The Waterloo Institute for Sustainable Energy (WISE)

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University of Waterloo

Presented to the
IIT-R Delegation at UW
June 28th, 2010

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The Waterloo Institute for Sustainable Energy (WISE)

- Founded in April 2008
- A top strategic priority of the University of Waterloo
- Full spectrum of energy R&D, education and training, partnerships and commercialization activities
- 75 + faculty members work as multi-disciplinary teams across faculties of Engineering, Science and Environment

Vision

To establish WISE as a recognized centre of expertise and excellence

for development of energy systems and policies sustainable over the long term

To promote innovation

to enhance national social, economic and environmental performance by creating options and alternatives to existing energy production and delivery systems

To conduct collaborative research in support of goals identified by utilities, business, government agencies and civil society groups

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World at Night

Energy, Economic Development, Life Quality

Enhanced Well Being
Life Expectancy: 80 yrs

10^4

IMPROVED LIFE QUALITY
Life Expectancy: 60 yrs

10^3

BASIC QUALITY OF LIFE
Life Expectancy: 60 yrs

10^2

SURVIVAL
Life Expectancy: 40 yrs

Annual
$GDP/Capita

Annual
kWh/capita

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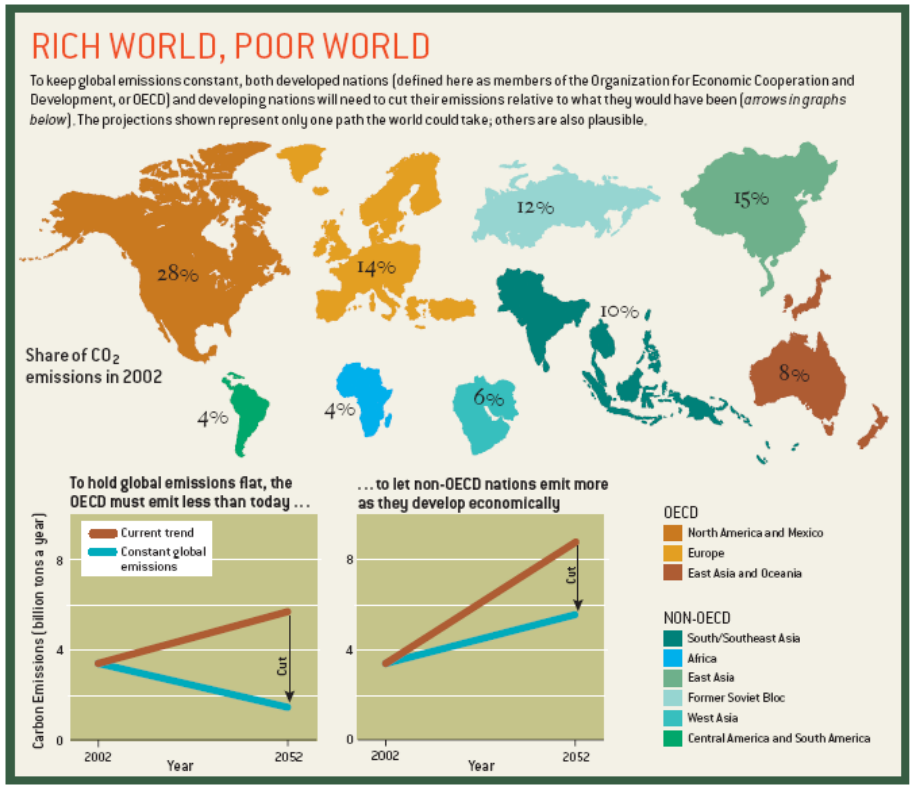
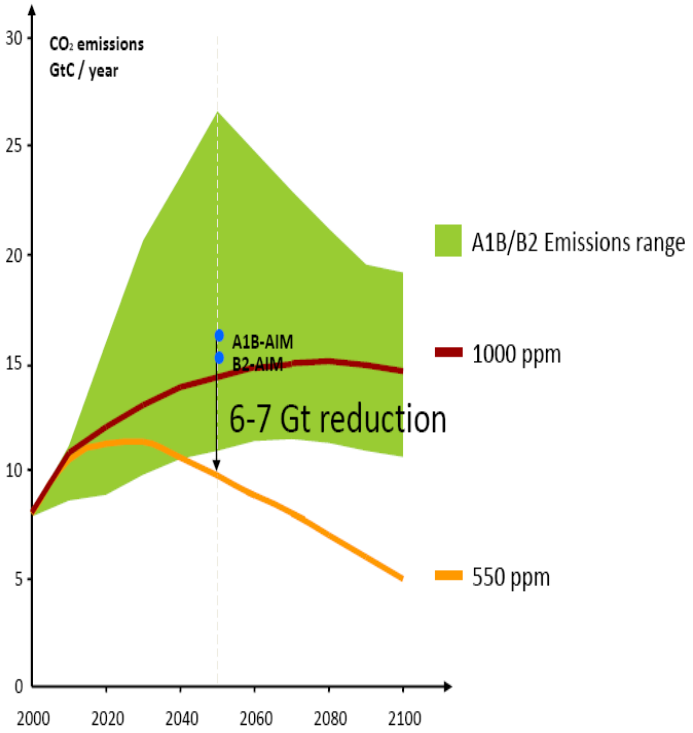
The global challenge: how to de-carbonize



Achieving a lower CO_2 stabilization



Source: R. Socolow and S. Pacala, Scientific American, Sept.2006

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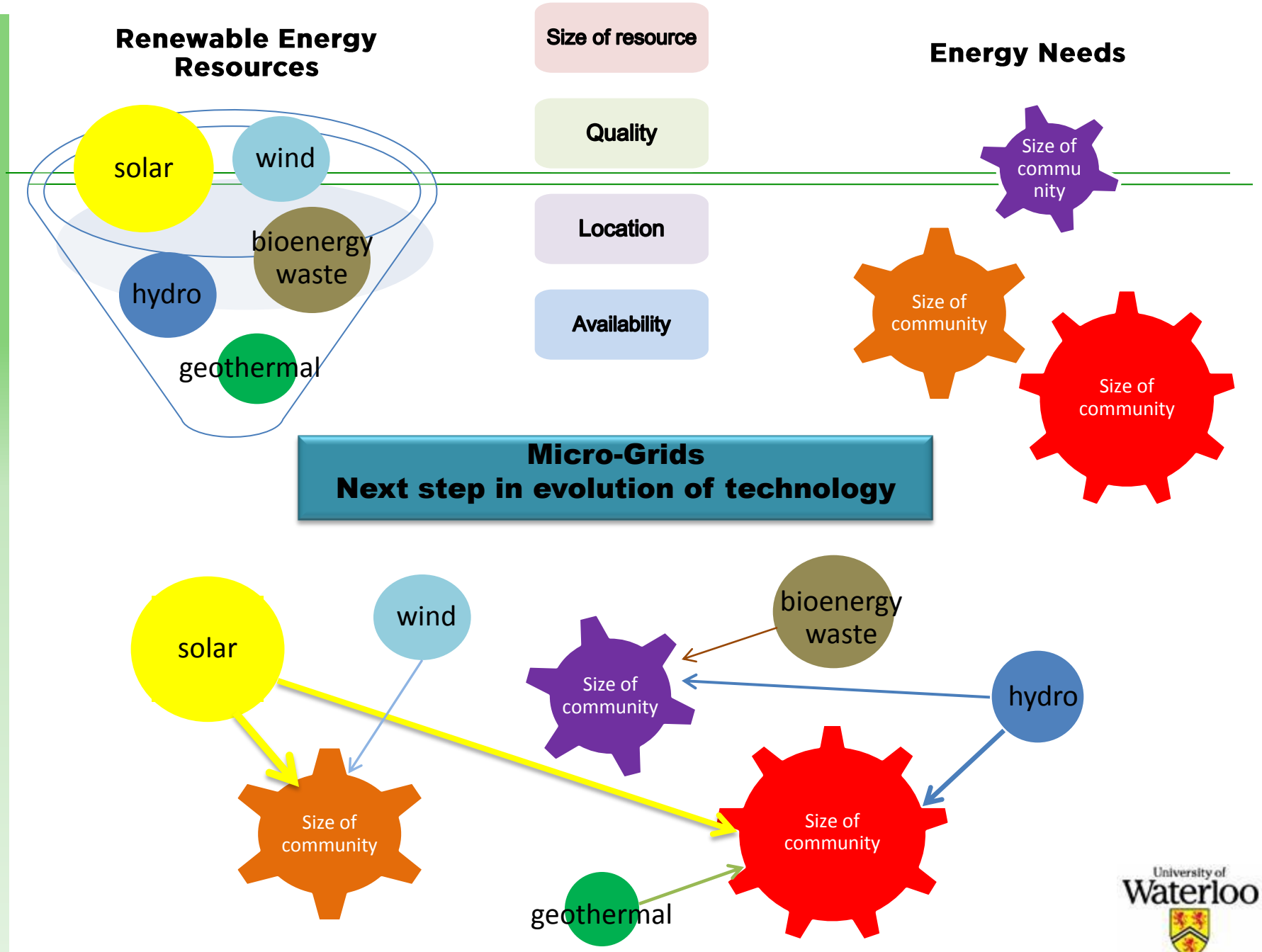
Global Vision is an integrated model of electrification to meet basic human needs at 1000kWh/person.a

- Can we engineer this vision?
- What role for “smart micro-grid” systems to help meet specific needs of rural and remote communities primarily through use of renewable resources?
- Can we link Ontario developments to a global opportunity?



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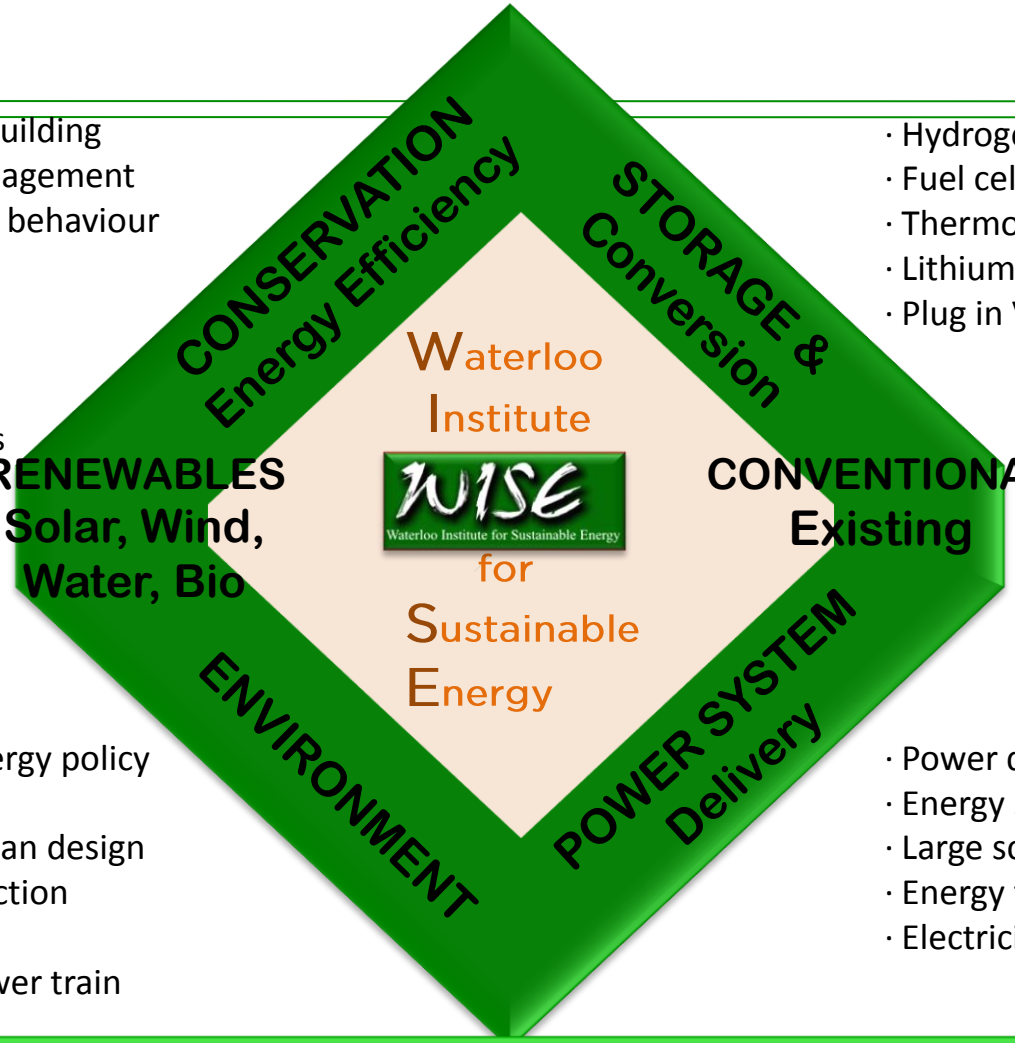
SUSTAINABLE ENERGY:
Policies, Programs, Directions



· Sustainable building
· Demand management
· Conservation behaviour

· Hydrogen production
· Fuel cells (solid oxide and PEM)
· Thermoelectric materials & devices
· Lithium ion batteries
· Plug in Vehicles

· Centre for Advanced Photovoltaics, Systems & Devices (CAPDS)
· Solar thermal applications
· Wind turbine design & performance
· Bioenergy
· Distributed generation

·CCS
· Clean diesel engines
· Clean coal technology
· Nuclear power plant reliability

· Sustainable energy policy & planning
· Sustainable urban design
· Emissions reduction
· Green batteries
· Green auto power train

· Power quality
· Energy systems reliability
· Large scale optimization
· Energy forecasting
· Electricity markets

Preserve & Create Energy Options
Multi-Disciplinary Research Teams
Economic Growth & Environmental Performance
Business, Government, Industry Engagement

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Selected Highlights

Off - grid hybrid power system for remote Communities

- Decrease or eliminate diesel dependency and provide a lower-cost, environmentally friendly solution for remote communities.

Energy Hub Management System

- SW Ontario study of 65 microgrids: residential, industrial, commercial, institutional, and agricultural sectors
- Empower energy hubs to facilitate entities at different locations that require energy (e.g., manufacturing, farms, homes) to control, in real-time not, only demand but production, storage and ability to export and import energy

Connecting Solar Farms to the Grid

- Comprehensive solutions to help grid operators incorporate large-scale solar farms to their networks.

- Ontario Smart Grid Forum
- Plug-In Hybrid Electric Vehicles Ontario Action Plan
- "Affordable solar for the masses"- A major international initiative
- Integration of Distributed Generation into system
- Advanced batteries and storage technologies

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Why Smart Grids?

Ontario Context

Define provincial smart grid objectives

Set timelines for implementation

- Realistic timeframes based on available technologies and how they can be used to achieve objectives

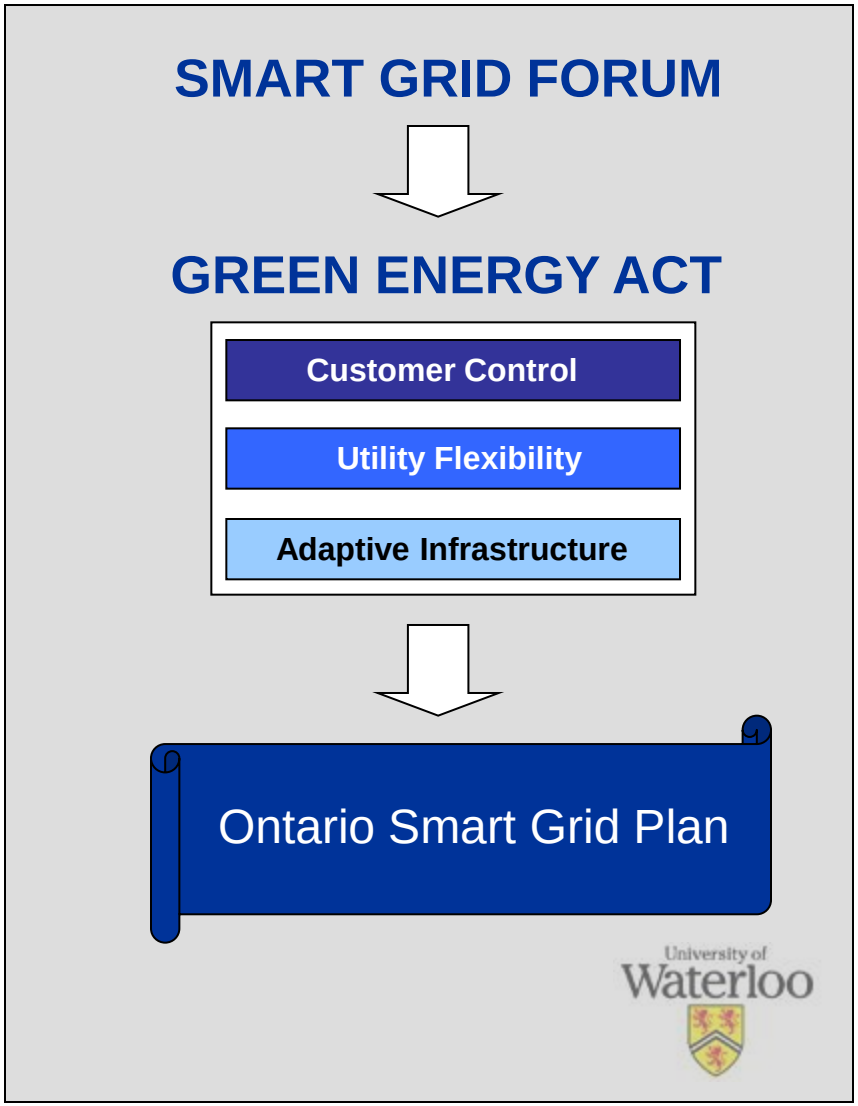
Identify responsibilities

- Roles and next steps for OEB, IESO, LDCs, OPA, and ESA

Identify areas where provincial coordination will be required

Set the framework to encourage manufacturing and identify Ontario-based investment opportunities

- MEI will be able to identify investment opportunities for smart grid technologies and encourage Ontario-based manufacturing in those areas

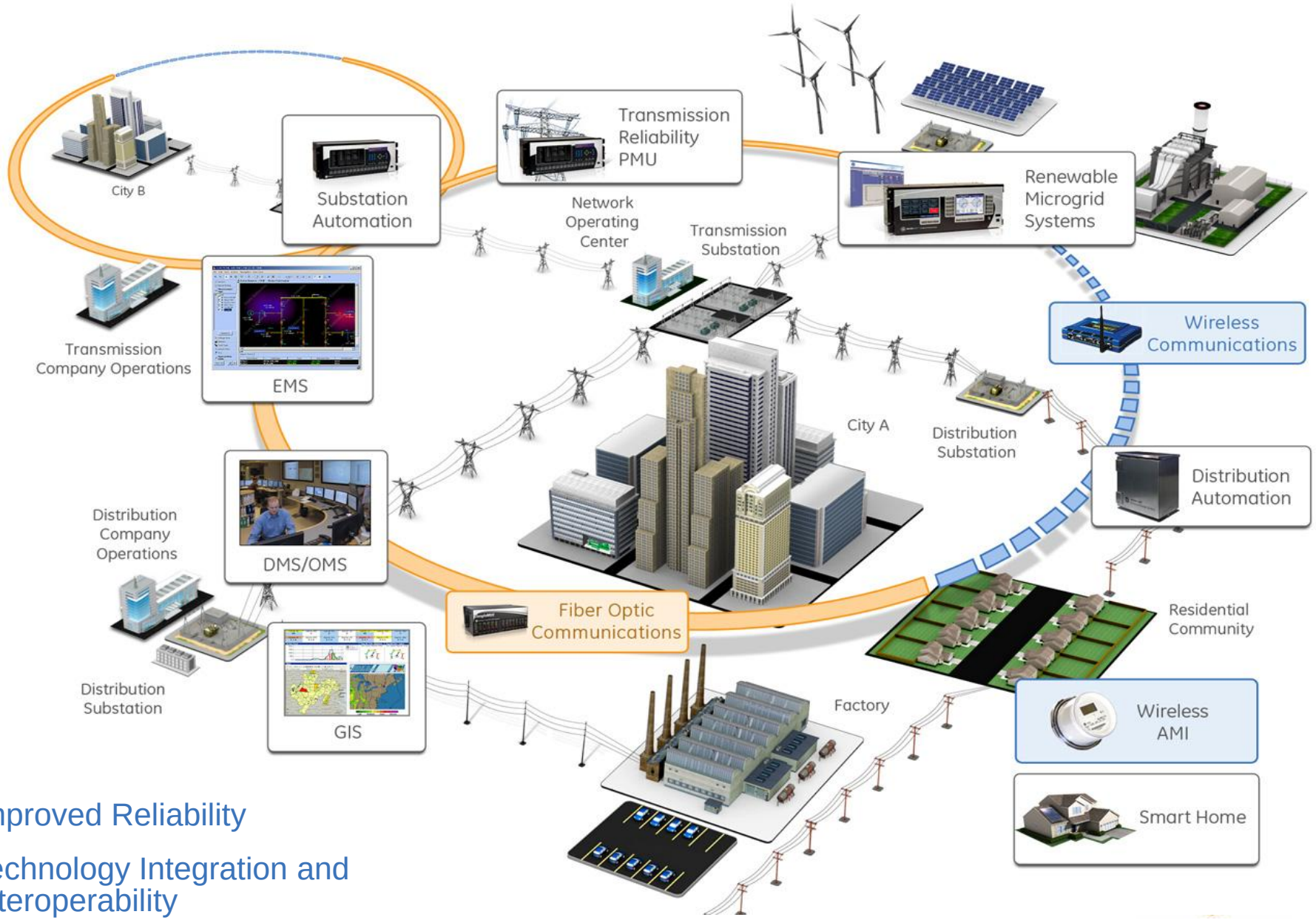


The Green Energy Act and evolution of the grid…

The GEA sets the objectives and framework for smart grid to "improve the flexibility, security, reliability, efficiency and safety" of the electricity grid.

GEA Smart Grid Objective	*Focus Area*	*Expected Outcomes*
i. "expanding opportunities to provide demand response, price information and load control to electricity customers;"	**Customer Control**	• Smart meters • Time-of-use rates • In Home Displays • Load control → More Conservation
ii. "enabling the increased use of renewable energy sources and technology, including generation facilities connected to the distribution system;"	**Utility Flexibility**	• Customer based micro-generation • More distributed generation, used more efficiently (i.e. less transmission investment) → More Renewables
iii. "accommodating the use of emerging, innovative and energy-saving technologies and system control applications;"	**Adaptive Infrastructure**	• Mobile charging infrastructure to support EVs • Storage opportunities • Keeping room for innovative technologies → More Innovation

Key Smart Grid Technologies



Improved Reliability

Technology Integration and Interoperability

2 kW EV Charging Station

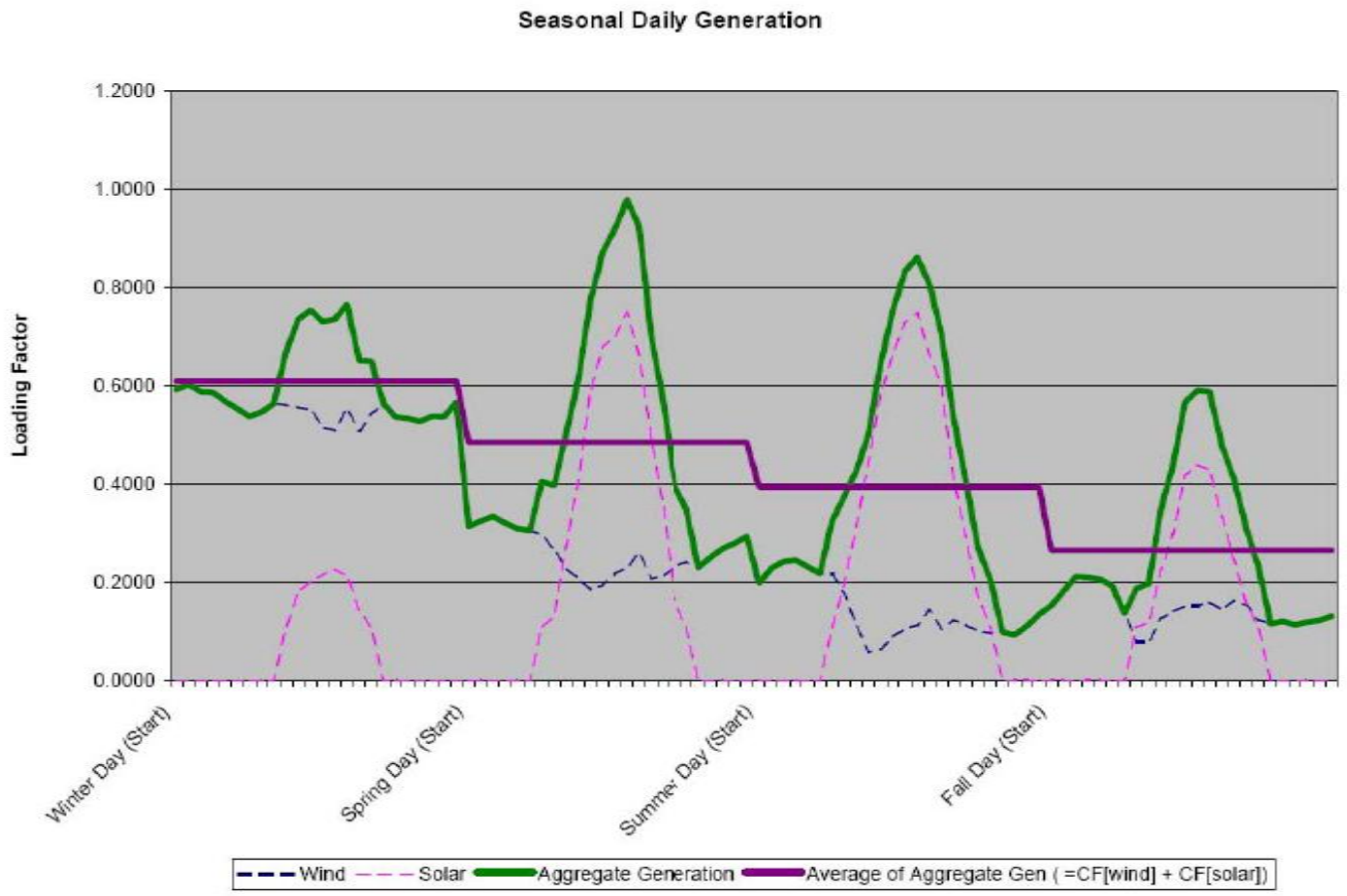
10 kW EV Charging Station

30 kW EV Charging Shade Structure

300 kW EV Charging

Source: steve@renewables.com

Benefits of Diversity and Distributed Resources



 Source: R. Seethapathy, Hydro One Presentation to the Ont Smart Grid Forum

Microgrid Benefits

Choice(s): Extend existing grid? Or build microgrids?

- **Reduced cost**—reducing the cost of energy service for affordability
- **Reliability**— attain level of reliability comparable to grid system
- **Green power**—manage the variable nature of renewables and promote deployment and integration of energy-efficient and environmentally friendly technologies
- **Service differentiation**—tailor to specific needs of a wide range of communities; provide levels and quality of service at different price points

When operating in grid parallel mode :

- **Power system**—assisting in optimizing the power delivery system, including the provision of Services
- **Security**—increasing the power delivery system's resiliency and security by promoting the dispersal of power resources

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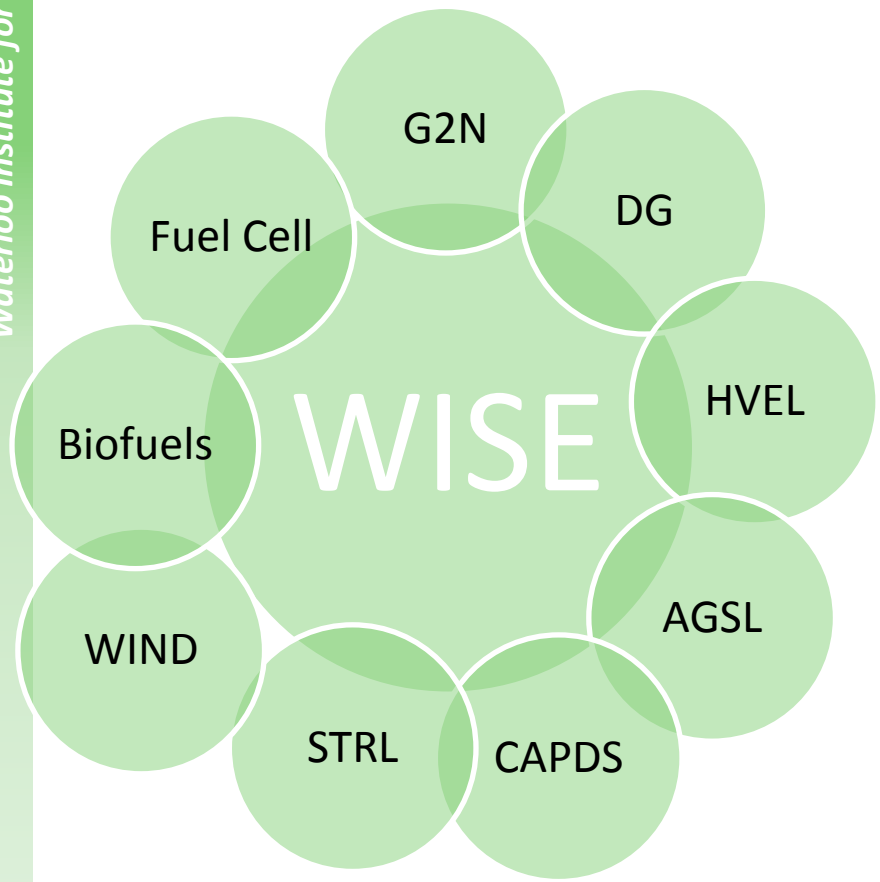

G2N Giga-to-Nano Lab

- Andrei Sazonov, Electrical & Computer Engineering

DG Distribution Generation Lab

- Ehab El-Sadaany, Electrical & Computer Engineering

HVEL High Voltage Engineering Lab

- Shesha Jayaram, Electrical & Computer Engineering

AGSL Advanced Glazing System Lab

- John Wright, Mechanical & Mechatronics

CAPDS Centre for Advanced Photovoltaic Devices and Systems

- Siva Sivoththaman, Electrical & Computer Engineering

STRL Solar Thermal Research Lab

- Michael Collins, Mechanical & Mechatronics

WIND Lab

- David Johnson, Mechanical & Mechatronics

Biofuel/Biomass Lab

- Ray Legge, Biometric Engineering & Environmental Engineering

Fuel Cell Lab

- Michael Fowler, Chemical Engineering

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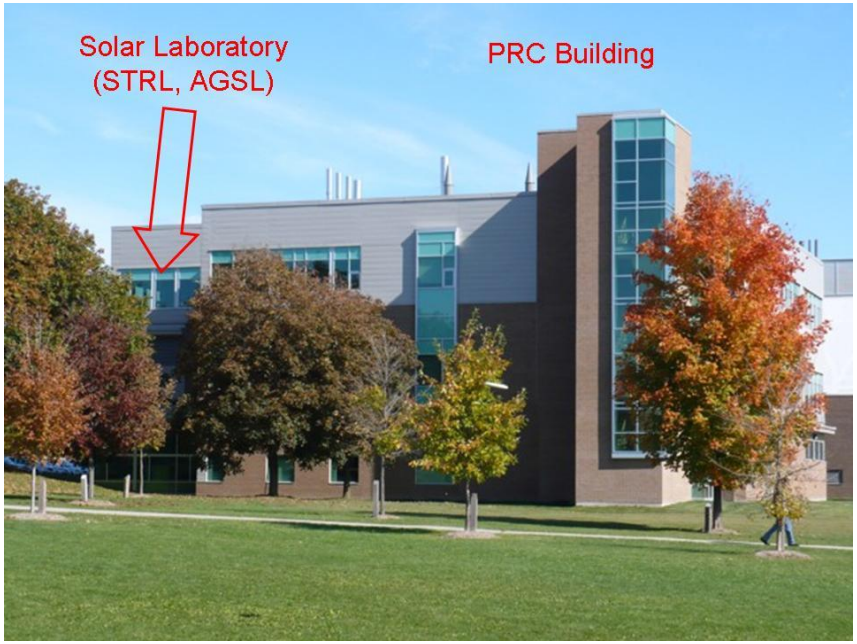
Resources



CAPDS, STRL, AGSL Labs

HVEL 800 kV 60 kJ Impulse Generator

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Resources

The world class UW Live Fire Research Facility, a large-scale indoor wind generation facility

Small turbine testing in the indoor wind generation facility allows complete control of wind speeds from 0-18 m/s.

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Resources

Center for Advanced Photovoltaic Devices and Systems (CAPDS) -Photovoltaic material synthesis, cell and module fabrication laboratories

Giga-to-Nano (G2N) LaboratoryAdvanced flexible electronics fabrication and nanoelectricdevice integration

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Summary

A strategy that links smart grid development and economic development will likely work if it can draw from, or rest upon, these 3 pillars:

- Innovation
- Meeting Ontario needs and expectations
- Understanding of Global opportunities and challenges

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