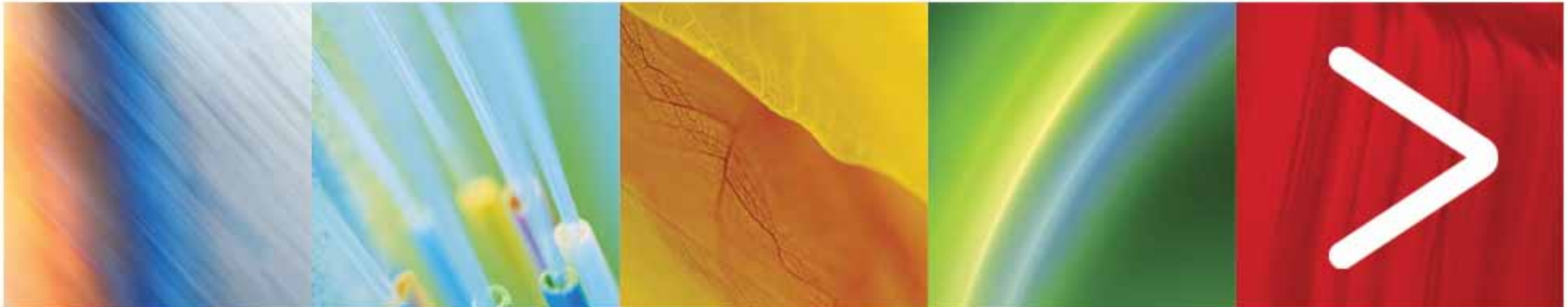
Competitive with FiT rates globally

	Rate (¢/kWh)	Details
Ontario	80.2	<10 kW, rooftop
Italy	85.7	1-3 kW, building integrated
Italy	78.5	1-3 kW, rooftop
Germany	76.4	<30 kW, building integrated
Germany	70.3	<30 kW, rooftop
France	78.5	Building integrated
France	42.8	All other systems
Spain	60.0	All systems
Japan	58.2	All systems

Source: "Feeding the Grid Renewably", Feb. 2008, The Pembina Institute, Toronto

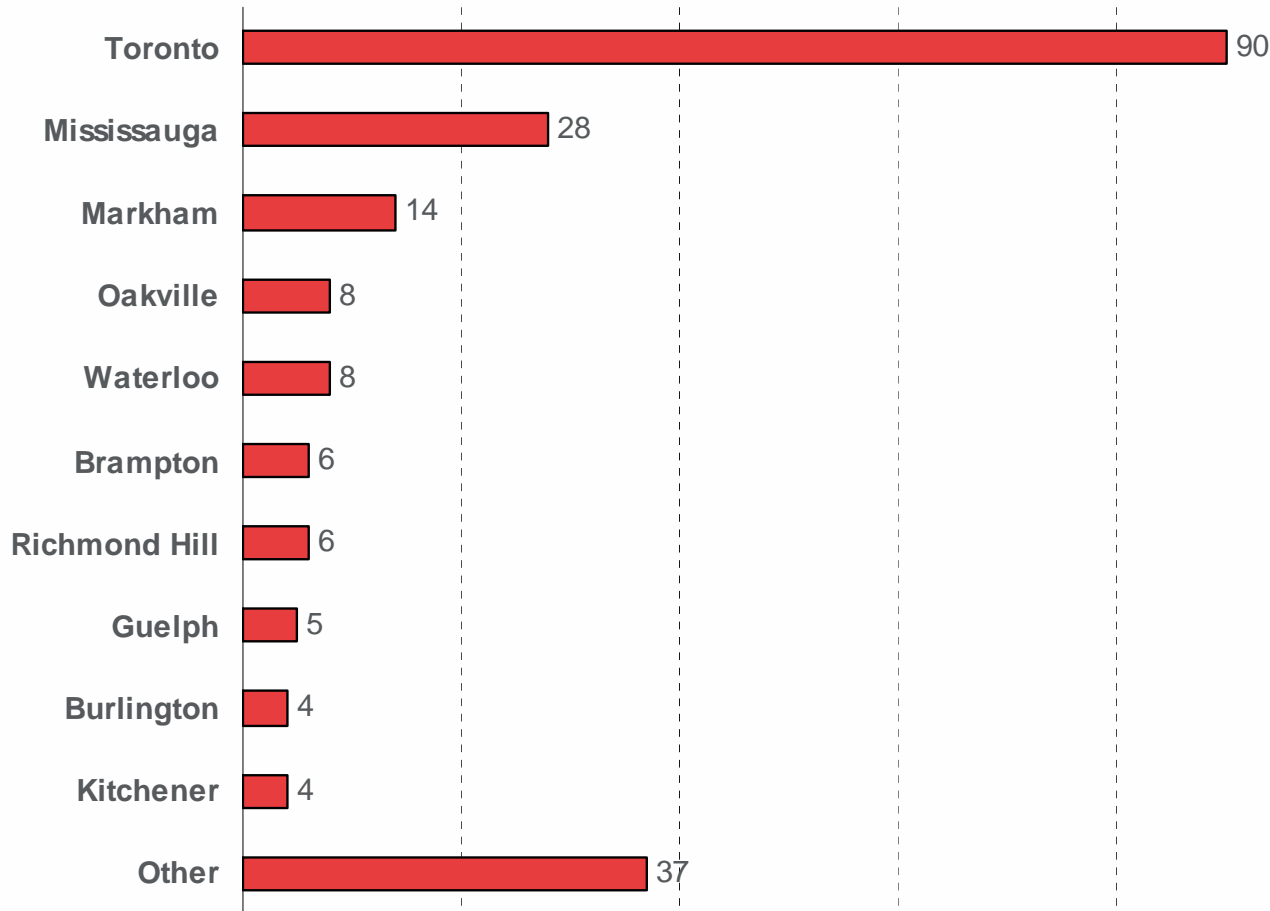
For Japan: Article: http://www.energymatters.com.au/index.php?main_page=news_article&article_id=335

Solar Industry in Ontario

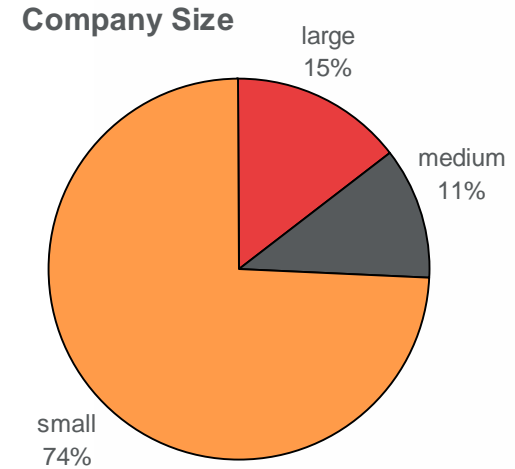
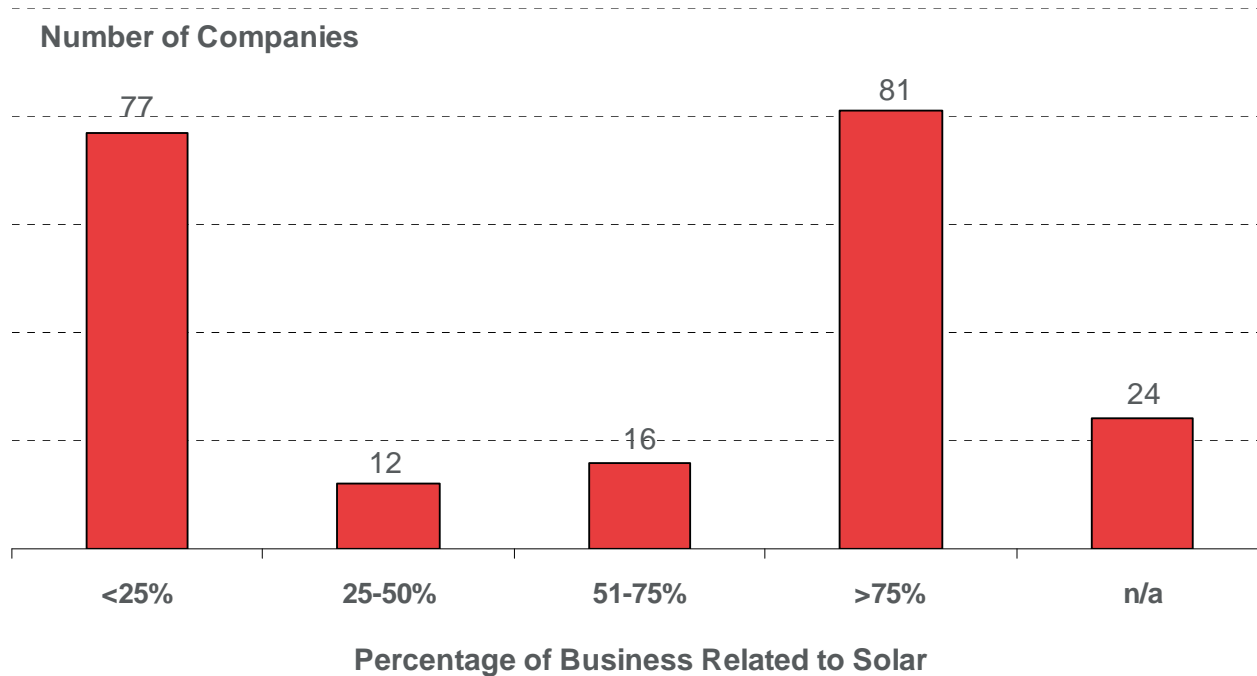


A growing hub with 200+ companies

Number of Companies by City



Source: Canadian Solar Industries Association, Industry Canada

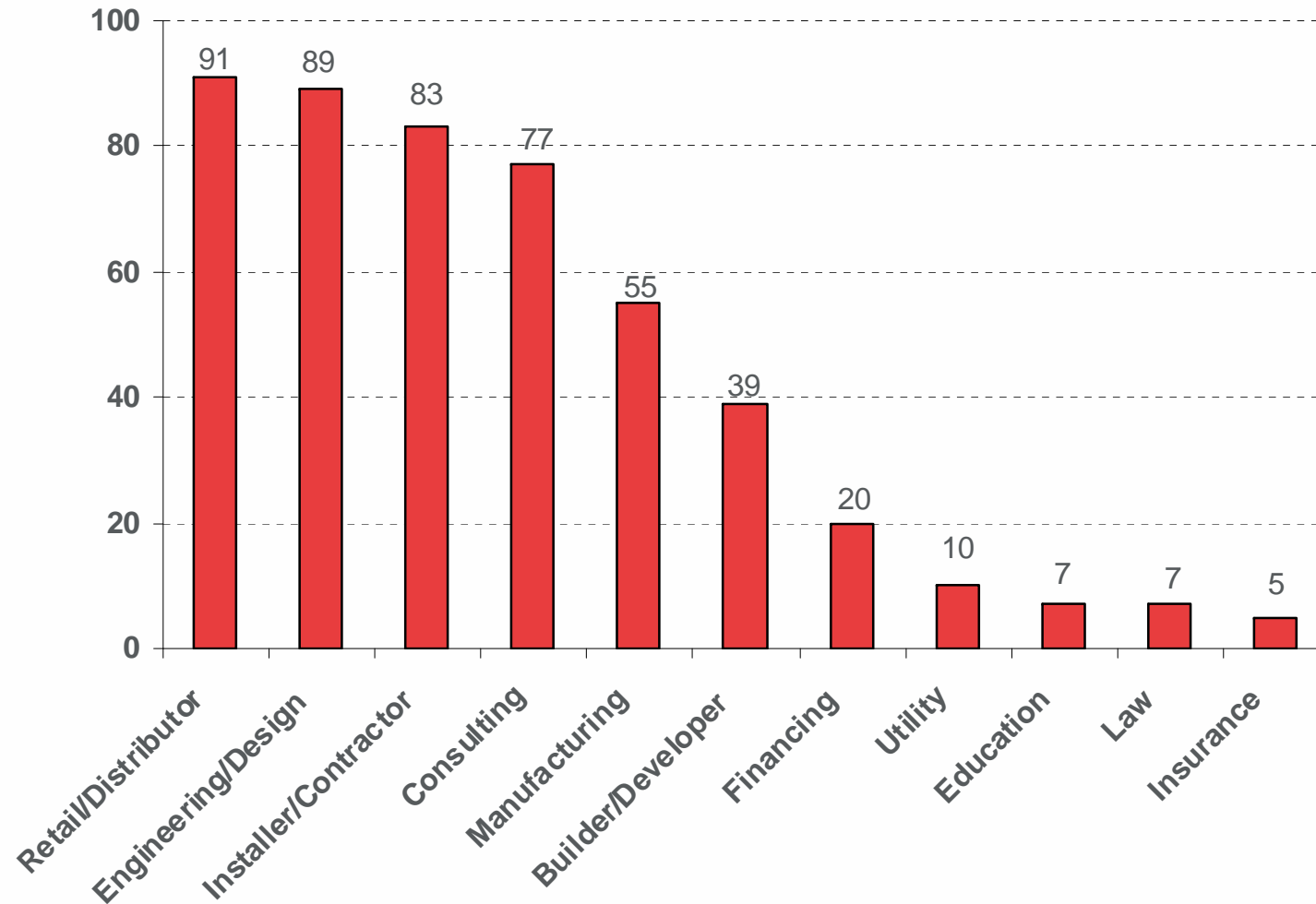


- Most companies in the solar energy sector are small companies involved in designing and installing PV products for public and commercial needs

Source: Canadian Solar Industries Association, Industry Canada, Profile Canada

Industry Sector

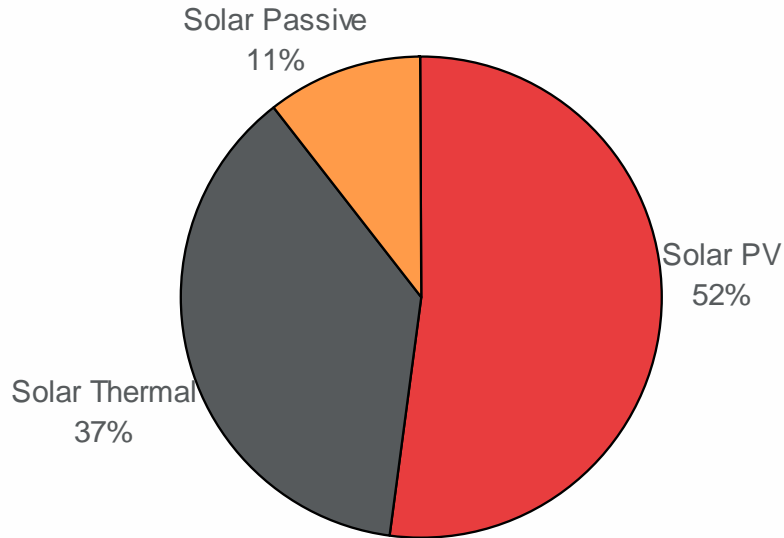
(note that companies may have expertise in multiple areas)



Source: Canadian Solar Industries Association, Industry Canada, Profile Canada

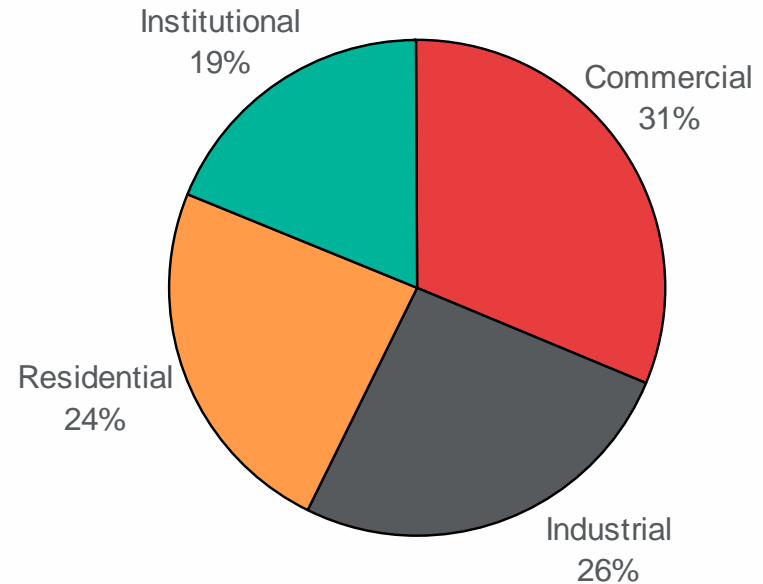
Technology Sectors

(some companies provide more than one type of solar technology)



Target Market Sectors

(some companies provide services for multiple sectors)



Source: Canadian Solar Industries Association, Industry Canada, Profile Canada, company websites

Highly-skilled labour force

The region is producing an educated and highly-skilled workforce

- 5,900 employees in 210+ companies
- Over 3,400 university graduates (all levels) in solar energy related programs in 2007
- 41 undergraduate and 24 graduate related programs in 7 universities

Recent developments in Ontario fueled by the GEA



- Napanee, Ontario gets Canada's largest and North America's 3rd largest solar farm
- Joint venture between SunEdison and SkyPower Corp. of Toronto

- First Solar is developing a massive solar farm near Sarnia, Ontario
- Estimated system capacity is 80 MW and is one of the largest farms under construction in North America



Source: Toronto Star (October 2009), www.solarbuzz.com, www.dmwelectrical.com, www.renewbl.com

Established Ontario companies are investing in solar energy



- Believes that electronics manufacturing services translate well into the PV industry
- Collaborations with McMaster University on solar cells (and many other institutions on energy and environment technologies)



- Canada's second largest auto parts manufacturer after Magna International
- Looking into opportunities in the solar sector worth \$200 million
- Linamar is manufacturing high volumes of power conversion units for Sterling Energy Systems (based in Arizona, US)

Source: Photovoltaics Workshop (McMaster University 2009), Globe and Mail (Oct. 29, 2009), Solar Thermal Magazine online

Innovative emerging companies gaining global reach



“We have reviewed hundreds of investment opportunities over the last few years and only invested in Morgan Solar and four others. Their [concentrated solar PV] technology is revolutionary, highly efficient and simple to manufacture at very low costs. We see a winner in the making...”

Pedro Velasco, Director of Non-Energy Businesses at Iberdrola Group, one of the five largest electrical utilities in the world.

Conserval Engineering Inc.

- Their SolarWall Collector is touted as one of top 2% of energy-related inventions by US Department of Defense
- Used in 30 countries by private and public sector organizations (US/Canadian government, NASA, Ford, FedEx, Wal-Mart, 3M)
- SolarDuct line of rooftop PV/thermal systems named the 2008 readers' choice top new product (*Metal Construction News*)

Innovative emerging companies gaining global reach



- Waterloo-based company that developed a proprietary method for manufacturing high-purity solar-grade silicon
- Earned 15th spot on the Deloitte Technology Fast 50™ list of Canadian companies
- German government is offering €9.54 million of funding towards launching ARISE Technology Centre GmbH in Gelsenkirchen



- An award-winning Toronto company
- Founded in 2006 and has raised more than \$50 million in financing, venture capital and grants
- Developed a unique metallurgic process to purify silicon for polycrystalline solar cells
- Recipient of an inaugural Red Herring Top 50 Award, as one of the most innovative and promising Canadian companies

Source: Company websites, www.cleantech.com

Building-Integrated Photovoltaic (BIPV) Systems

Canada's First Solar Neighbourhood in Waterloo

- Commercial and residential buildings account for 30% of energy use and 50% of electricity use in Canada
- An effort to introduce affordable grid-connected PV systems and eliminate barriers to adoption

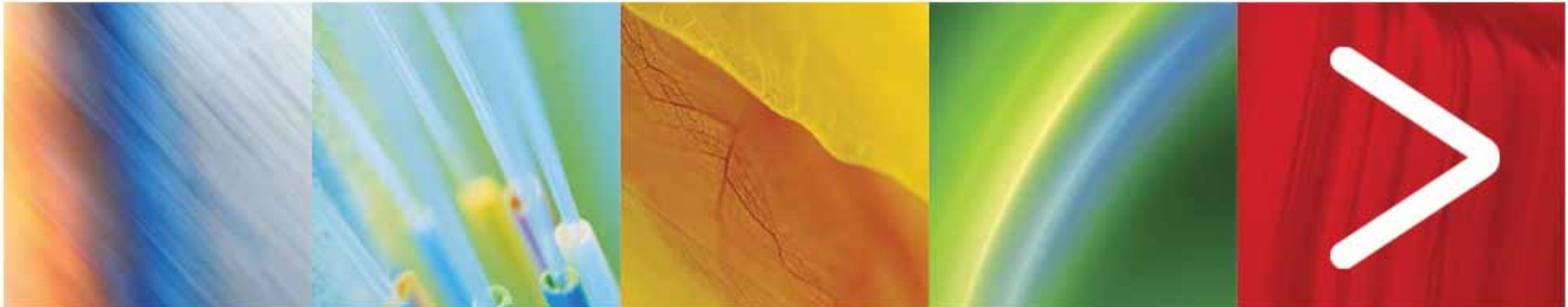


NSERC Solar Buildings Research Network (SBRN)

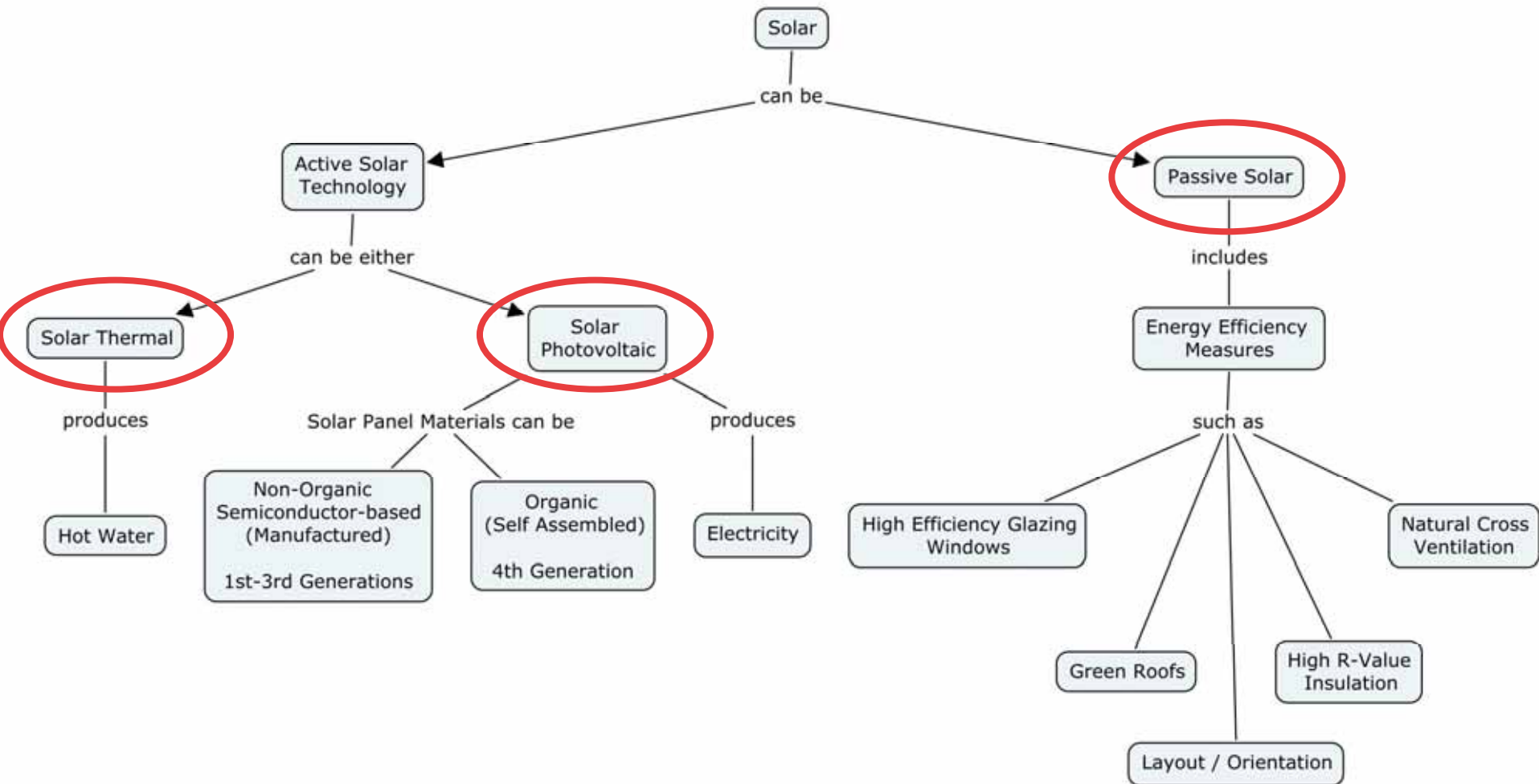
- Demos of innovative PV
- Network of 25 researchers from 12 universities and collaborators from government labs and industry
- ~\$10 million support for 2005-2010 and \$19.2 million infrastructure funding proposal to CFI

Source: CanmetENERGY and ARISE Technologies

Global Status in Solar Research and Patents



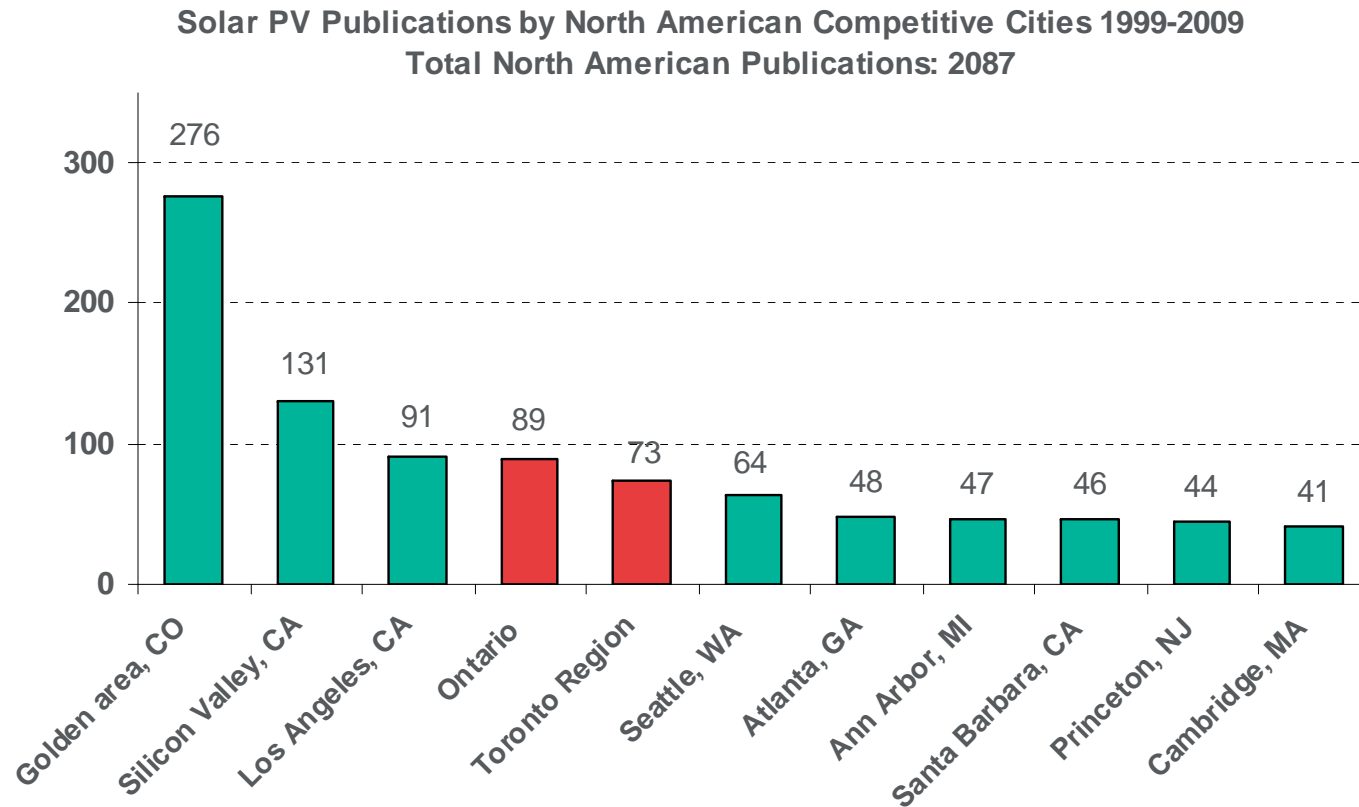
Solar technologies



Source: Liliana Diaz Olavarrieta

Solar photovoltaic

The Toronto Region's research output is on a par with leading North American cities



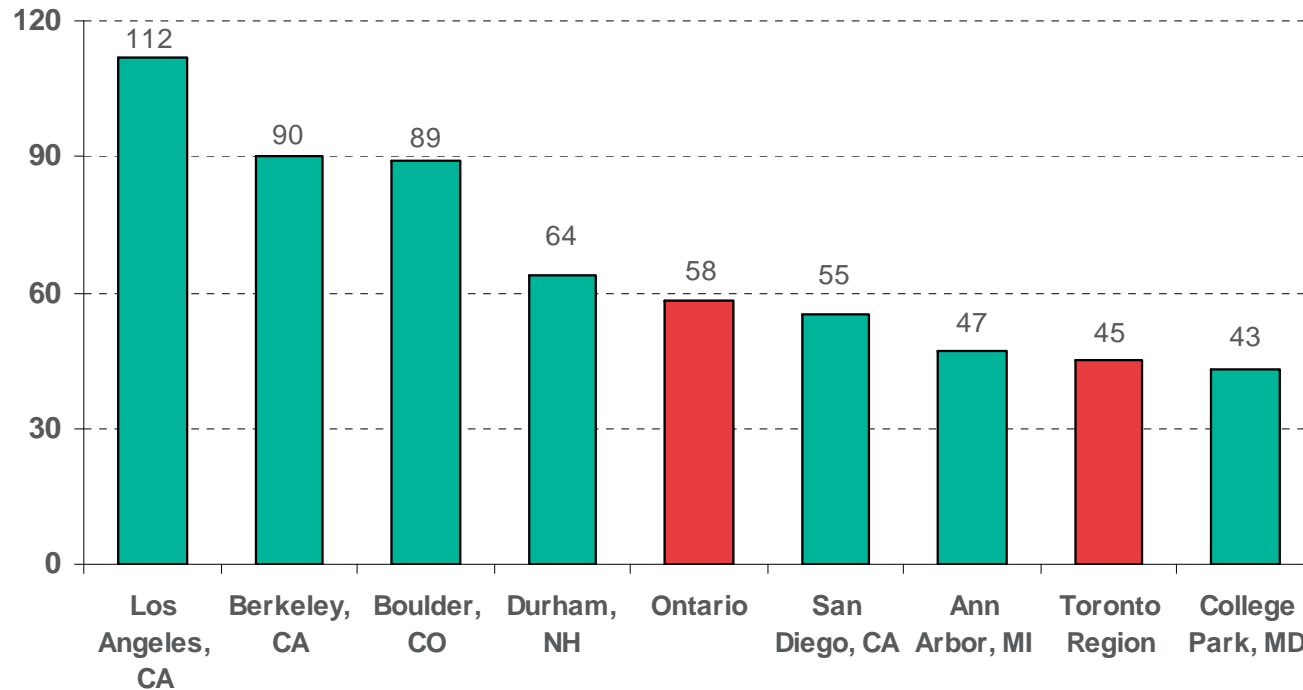
Note: National Renewable Energy Lab is in Golden, CO with 227 publications

Source: ISI, September 2009

Solar thermal

The Toronto Region's research productivity is comparable to leading North American regions

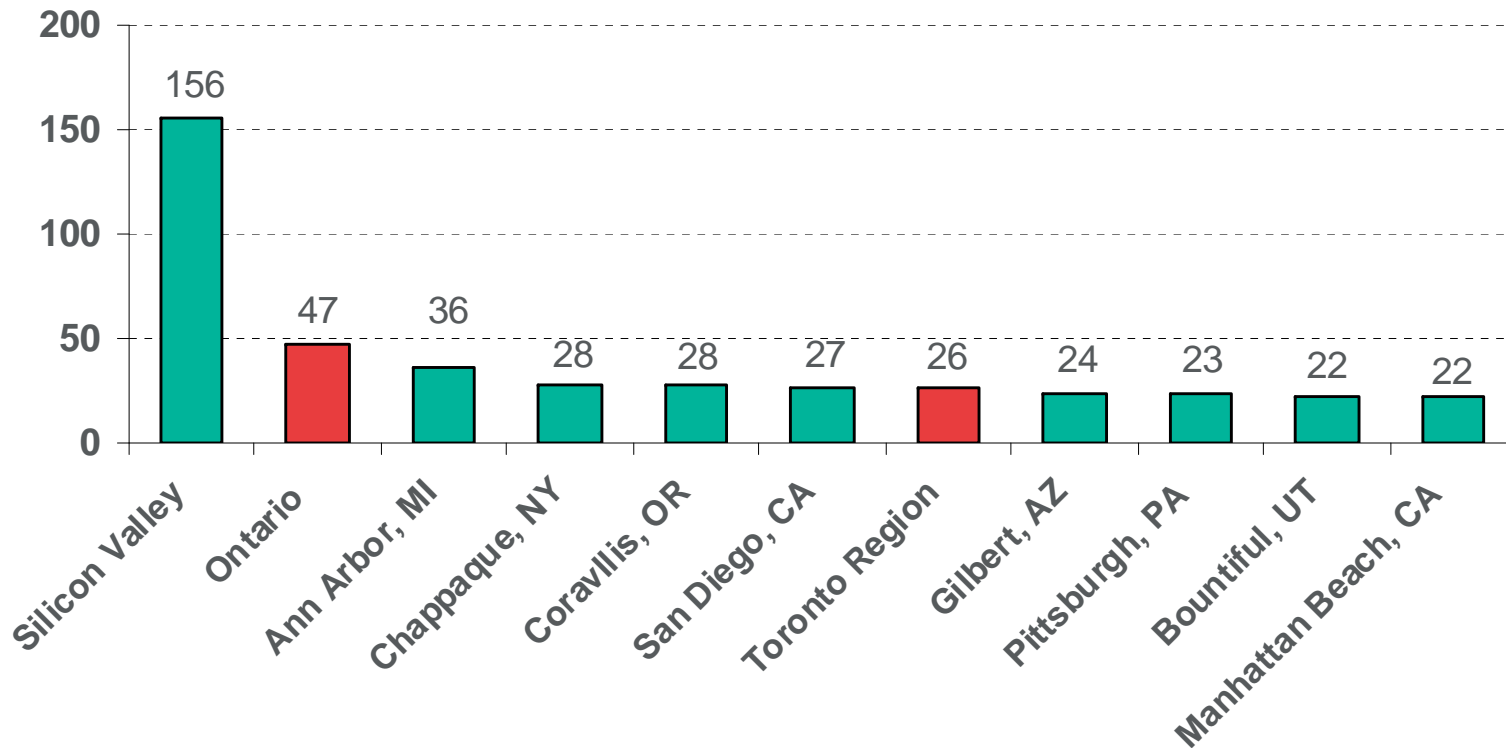
Solar Thermal Publications by North American Competitive Cities 1999-2009
Total North American Publications: 1946



Source: ISI, October 2009

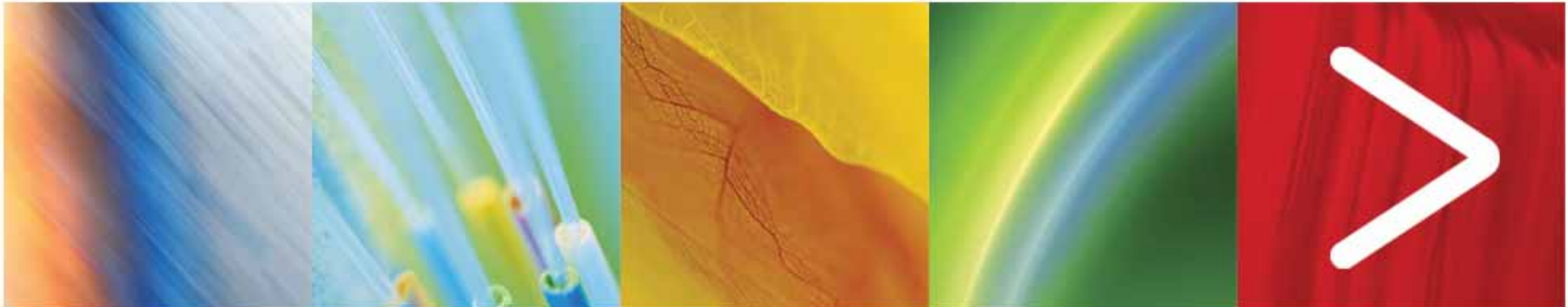
Solar thermal patents

Solar Thermal Related Patent Records by North American Competitive Cities (1999-2009)



Source: Delphion, October 2009

Research Institutes and Scientific Expertise



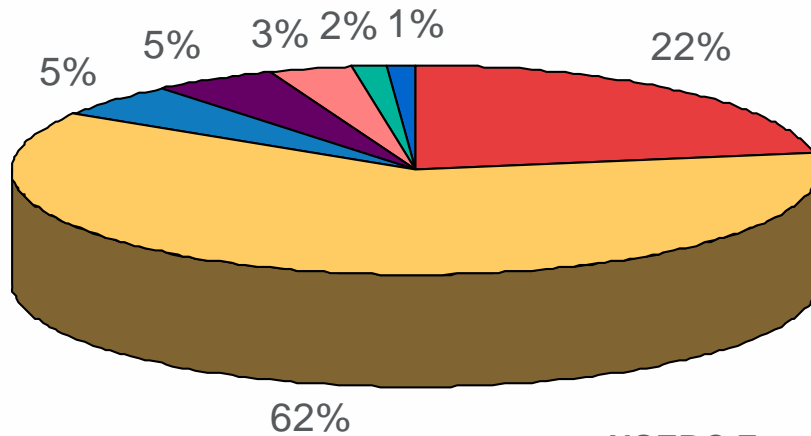
Centre of advanced R&D: 22 related research institutes

- Selected research groups and institutes

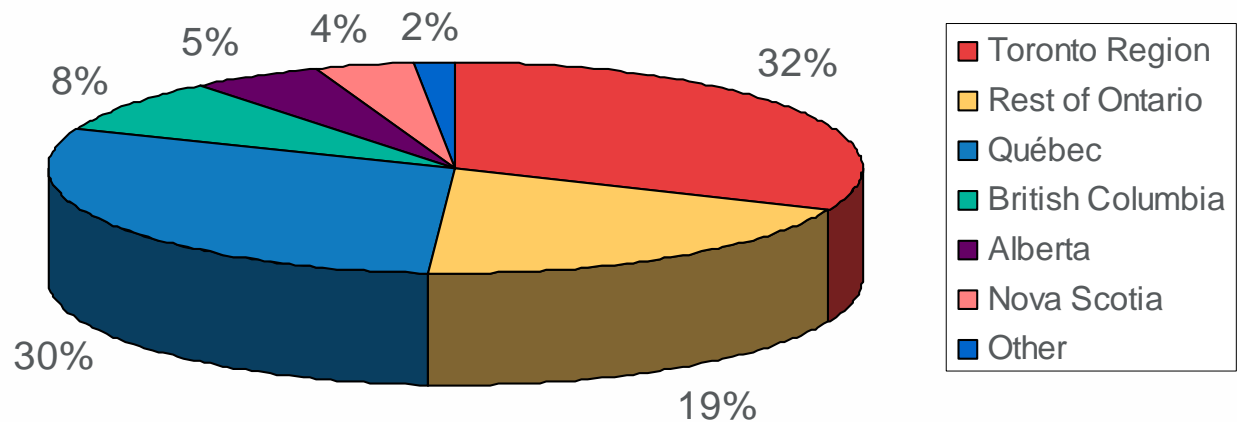
McMaster University	Center for Emerging Device Technologies McMaster Institute for Energy Studies Brockhouse Institute for Materials Research
University of Guelph	Electrochemical Technology Centre Centre for agricultural Renewable Energy and Sustainability
University of Toronto	Advanced Photovoltaics and Devices Group Institute for Optical Science Photonics Group
University of Waterloo	Centre for Advanced Photovoltaic Devices and Systems α -SiDIC: Amorphous Silicon Devices and Integrated Circuits Laboratory Power and Energy Systems Group Waterloo Institute of Sustainable Energy
York University	Institute for Research and Innovation in Sustainability

NSERC and CFI Funding (1999-2009)

CFI Funding in Canada by Province
Total: \$24,064,513



NSERC Funding in Canada by Province
Total: \$13,094,455

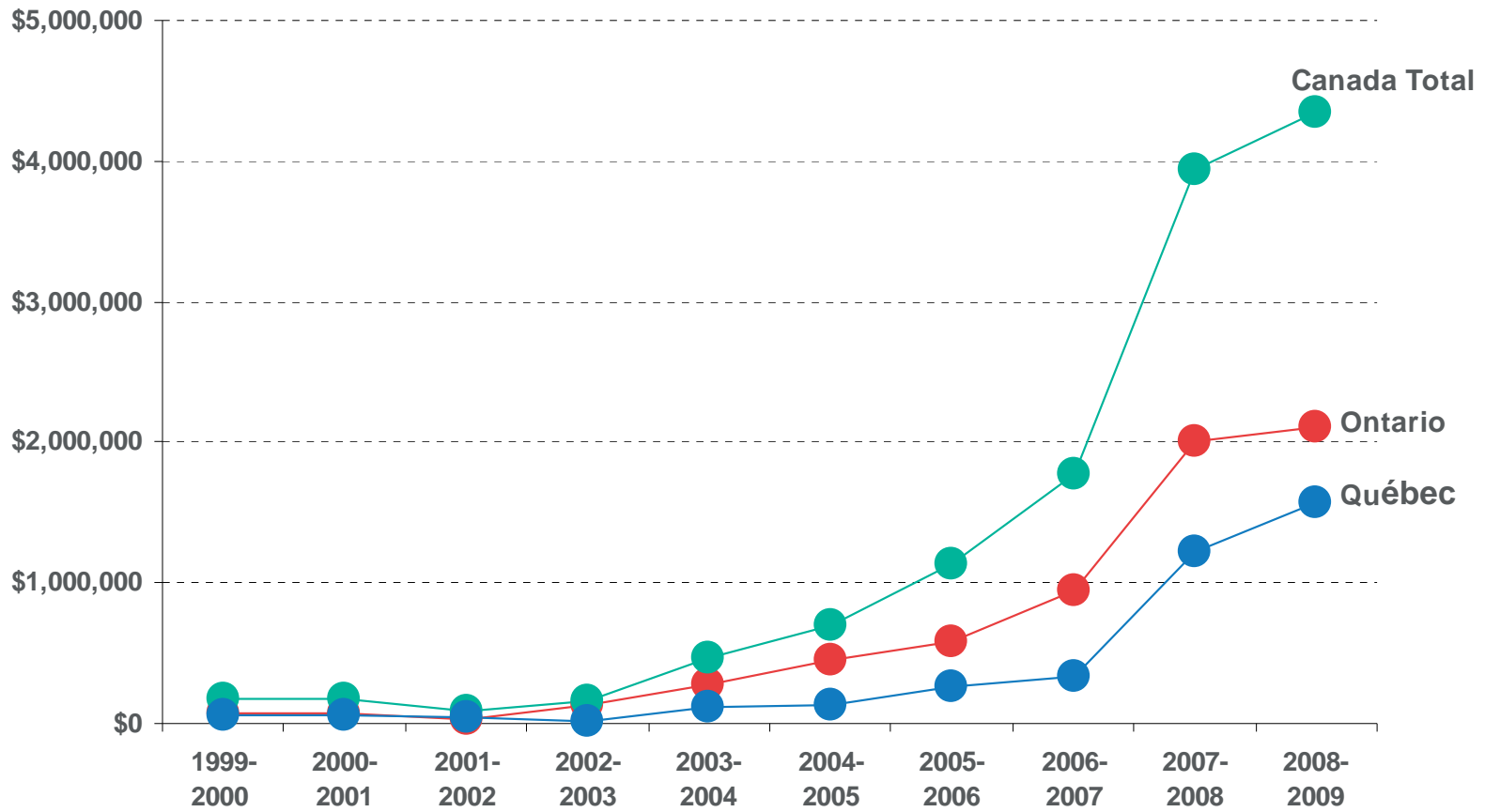


- Toronto Region
- Rest of Ontario
- Québec
- British Columbia
- Alberta
- Nova Scotia
- Other

Source: NSERC, CFI October 2009

Increase in public funding for solar energy technologies

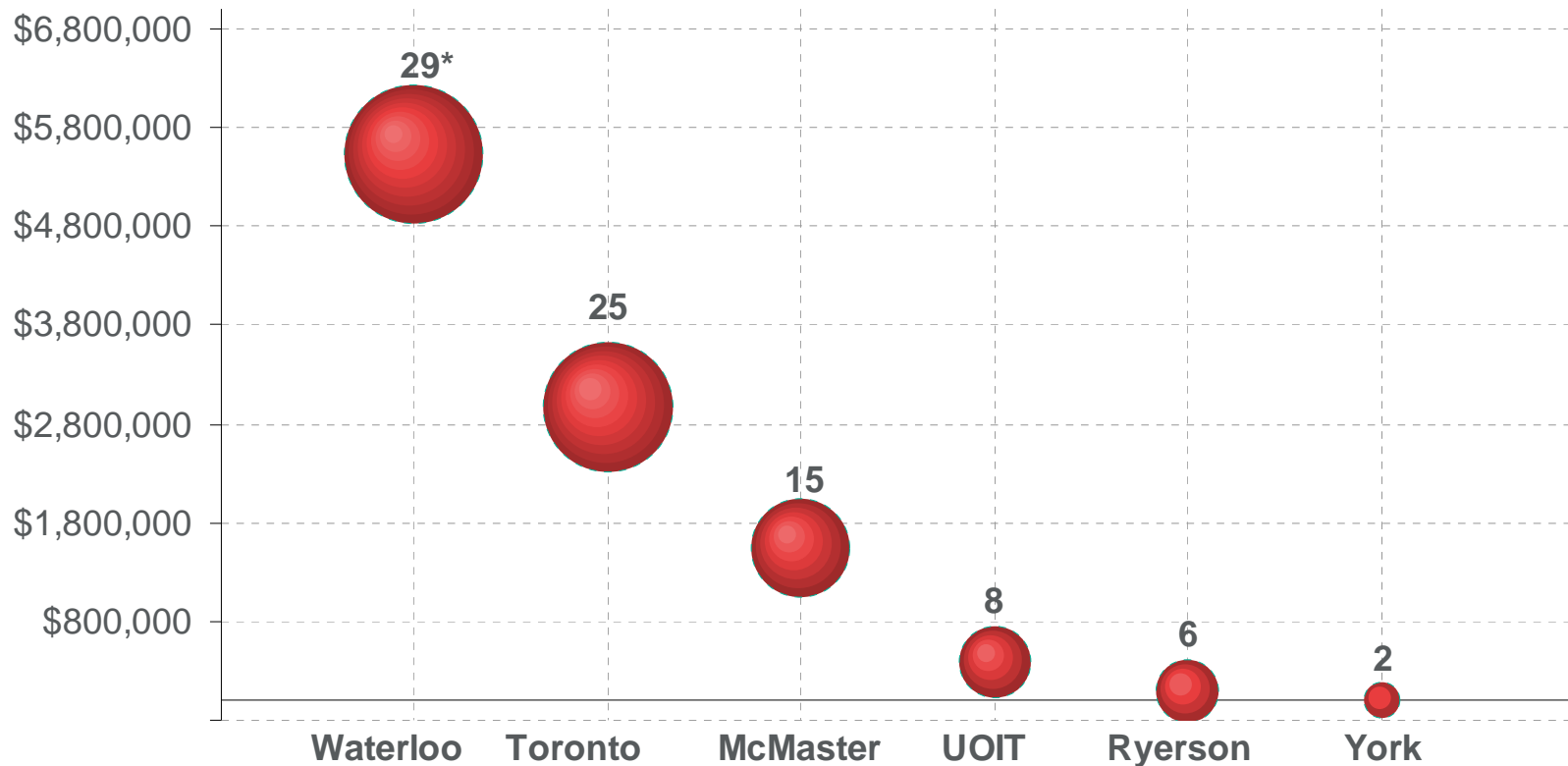
NSERC Funding by Fiscal Year for Top Recipients



Source: NSERC, October 2009

Research funding in the Toronto Region (1999-2009)

Combined NSERC and CFI Funding by Institution



*Number of experts.

(86 experts in the Toronto Region. Guelph University is not shown.)

Source: NSERC, CFI, October 2009

Solar nanotechnologies

Nanotech is expected to deliver efficiency improvements in PV applications and **Ontario is a hub of nanotech activity**.

- 271 nano-related researchers in 19 institutions across Ontario (58% in the Toronto Region)
- 15 researchers across the Toronto Region are involved in solar nanotech

- Advanced R&D centers

University of Toronto	Advanced Photovoltaics and Devices Research Group
University of Waterloo	Centre for Advanced Photovoltaics and Devices Research
McMaster University	Center for Emerging Device Technologies

Solar nanotech researchers in the Toronto Region

**Nazir Kherani, Harry Ruda, Ted Sargent,
Gregory Scholes, Stefan Zukotynski**

Thin film amorphous and nanocrystalline semiconductors, colloidal quantum dots for photovoltaics; fundamental nanoscale phenomena.

Franco Gaspari, Anatoli Chkrebti

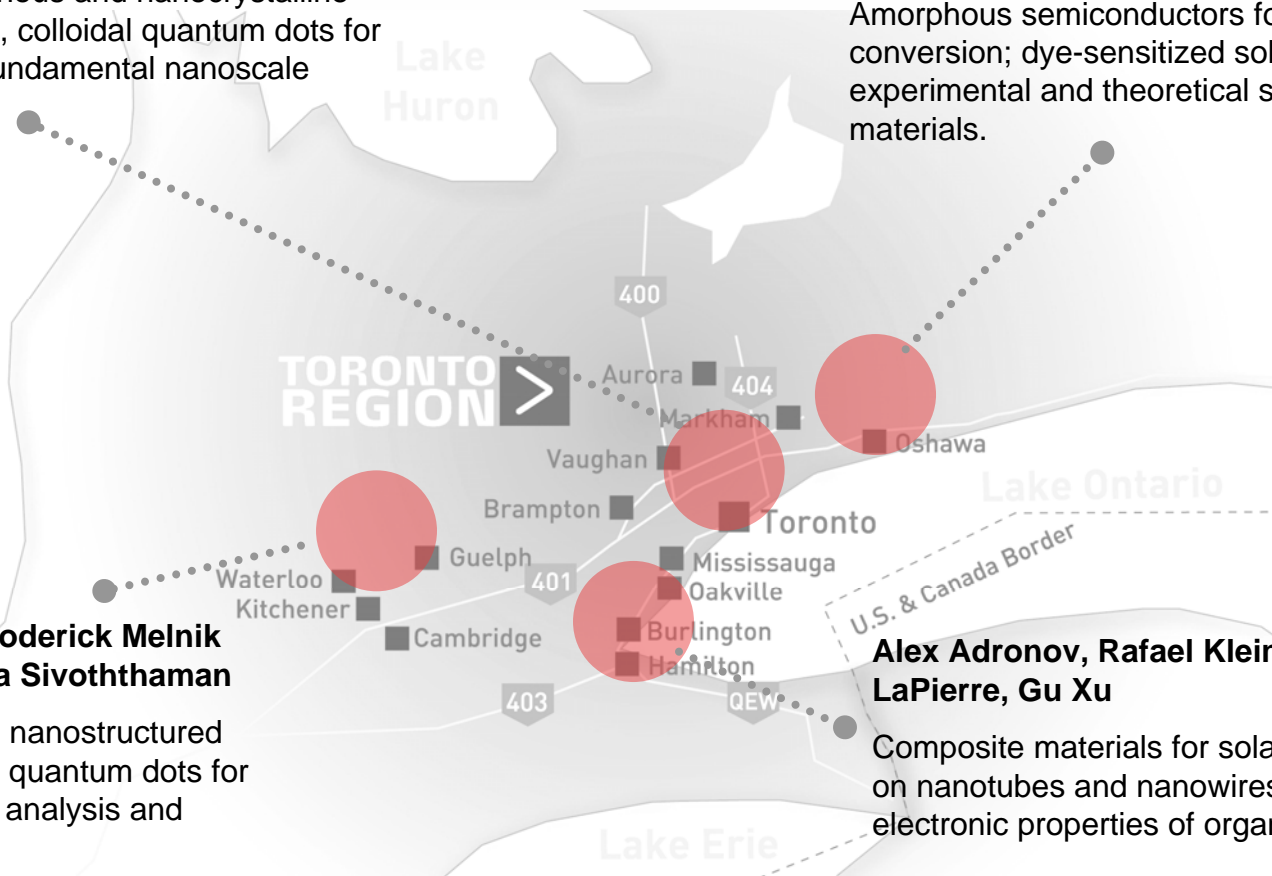
Amorphous semiconductors for solar energy conversion; dye-sensitized solar cells; experimental and theoretical studies of PV materials.

**Hany Aziz, Bo Cui, Roderick Melnik
Kam Ton Leung, Siva Sivoththaman**

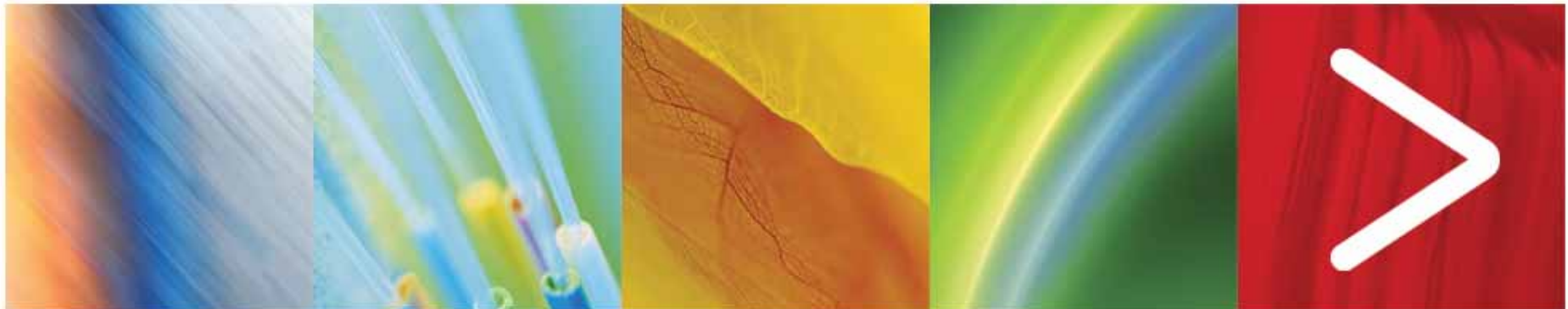
Organic photovoltaics; nanostructured materials and colloidal quantum dots for solar cell applications; analysis and modeling.

Alex Adronov, Rafael Kleiman, Raymond LaPierre, Gu Xu

Composite materials for solar cells based on nanotubes and nanowires; optical and electronic properties of organic devices.



Federal Government Programs and Incentives



Federal funding programs and incentives

ecoEnergy for Renewable Power

- \$1.48 billion for increasing Canada's supply of clean electricity from renewable sources
- 1¢/kwhr for up to 10 years with max contribution of \$80 million

ecoEnergy Retrofit for SMEs

- Financial assistance for energy-saving retrofits
- 25% of projects costs to a maximum of \$50,000 per application or \$250,000 per corporation

Accelerated Capital Cost Allowance for Clean Energy Generation

- Write-off of capital expenditures on equipment for producing energy more efficiently (rates of 30% or 50% available on a declining basis)

Federal programs continued

Sustainable Development Technology Canada™

- A government-supported foundation that finances demonstrations of environmental technologies
- One of the largest global players in financing cleantech with a portfolio valued at \$1.3 billion
- Ontario has received ~39% of \$425 million investments to date

Canadian Photovoltaic Programme (Natural Resources Canada)

- Contributes its expertise to innovative partnerships
- Research projects are carried out on a cost-sharing basis with industry, universities, research groups, and other agencies
- Accelerates tech deployment in Canada and facilitates use of PV systems in building

Supporting associations and networks

Ottawa, Ontario	<p>Solar Energy Society of Canada (SESCI) GreenHeat Partnership Canadian Solar Industries Association (CanSIA) CanmetENERGY (Natural Resources Canada)</p>
Montréal, Québec	<p>Solar Buildings Research Network with Toronto Region universities as participating members (Ryerson, McMaster, Toronto and Waterloo)</p>
Mississauga, Ontario	<p>National Solar Test Facility (NSTF)</p>
Toronto, Ontario	<p>Ontario Sustainable Energy Association Ontario Energy Association Pembina Institute Toronto Atmospheric Fund Association of Power Producers of Ontario Electro Federation Canada Canada Green Building Council – the Greater Toronto Chapter</p>

Green building initiatives in Canada

- **Canada Green Building Council (GBC)** encourages a whole-building approach to sustainability through LEED in Canada (Leadership in Energy and Environmental Design™)
- More than 6000 LEED® Accredited Professionals in Canada since 2001

LEED Canada Initiative

- Close collaboration with the US GBC to develop the next-generation integrated North American system

GREEN UP Program

- Conducting national pilot projects to engage various market sectors to establish performance metrics

Source: Canada Green Building Council (CaGBC) and the Greater Toronto Chapter

Summary: Solar energy in the Toronto Region

- Established research infrastructure
 - 86 experts conducting internationally recognized R&D at 22 related research institutes
 - One of the leading North American regions in solar PV and solar thermal publications
- Strong industry and skilled labour force
 - 210+ companies with 5,900 employees
 - Over 3,400 graduates in solar energy-related engineering and science programs
- Sophisticated electricity infrastructure and customer base
 - Leading customers include Ontario Power Generation, Hydro One Networks, Toronto Hydro Corp and Ontario's large IT and financial services institutions
- Ontario's Green Energy Act offers strong incentives for investment into renewable energy projects
 - Significant premium (up to 80.2 ¢/kWh) for electricity generated from solar energy

For more information, contact us:

**Toronto Region Research Alliance
MaRS Centre, Heritage Building
101 College Street, Suite HL30
Toronto, Ontario M5G 1L7
Email: info@trra.ca
Tel: 1 416 673 6674
Fax: 1 416 673 6671**