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Where Next Happens

How Innovative Technologies & New Thinking are Shaping the Smart Grid and Ontario's Energy Future

Robert (Bob) Stasko.
Director, Business Development
Centre for Energy

Introduction **and Outline**

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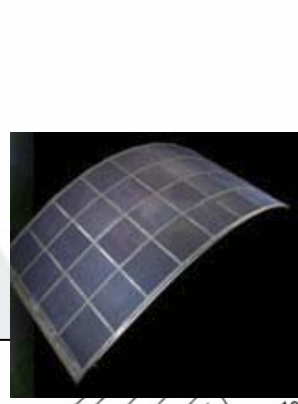
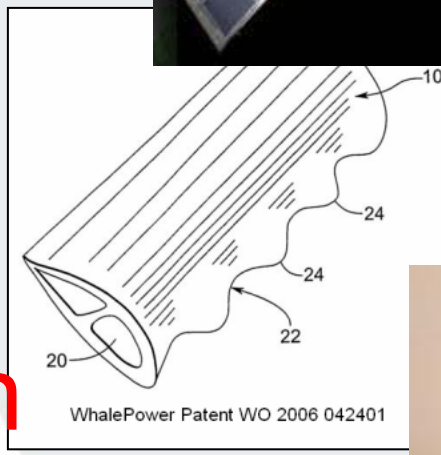
1. What is OCE?
2. Ontario Electricity Sector Agenda for Smart Grid
3. Smart Grid, DG and Electric Transportation
4. Summary and Conclusion





Excellence in Energy Technology

Ontario Centres of Excellence

Ontario Centres of Excellence (OCE) Inc. established over 20 years ago as a separate non-profit agency outside of the Ontario government

- **Leading driver of the research to commercialization process with a strategic focus on improving Ontario's competitiveness through innovation.**
- **Key partner with industry, universities, colleges, research hospitals, investors and governments.**
- **Est. 1987**

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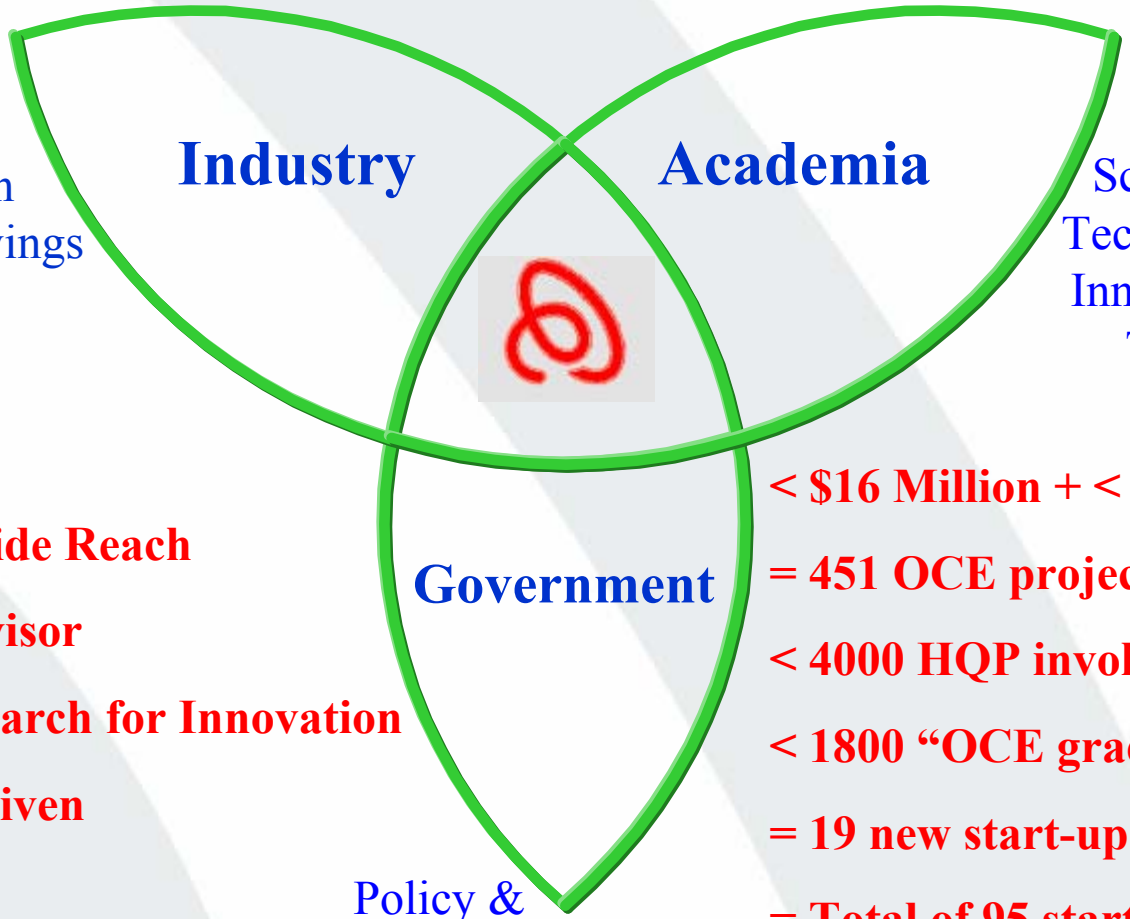

Jobs & Wealth Creation / Savings

Science & Technology Innovation, Training

Policy & Regulations

Network

Province-Wide Reach

Trusted Advisor

Proactive Search for Innovation

Outcome Driven

< $16 Million + < $33 Million

= 451 OCE projects

< 4000 HQP involved

< 1800 "OCE graduates" - jobs

= 19 new start-ups

= Total of 95 start-ups with

< $85 Million follow-on investments

Enabling Innovation through Collaboration

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McMaster University
University of Guelph
CONESTOGA Connect Life and Learning
Centennial College
hydro One
ARISE Technologies Corporation
GM Canada
PCI Geomatics
C3 Environmental Limited
University of Waterloo
UOIT
Université d' Ottawa
University of Ottawa
noranda
REGENENERGY
StormFisher Biogas
York University
Carleton University
TECHINT
University of Windsor
Queen's University
SFL
Enbridge Consumers Gas
Esso Imperial Oil
Western
Ryerson University
Seneca
OPA Ontario Power Authority
DSEA
Algonquin College
GEOIDE
CPPI
Ontario Power Generation
FCM.ca
CEATI International
Ontario
CSA ASC
Canadian Water Network
Sustainable Development Technology Canada
ARC-CNRC Industrial Research Assistance Program
NSERC CRSNG
Environment Canada / Environnement Canada
Natural Sciences and Engineering Research Council of Canada / Conseil de recherches en sciences naturelles et en génie du Canada

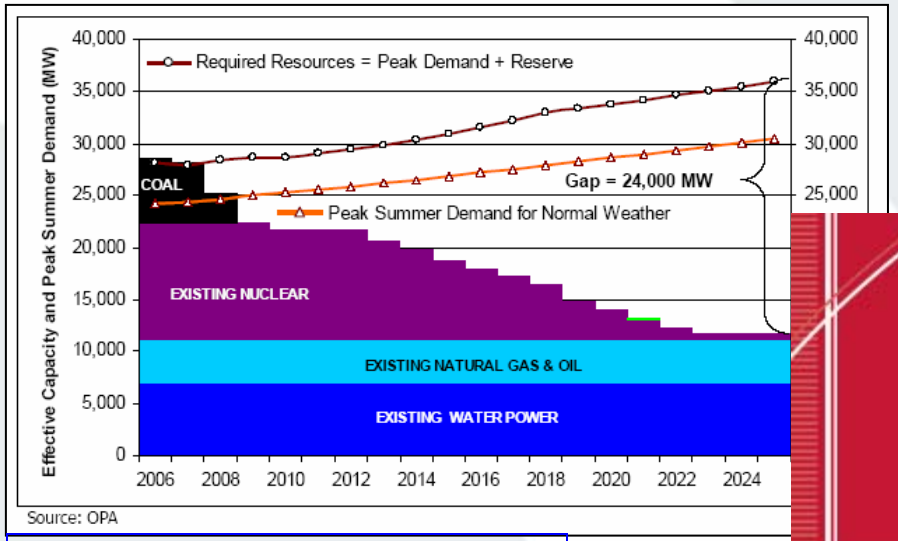
Ontario Innovation Agenda

bio-economy and clean technologies, advanced health technologies, pharmaceutical research and advanced manufacturing, digital media, and information and communications technologies.

The innovation agenda recognizes the importance of remaining open to new directions. Areas of focus will evolve as new markets develop and social needs evolve. What will remain constant is the need for an area to prove its relevance to Ontario's economy. Our research investments must strive to create leadership not just in the academic community but in the global economy as well.

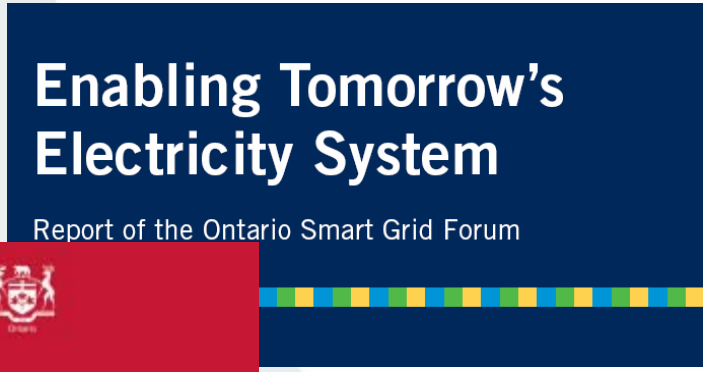
Ontario Context

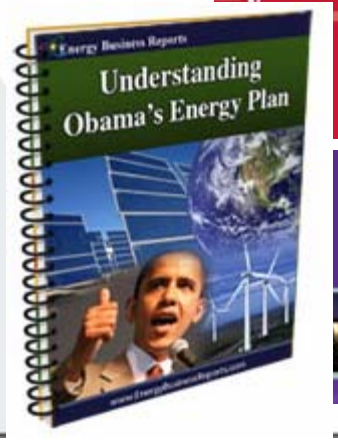
Energy is <u>the</u> critical sector for Ontario's economy, environment and society – it is at the centre of the climate change debate, fundamental to human welfare and essential to economic prosperity.



Over the next 20 years, about 80% of Ontario's electricity generating capacity … will need to be replaced or refurbished.

OPA 2007, IPSP.





Green Energy Act: The Main Intent is to Enable More Renewable Generation

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- **Directs wires companies to give 'priority' access to grid connection for renewable energy generation projects.**
- **Authorizes the Minister of Energy and Infrastructure to direct the OPA in launching new electricity supply RFPs, particularly for renewables.**
- **Allows the Minister to direct the OPA to develop and implement a Feed In Tariff fee structure for renewables.**
- **Directs LDCs to connect any new (renewable) generation that meets all technical requirements.**
- **Allows LDCs and Municipalities to own and operate renewable generation assets of 10MW or less.**
- **Empowers a new class of 'Energy Cooperatives' as a business model that will accelerate the development of distributed, renewable energy sources.**

The Challenge in Ontario When the IPSP is approved

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SUPPLY MIX	2005	2025
Nuclear	14,000	14,000*
Renewables	7,885	15,700
Coal	6,434	0
Natural Gas and CoGen	4,976	9,400
Conservation	675	6,300

- **Renewable Generation X 2**
- **Coal -> to zero**
- **Conservation X 10**

UNITS: MWe

- *80% of existing nuclear plants will be re-powered or replaced

A clear need for innovation…

What is Distributed Generation ?

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- **Distributed Generation (DG) - small-scale, modular, power generation units located close to where the energy is used. Often renewable sources (but not necessarily)**
- **Drivers:**
  - Electricity Price Volatility and Risk
  - Need to generate closer to loads
  - Environmental Concerns
  - New Power Market Entrants
  - Higher Efficiency / Cogeneration
  - Power Quality & Reliability
  - Technology Development

What Constitutes Conservation?

CAN BE ALL OF THE FOLLOWING:

- Load Reduction
- Peak Shifting and Reduction
- Demand Response
- Energy Efficiency Improvements

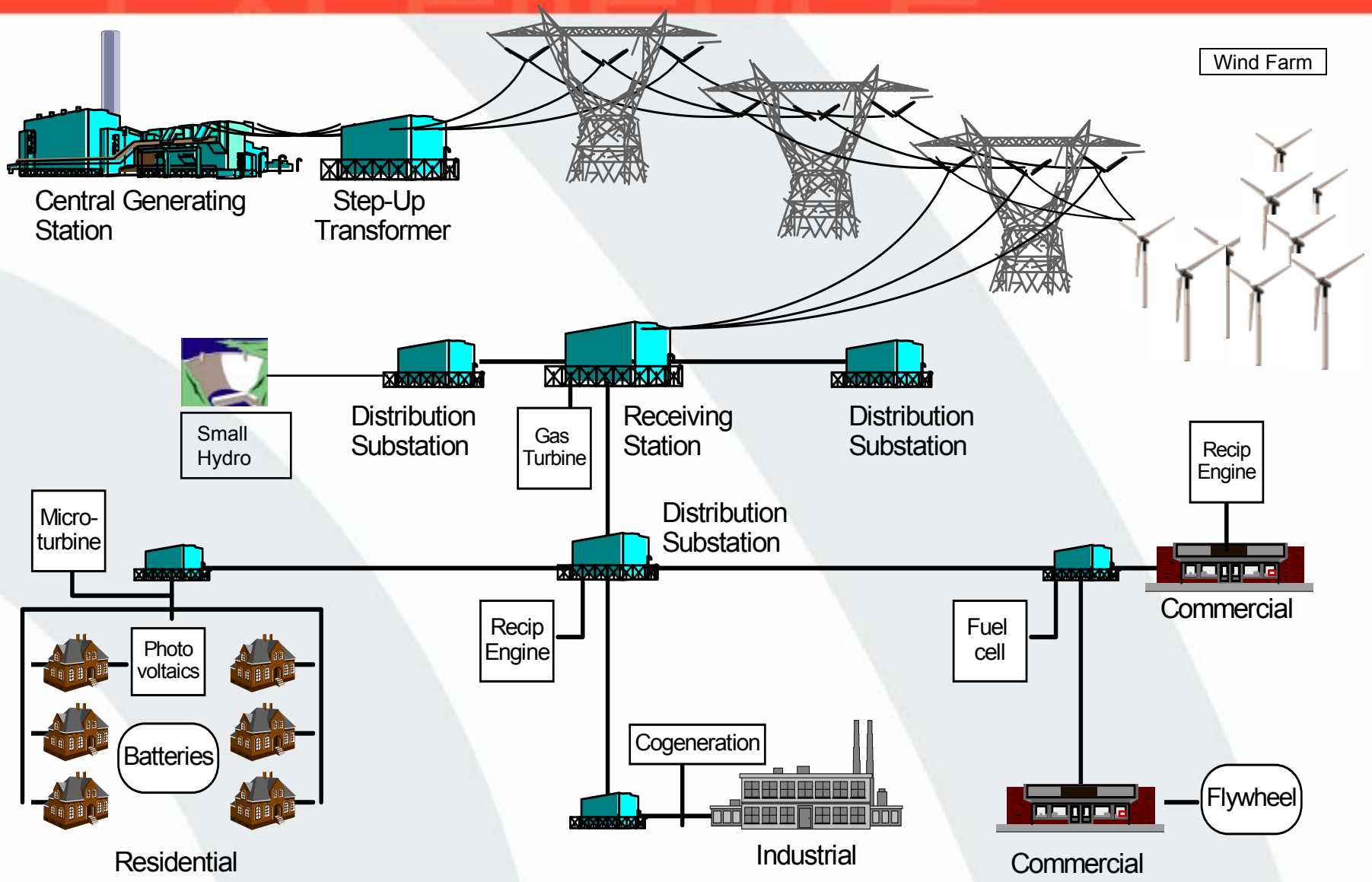
CAN ALSO INCLUDE THE FOLLOWING

- Behind the Meter Self-Generation
  - Ground Source Heat Pumps
  - Solar (thermal and photovoltaic)
  - Wind, micro hydro or Biomass
  - Clean micro CHP
  - Storage technology to store off peak and renewable power

Conservation: the NEW paradigm

- No longer linked to human behavior, although voluntary measures still important at the residential level
- Depends heavily on 'hard wired' technology solutions such as advanced cooling/heating, advanced lighting systems, improved industrial processes, high efficiency motors, advanced building controls, self-generation etc.
- Has become an integral part of planning for future energy supply, where the cost is demonstrably less than cost of new generation.
- Will no longer be a reaction to constraint, but rather a cultural shift reflecting the rising cost of electricity production
- Is taken very seriously by industry, the commercial sector, utilities and the public at large.

The Emerging Electricity Network



[14]What is a ‘Smart Grid’ ?

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- One that maximizes the capacity of the system via use of sophisticated monitoring, communications and control hardware and software
- One that is proactive and self-healing
- One that allows bi-directional electricity flow thereby enabling net metering and local generation
- One that effectively manages intermittent sources of generation such as wind and solar
- One that makes effective use of energy storage and VAR support to reduce line losses and work around system constraints
- One that fully enables a distributed energy solution

The Quantum Leap to Smart Grid

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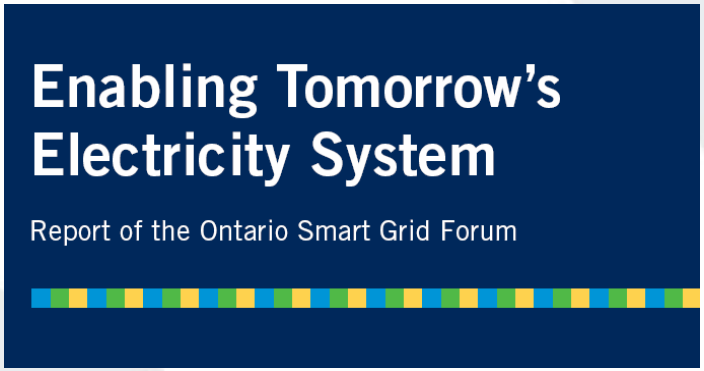
Feature	Existing Grid	Future Grid
Components	Electromechanical	Digital
Communications	One-way	Two-way
Billing	Single Tariff	Multi Tariff, Time of Use
Generation	Centralized	Distributed
Network Topology	Hierarchical	Peer-Peer, Adhoc
Sensors	Few	Everywhere
Visibility	Blind (Dx)	Self Monitoring
Restoration	Manual	Self-healing
Reliability	Forced Outages	Adaptive, Islanding
Maintenance	Reactive	Pre-emptive
Testing	Manual / Local	Self-check / Remote
Load Management	Over-Provisioned	Demand Response
Control	Centralized	Distributed / Localized
Customer Relations	Broadcast	Peer-Peer, Portals

Report of the Smart Grid Forum



Smart grid is a modern electric system. It uses sensors, monitoring, communications, automation and computers to improve the flexibility, security, reliability, effeciency and safety of the electricity system.

Smart grid includes DG, accommodates electric vehicles and provides greater customer choice.

Ontario is well-position to be a global leader in smart grid technologies (smart meters are deployed, we have an established research capability, the green energy act is supportive and the electricity market provides price signals to drive consumption and production decisions.

The OCE should develop a Task Force to produce a framework for smart grid research in Ontario that would include funding targets and mechanisms.

2009 Ontario Budget

- $50 million over 5 years to enable and research, capital and demonstration projects projects necessary to support the development of a smart grid in Ontario.

A green economy encourages more energy-efficient and environmentally sustainable production and consumption. It does so by taking into account the costs of environmental degradation and rewarding more sustainable economic growth.

Enhancing the Innovation Demonstration Fund ($50 million over 4 years) the government will continue to partner with innovative companies to develop emerging technologies with a preference towards bio-based, alternative energy and environmental technologies.

Smart Grid Forum Report, Provincial Budget and Funding for Smart Grid R&D

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- The Smart Grid Forum Report recommended that the Provincial Government allocate funds specifically for Smart Grid R&D and pilot installations in Ontario
- The most recent Provincial budget allocated $50M for Smart Grid R&D and demonstration projects here in Ontario (10M$/annum for 5 years).
- Treasury Board will determine when, how and to which organizations this money will be released and for what.
- The GEA will empower LDCs to embark on 'Smart Grid' demonstration projects, and that capital cost recovery will be allowed by the OEB. LDCs can also own and operate DG demo projects up to 10MW per project

How to Implement Smart Grid Solutions

- Perform a comprehensive technology scan of all promising smart grid solutions
- Review best operational practices implemented in other jurisdictions, or soon to be implemented
- Develop a plan specific to the needs of the Ontario grid
- Identify needed system changes or upgrades
- Address regulatory barriers to implementation
- Embark on R&D and Demonstration Projects that lead the way

- DEVELOP MADE IN ONTARIO TECHNOLOGY SOLUTIONS THAT CREATE ECONOMIC BENEFITS

What is the Role for OCE in addressing Smart Grid Technology Deployment?

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- OCE has no direct role in deploying early and readily available smart grid technology
- LDCs, HydroOne and IESO will be in the vanguard of quick action using existing technology and suppliers
- However, OCE can assist in identifying and evaluating next-generation smart grid technologies that could have a longer and more transformative impact.
- Communications and Information Technology will become the dominant mechanisms to smarten the grid
- LDCs and OCE can work together to define the key future C3I technologies, and create opportunities here in Ontario to co-fund, develop and deploy them.

What is the Role for OCE to Enable Distributed Generation Solutions ?

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- OCE does not have a role and mandate to implement near term DG solutions; this is clearly the arena of the other sector agencies and private sector suppliers
- However, OCE does have the mandate to work with collaboration partners on the NEXT generation of DG technologies. These may have the greater impact in the long run.
- Technologies of interest would include advanced solar, small wind, fuel cells, distributed storage and micro-CHP; the intent is to develop local developers and suppliers
- ALL of these can proceed if industry collaboration partners and academia work together here in Ontario

What is possible now and how Futuristic can it get ?

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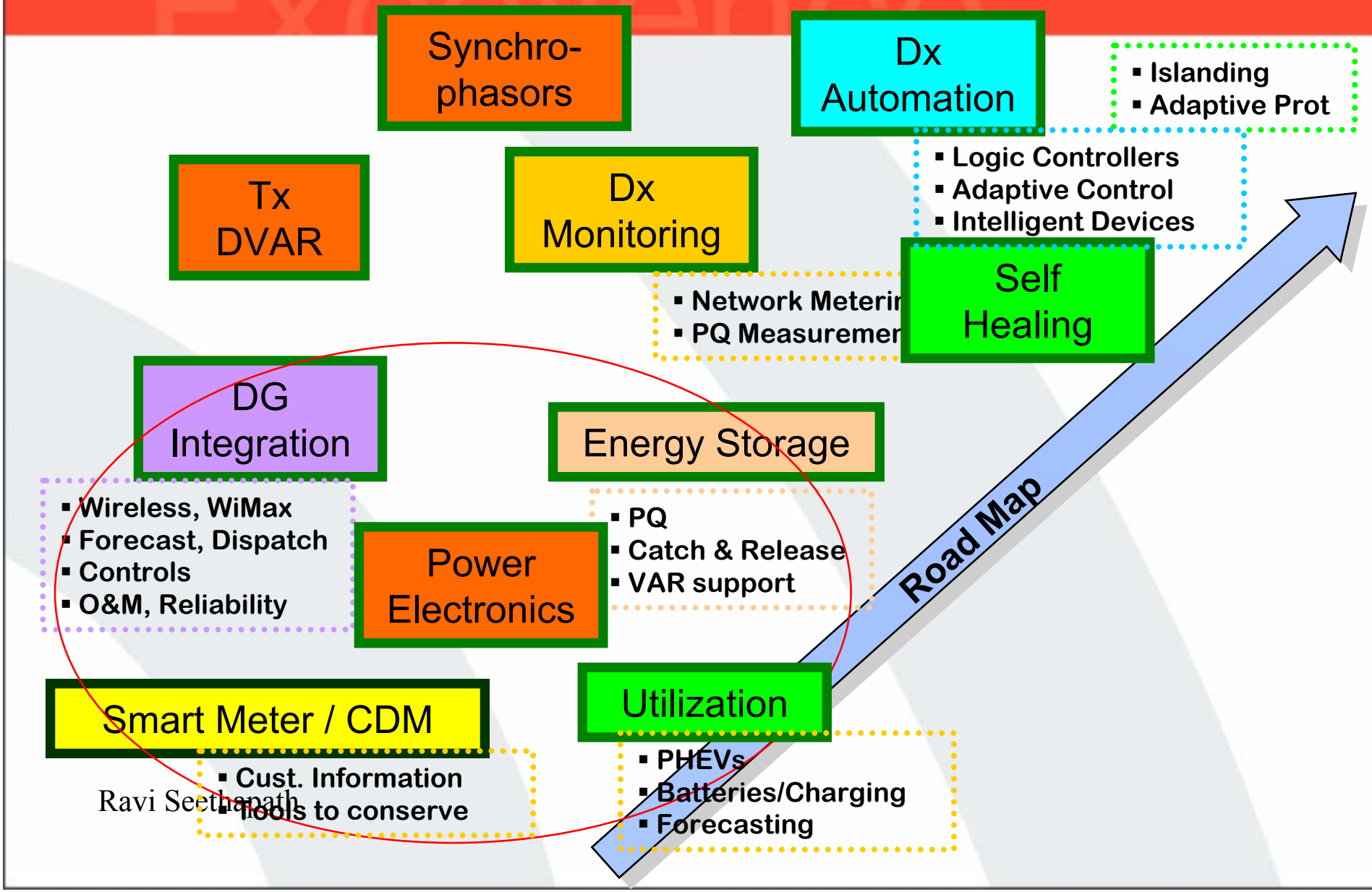
- Real time monitors for retail power consumers that run off internet platforms. You can check your hourly consumption and price points via Google or on your TV, and change your AC settings on your blackberry.
- Plug in electric vehicles: no matter where you plug in to charge the car battery the resulting cost ends up on your electricity bill with all the key attributes including supplier of choice (more about this later).
- Plug and play grid connection for micro-generation: someone can install a rooftop solar panel or wind turbine with a 'smart connecting inverter' that plugs into the grid and automatically controls the connection in tandem with the LDC advanced control system.

Hydro One Smart Grid Road Map



Ravi Seethapath

Ontario Centres of Excellence

Where Next Happens

How Low Emission Electric Fuel can Green the Transportation Sector in Ontario

Robert (Bob) Stasko.
Director, Business Development
Centre for Energy

Ontario Government Policy Direction on Plug In Vehicles

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- The Premier's office has indicated that the Ontario government intends to take a leadership role with PEVs
- Several ministries are working together to develop a common policy direction for Electric Vehicles
- The MOT/MEDT will soon release a study report on the Ontario government's plans regarding PEV automakers
- MEI has stated that defining and facilitation deployment of charging infrastructure will become a part of the Smart Grid initiative, which it also intends to lead.
- Electrification of Transportation is important enough to require a coordinated effort by all sector participants in order to make it a successful transition

Background: Why PEVs are a hot topic

- The cost of Petro-Fuels can only go up over time
- Transportation is becoming the major source of CO2 emission, and governments must take action to reduce emissions through taxes, incentives and regulation.
- Many automotive OEMS are developing electromotive platforms that are either hybrids or pure electric (batteries or fuel cells) as part of their 'renewal' or to promote a 'green car' market brand.
- Electricity has the potential to be a 'green' fuel for transportation, but it will only fulfill this expectation if a coordinated policy and plan is developed by all sector participants working together with a common vision.

Ontario Advantages for the PEV

- If done correctly (using emission free electricity to charge overnight) the environmental benefits are substantial; CO2 emissions can be reduced and urban air quality will be enhanced
- There will be ample off-peak generation capacity in the system for some time to come.
- The fueling infrastructure is 80% to 90% in place. What is needed now is ‘smart charging’ that links to ‘smart meter’ customers even when fuelling away from home
- Electricity has the potential to be a transformational fuel for transportation, but to fulfill this expectation the framework for infrastructure development and charging protocols needs to be planned with great care.

Barriers to Deployment of PEVs

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- Battery technology is not optimal (hence hybrids as a bridge to all electric) – may require battery change-outs
- Capital cost is still higher than for vehicles using conventional fuels (however, fuel is cheaper)
- Unfamiliarity with technology at both consumer and service providers, and for First Responders
- Infrastructure needs to be easy to access and use, equivalent to conventional fueling norms (not there yet)
- Government policy, incentives, regulations not in place
- The market pull for PEVs is powerful, and car makers are trying to manage expectations while still providing consumer-ready products with standard warranties.

Why Smart Cars need to communicate with Smart Grids: Customer Choice!

- Customers will buy very smart cars that talk to drivers, email maintenance schedules, access the internet and link to satellites. The grid has to get just as smart.
- The CO2 attribution of a kilowatt of 'fuel' will be important for many customers. This has to be tracked
- Customers will want choice for fuel providers (example: Non-emitter, totally renewable or best price). How can this be implemented?
- No matter where the car gets plugged in, the bill for the charge should go to the right customer or meter. This should be seamless and invisible to the user.

Electric Charging of Vehicles: The Potential Impacts on LDCs

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- Little impact on system loads in the near future
- However, at maturity could be a load twice as large as former electric water heater loads!
- Ensure that most charging is done 'off peak' or is interruptible to avoid system impacts. Success should provide sufficient capacity in most jurisdictions.
- Systems that have local capacity constraints will be most affected, need to enhance capacity or restrict use
- Large off-peak loads could still cause problems with accelerated aging of distribution equipment
- Many of the potential problems can be addressed by time of use incentives, regulations and application of Smart Grid Solutions. Time to start is now.

Smart Chargers: who takes the lead in developing codes, standards and protocols?

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- **Safety Issues:**
  Charging will not only be in garages, but on streets, parking lots and public buildings

- **Control Software and Protocols** (LDCs? Telecoms?)
  There are already too many independent developers and large corporations working at cross-purposes. An open platform should soon be available.

- **Voltage/Current Standards**
  220 volts at 30 amps can charge a PHEV in 90 minutes or less; 110 at 15 amps can take all night. The former is optimal for many reasons.

Electricity and Public Transportation: its NOT all about cars and trucks.

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- In the US the Obama Stimulus has allocated major funding for renewal and upgrades of urban public transit systems. At least 60 cities are planning new electric trolley or light rail systems (many had them ripped out in the 40s and 50s).
- The US DOT has targeted urban transit, trucking, rail and marine applications for electrification with major funding for R&D and demonstration projects. It is likely that this trend will be exported to Canada.
- At the very least these will be new loads for LDCs, but also opportunities to seek innovative and cost effective solutions to existing transit problems that also manage new electricity loads.

Why can Hydrogen Fuel be considered as 'Wireless' Electricity?

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H2 from Electrolysis of Water:

Pro: Distribution system in place, can be made with low emission electricity, water plentiful, can be part of a distributed 'demand response' business model

Con: Capital intensive, and production cost depends on local electricity rates

H2 from Methane Steam Reforming:

Pro: Could be cheaper than incumbent transportation fuels (per mile) and could be reformed locally at existing gas stations

Con: Produces 8 Kg of CO_2 for each Kg of hydrogen (plus other emissions) and production cost depends on natural gas price. Is likely not much better than other alternate fuels such as biodiesel or methanol

The Economic Case to Avoid the Cost of Overhead Wires

- The present assumption for design of urban rail transit is that power will be supplied via overhead wires
- Various studies cost such wires out at about 5M$ per Km to install in urban settings (not including the NPV of future maintenance costs)
- Overhead wires are problematic in northern climates, have esthetic issues and conflict with other overhead elements such as trees, utilities and bridges
- On-board fuel storage via advanced batteries and hydrogen (derived from off-peak electricity) will avoid this cost and will provide added benefits of operational fuel selection and regenerative braking to save energy.

Future Application of Distributed Battery Storage for Demand Response

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- Once a significant number of plug-in vehicles are deployed in the Ontario grid, the potential for use as part of a Distributed Storage System becomes practical
- Smart Grid technology could 'manage' battery loads in an optimal way, allowing for:
- 1) restricting charging for customers who sign up for interruptible rate plans or who are in congested areas
- 2) dispatching the power back to the grid via 'smart' inverters thereby providing spinning reserve and VAR support as needed.
- Again, smart grid technologies need to be in place to manage this valuable distributed resource opportunity

Distributed Energy Technologies

- Wind Turbines
- Micro-turbines
- Recip. Engines
- Gas Turbines
- ORC Engines
- Mini-Hydro
- Fuel Cells
- PV-Solar
- Biomass Conversion
- On-site Energy Storage

Meeting the Challenge
Cleanfield Energy Corporation

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Cleaner Energy with Ontario-Grown Turbine

- Vertical-Axis Wind Turbine generating clean, reliable electricity
- Tower and rooftop installation
- Field trials at the McMaster Innovation Park in Hamilton
- Studying urban applications
- Residential and commercial markets

CLEANFIELD ENERGY

Status of Fuel Cells

Fuel Cell Energy (FCE)

MCFC 250kW CHP Product

1MW integrated power plant installed at Enbridge HQ in North Toronto

Resource Recovery

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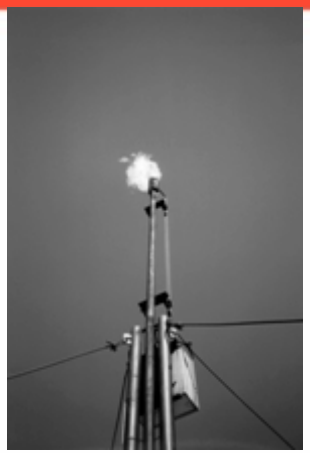
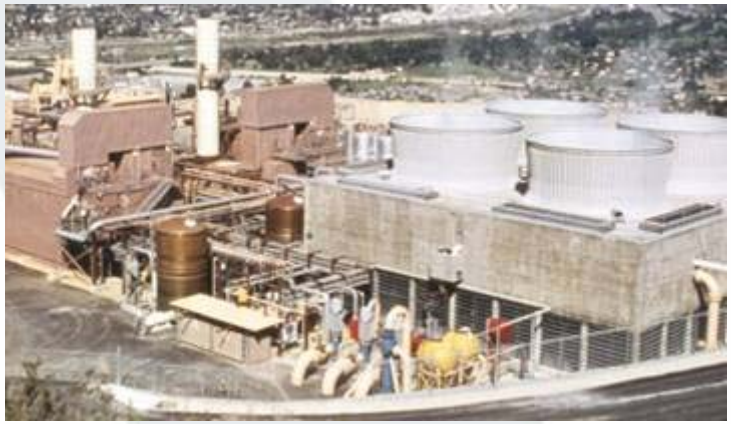
Key Drivers

- *Create useful electricity from waste*
- *Capture of Landfill & Digester Waste Gas Emissions (Methane)*
- *Reduce and capture flare gas*
- *Oil Waste Gas Recovery*





Micro-generation: The Closing 'Gap'

- **Formerly, power production was 98% the business of power utilities**
- **Presently, the lower capital costs, the added security and the CHP benefits of DG could change the market**
- **Soon there will be little or no 'space' between local power/heat generation and domestic appliances such as furnace boilers and water heaters**
- **Micro-generation technologies will be generally available at the residential level within 10 years or less. They would include: solar-voltaic, micro-wind, micro-turbines, fuel cells and sterling engine co-gen.**

DG Applications Matrix

	100 kW or less	100 to 1000 kW	1 MW to 10 MW	10MW or more
Near Term (1-5 yrs)	PV Solar Run of River hydro Urban and Rural small wind	Recip Engines ORC waste heat recovery Run of River or Small Hydro Microturbines	Recip Engines Combustion Turbines Wind (single) BioFuels Small hydro	Combustion Turbines Wind farms Biomass (CoGen) Medium Hydro
Mid term (5-10 yrs)	Sterling engine devices Fuel Cells	PV Solar Fuel Cells Flow Batteries	Flow Batteries	Pumped storage

OCE Smart Grid Projects

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1. **Large-Scale Photovoltaic Solar Power Integration in Transmission and Distribution Networks**
2. Communication Protocol for Residential Electrical Demand Response In Home Devices (IHD)
3. Power Restoration System for Electrical Power Networks
4. Development of Grid Interface for Intermittency Mitigation device
5. Energy Mediator Grid Interface Blueprint
6. Energy Mediator (Hydrolyser™) Thermal Storage System (TOS) Blueprint
7. Reactive Power Ancillary Service Markets and Dispatch: Design and Analysis
8. Modeling and Analysis of a 1-MW Photovoltaic Plant as a Distributed Energy Unit
9. **Energy Consumption Management System (Energy Hub)**
10. **Maestro Pilot Installations and Energy Reduction Analysis**
11. Energy Storage for Solar Applications
12. Experimental and Theoretical Investigation of Flowing Electrolyte - Direct Methanol Fuel Cells
13. L.E.S. Smart Ballast
14. Large Energy Harvesting Solar systems with a "smart" interface.

$12 M

Smart Grid Projects

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- **University of Western Ontario, OptiSolar Farms Canada, BlueWater Power, London Hydro & Hydro One**
- **Large-scale photovoltaic solar power integration in transmission and distribution networks**
- **3 year *Collaborative* project: $6 million**

- **University of Waterloo, Energent, Hydro One, Milton Hydro & Ontario Power Authority**
- **Energy Hub Management System: Enabling and Empowering Energy Managers through Increased Information and Control**
- **3 year *Collaborative* project: $3.7 million**

- **Member IESO's Smart Grid Forum**
- **http://www.ieso.ca/imoweb/marketsandprograms/smart_grid.asp**

All project values include cash & in-kind from OCE and industry partners

Meeting the Challenge with StormFisher

- **An Ontario renewable energy company specialized in biogas, started by three entrepreneurs**
- **Utilizes agricultural and food processing by-products in order to create renewable energy in both electricity and direct-injection natural gas form**
- **Builds, finances, owns and operates its own facilities with engineering and technology from Europe: not a technology company**
- **Will have three industrial biogas installations online in 2009**
- **Landed $350 Million in capital from a Boston-based private equity firm**
- **Now have the largest pool of financing available for biogas projects in the world**

ReportonBusiness.com

POWER GENERATION

Inniskillin Wines taps into recycling

Cuts a deal with biogas developer StormFisher to take grape seeds and skins and turn them into electricity

RICHARD BLACKWELL
November 15, 2007

One of Canada's top wineries is gearing up to generate a new byproduct from the wine-making process - electricity.

Inniskillin Wines of Niagara-On-The-Lake, Ont., said yesterday it has signed a deal with startup biogas developer StormFisher Biogas, to take the skins and seeds left over after the wine-making

StormFisher BIOGAS

Meeting the Challenge
REGEN Energy Inc

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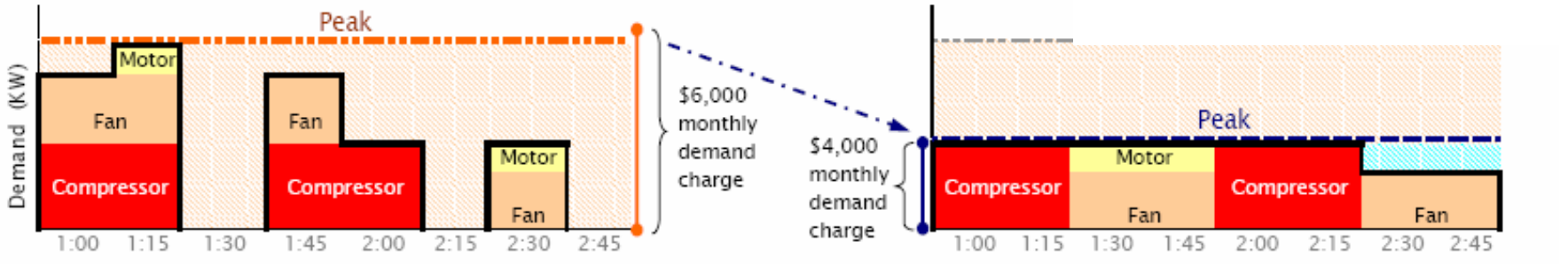
Reducing Peak Consumption for Commercial Users

- Pilot Project with OPA and Centennial College
- Wireless Load Management Controllers
- Applied Testing for College Students



REGENENERGY

Meeting the Challenge
Energent Incorporated

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Making the Grid Smart:
Transforming Energy Data into Meaningful Information

- Energy hubs enable real-time management of energy demand, production and storage
- Targeted for manufacturing facilities, farms, retail facilities, and houses
- $3.8 million research and pilot program with OCE, Hydro One, OPA, Milton Hydro and the University of Waterloo.

University of Waterloo

energent

[47] OCE – Energy R&D Priorities for 2010/11

THANK YOU! **www.oce-ontario.org**

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SOLAR –dropping the price of photovoltaic panels by an order of magnitude (e.g. from $0.80 per KWh to $0.08 per KWh).

STORAGE – dealing with the intermittent nature of renewable supply.

SMART GRIDS – enabling bidirectional energy flow; optimize distributed and/or congested generation with central generation.

PLUG-INS – electrification of our transportation system.

TALENT – developing the next generation of innovators (green jobs).