Overview of Microgrid Research and Development Activities in Canada

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Grid integration of Decentralized Energy Resources Program

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http://www.ctec-varennes.nrcan.gc.ca/

Overview

- Introduction
- Strategic approach
- Canadian microgrid activities
- Advanced distribution systems
- International collaborations
- Conclusions

CETC - Varennes

Energy Efficient Buildings

- Refrigeration Action Program for Buildings (RAPB)
- Continuous Building Optimisation

Efficient Industrial Processes

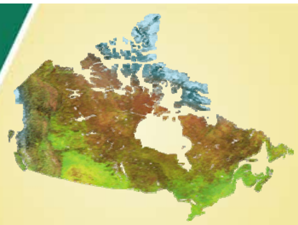
- Industrial Systems Optimization

Clean Power

- Grid Integration of Decentralized Energy Resources
- Photovoltaic Systems in Buildings
- Stand-Alone Photovoltaic Systems

RETScreen International

Canadian Interests



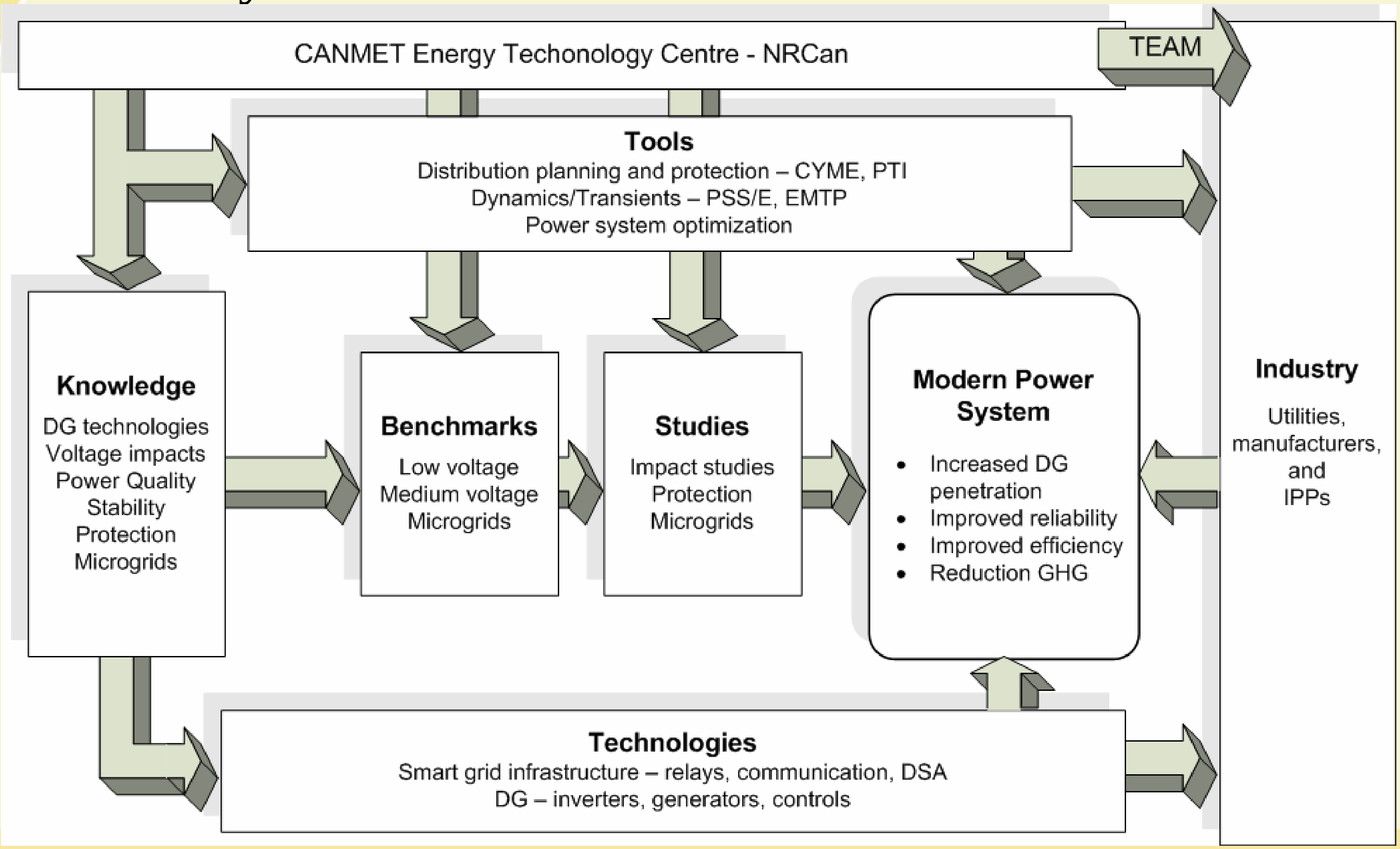
- Electrification of remote communities and islands
  - → Power generation systems for Non-Integrated Areas, and Northern communities
  - → Reduce the use of diesel fuel in remote communities
- Securing power supply to the customers:
  - → Continuity of supply (improved service on rural feeders)
    - Intentional islanding subsequent to faults on upstream feeders
    - Pre-planned islanding during substation maintenance
- Managing load growth and peak shaving
- New approach for distribution system planning (new systems and upgrades)

Activities and collaborations

- **Distribution Network and Planning Software Tools**
  - **CYME T&D : CYMDIST Enhancement**
- **Standards and Guidelines**
  - **IEC Technical committee, IEEE 1547**
  - **CIGRE C6**
  - **Adoption of harmonized standards and codes for Canada**
- **Distribution Benchmarks and Case Studies:**
  - **Fortis Alberta: High penetration case study**
  - **BC Hydro: Intentional islanding case study**
  - **Newfoundland and Labrador Hydro: Remote community medium penetration wind-diesel system**
- **CIGRE C6 and IEA Taskgroups**

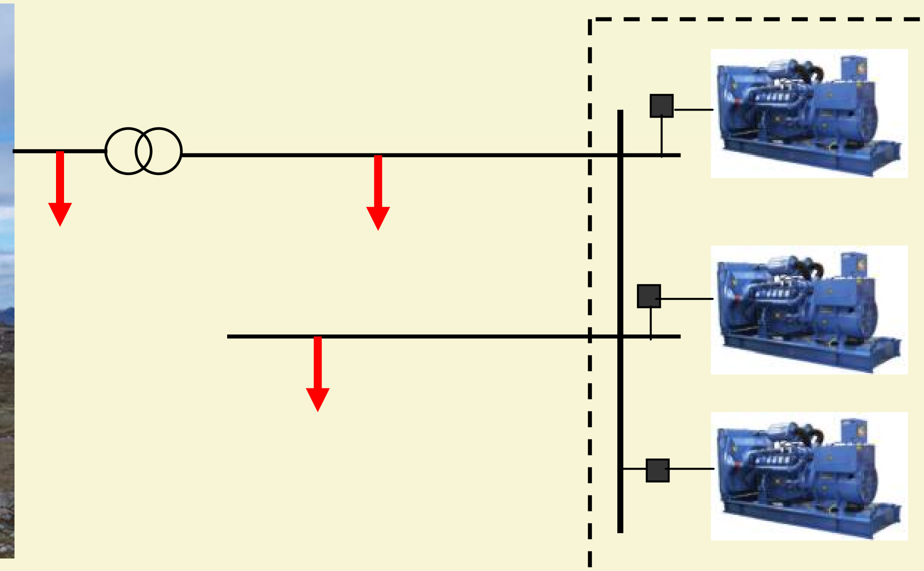
Strategic Approach

Addressing the issues and impact of Renewable and DG to the electricity distribution network



Study Case 1: Remote Microgrid

- A remote wind-diesel power generation system for an island



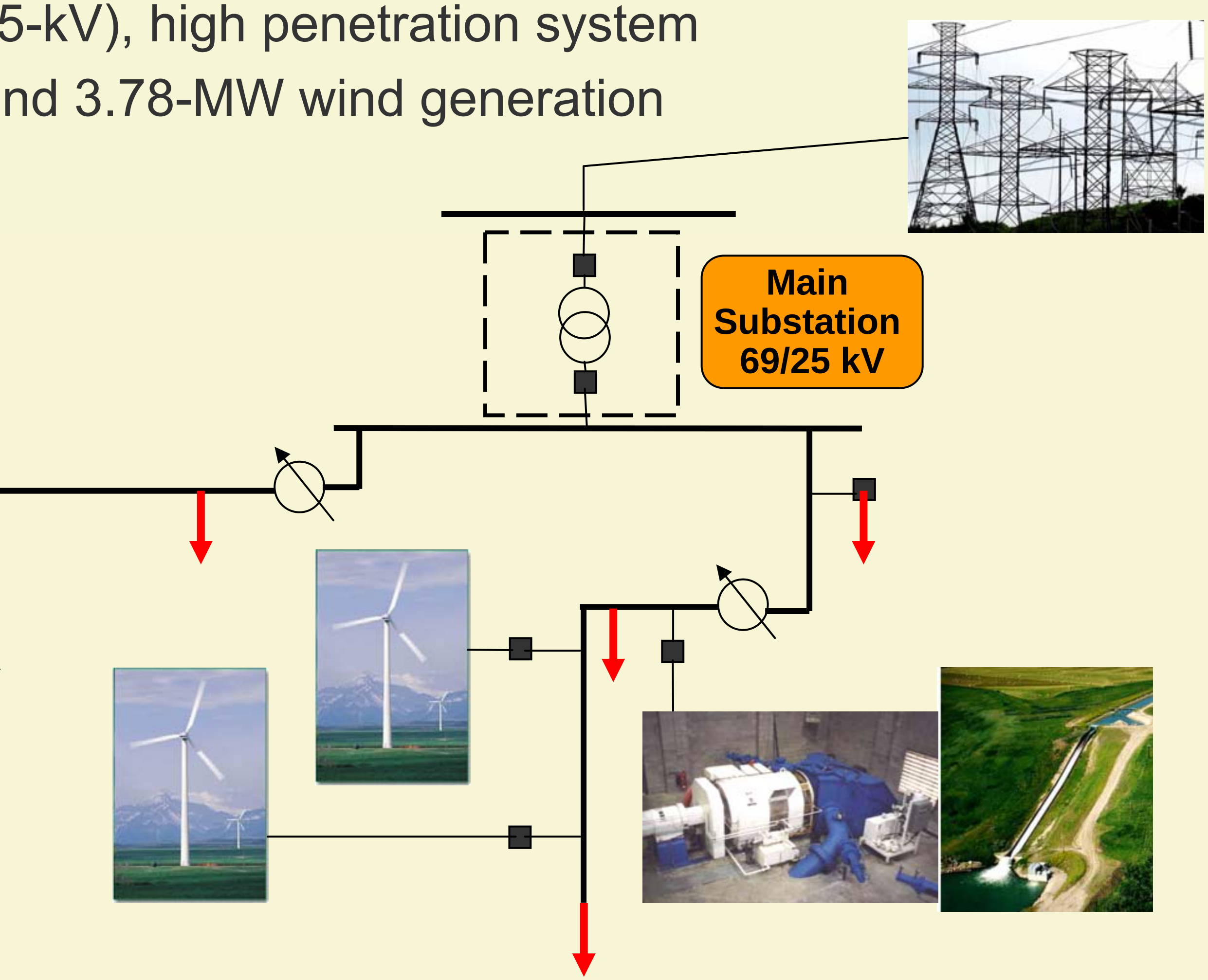
Wind Power Plant

Diesel Power Plant

Considered:
- Dynamic voltage and freq. control for islanding operation
- Power management (power sharing and load following)
- Modeling and analysis: steady-state, transient, and feasibility studies

Study Case 2: Utility Microgrid

- A medium voltage (25-kV), high penetration system
- 3-MW hydro power and 3.78-MW wind generation
- 4.82-MW local load



Considered:

- Bi-directional power flow
- Reactive power control
- Interaction of DGs and line voltage regulators
- Pre-planned islanding

Study Case 3: Intentional islanded network

- Boston Bar: 8.6-MVA peak Gen. supplies 3-MVA peak load
  - Transition between the utility and a hydro power generator

Secure Demand Supply

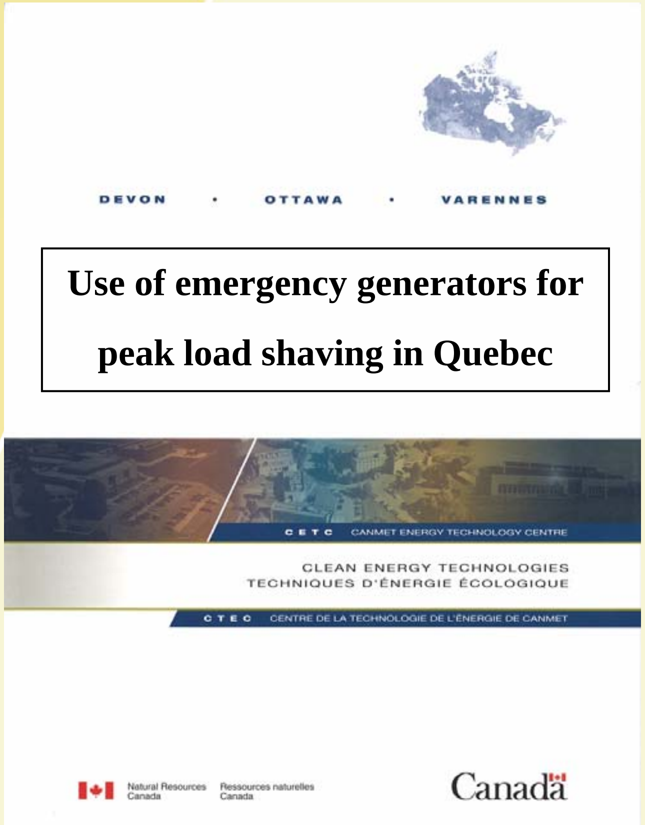
Generation and Load Control

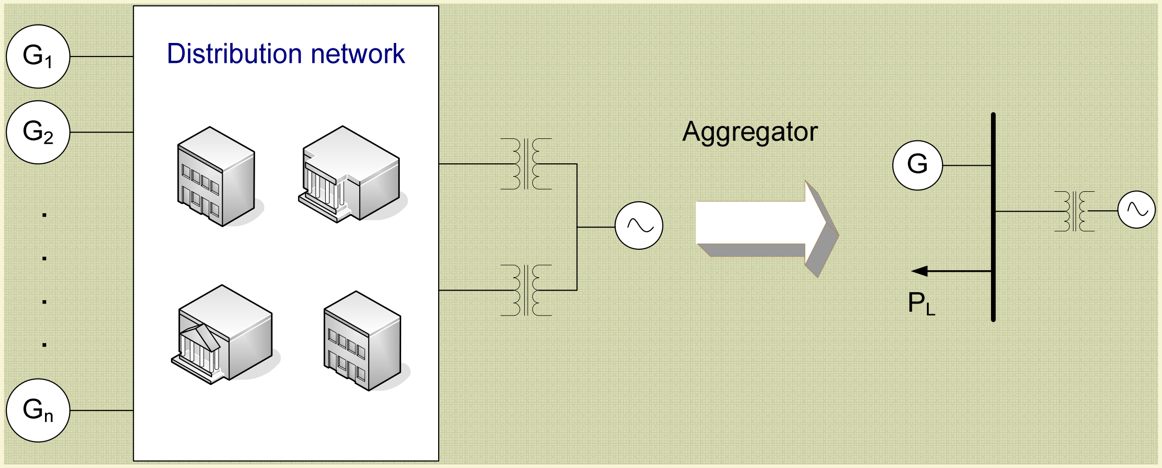
Run-of-river Hydro Power

Considered:

- Ride-through islanding transients by engineering the generator mass
- Local control of load and generation
- Telecommunication link with the Utility for updating the system status

DG Aggregated Cost-Benefits and Demand Response





Source: M. Cantin, CIMA

Needs - Tools and Training

Advanced DG Modeling with CYMDIST - *Product Highlight*

A recent survey* of Studies and Analysis Tools Used for Assessment of Distributed Generation Integration in Canadian Distribution Systems published by Natural Resources Canada's CANMET Energy Technology Centre - Varennes has shown that distribution companies are only beginning to integrate Distributed Generation (DG) and that this remains a relatively new and insufficiently understood topic. It concludes that knowledge regarding the impact on the operation and planning of the distribution system, and new technologies to facilitate its integration, would be welcomed to aid in this process.

Recognizing the fact that Distributed Generation (DG) is propagating rapidly on the distribution networks and that engineers must be equipped with better tools to assess the impact of DG on their electrical network, CYME has recently enhanced the functionality of its distribution analysis software CYMDIST in a significant way. The new release of CYMDIST features several improvements and functions including new DG models to investigate and simulate the impact of various types of DG on the distribution network.

The latest version of CYMDIST allows to study quickly and clearly the impact of DG. Namely, it provides the ability to model all types of DG including all electronically coupled DG such as wind turbines (synchronous or induction), gas turbine (high speed), energy storage, photovoltaic, etc. It also provides for islanded systems simulation (islanding capability) and with the ability to reduce the network (network reduction) to better see the impact of DG.

Enhanced DG Models

In CYMDIST the DG models are divided in three categories depending on how they are coupled with the electrical network:

- **Synchronous generators** that can be operated in three different modes: voltage control, fixed generation or swing.
- **Induction generators** that provide constant generation.
- **Electronic converters.** Electronic converters are used with wind turbines (synchronous or induction), gas turbine (high speed), energy storage, photovoltaic source and fuel cells.

DG Impedances Estimation

An **Impedances Estimation function** has been developed and introduced in the DG properties dialog box that provides typical values of these generator impedances if the data is not available to the user. The estimation functions are based on some standard tables for short-circuit calculations that provides a series of tables for different generator sizes and types. The estimation function implemented in CYMDIST provides the data that enables different "what-if" cases and that provides accurate results on the impact of DG.

* *The final survey report can be downloaded from:*
http://cetc-varennes.nrcan.gc.ca/en/er_re/inter_red/p_p.html?2006-070

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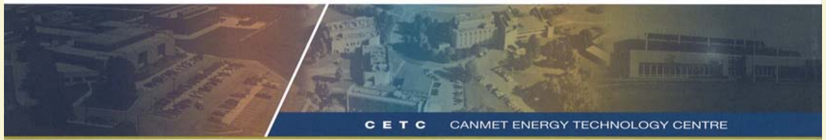
Survey - Assessment of Distributed Generation Integration in Canadian Distribution Systems



CETC CANMET ENERGY TECHNOLOGY CENTRE

CLEAN ENERGY TECHNOLOGIES
TECHNIQUES D'ÉNERGIE ÉCOLOGIQUE

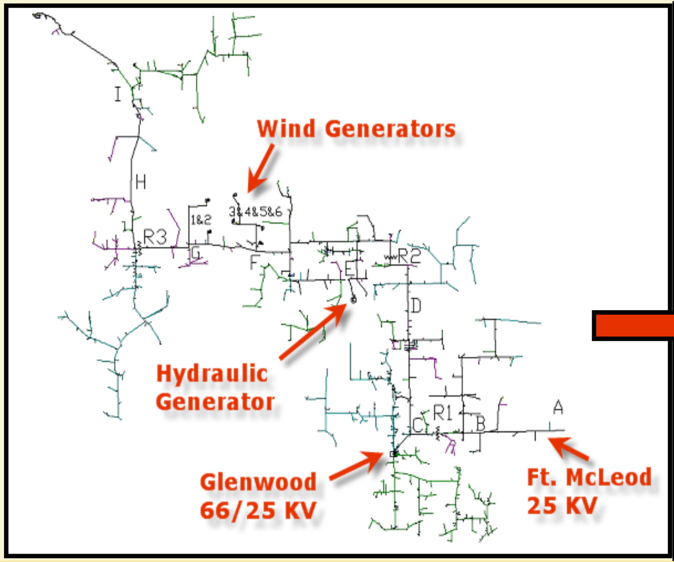
CTEC CENTRE DE LA TECHNOLOGIE DE L'ÉNERGIE DE CANMET

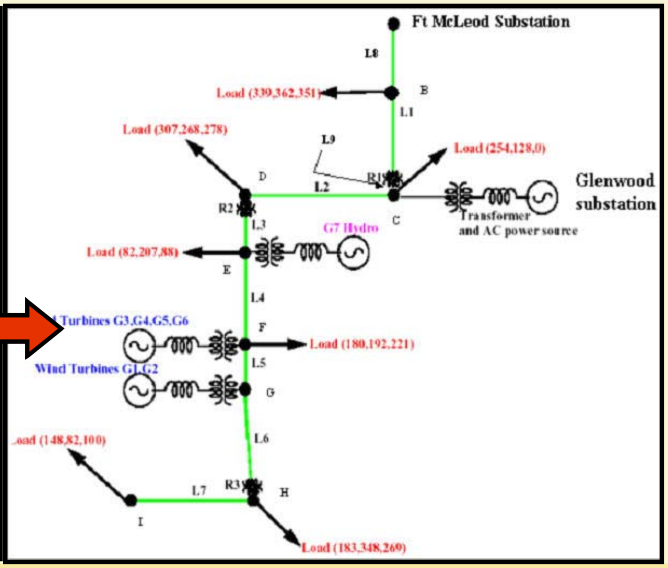
Natural Resources Canada | Ressources naturelles Canada

Canada

Tool: CYMDIST Enhancements

- Enhanced DG models for power flow and short circuit studies
  - Synchronous generators, Induction generators, and electronic converters
- DG Impedance Estimation
  - Calculating typical values for generator impedances
- Islanding Capability
- Automated Network Reduction:





Enhancing Interlaboratory Research

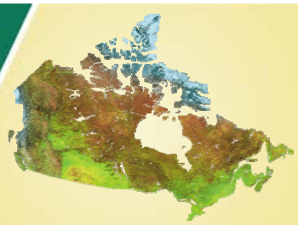
- **Low voltage (LV) test facility:**
  - Multiple inverters and interconnection test bench

- **120-kVA, 3ph Grid simulator**
- **5kW/15kW Solar Simulator**
- **Adjustable resistive, inductive and capacitive loads**

- **Medium voltage (MV) test facility:**
  - Distribution automations network study test site

- **A radial 25-kV feeder (20 poles, 370m)**
- **300-kW, 600 V, resistive, inductive and motor loads**
- **Power quality meters**

Standards and Codes - Consider Microgrid Applications



IEEE Standards (USA)

IEEE 1547 - Standard for Interconnecting Distributed Resources with Electric Power Systems
Contact: R. Deblasio, NREL (Chair)
Liaison: S. Martel, NRCan/CETC-V

IEEE 1547.1 - Standard for Conformance Test Procedures for Equipment Interconnecting Distributed Resources with Electric Power Systems
Contact: C. Whitaker, Endecon (V-Chair)
Liaison: S. Martel, NRCan/CETC-V

IEEE P1547.2 - Draft Application Guide for IEEE 1547 Standard for Interconnecting Distributed Resources with Electric Power Systems
Contact: R. Friedman, Resource Dyn. (Chair)
Liaison: S. Martel, NRCan/CETC-V

IEEE P1547.3 - Draft Guide For Monitoring, Information Exchange, and Control of Distributed Resources Interconnected with Electric Power Systems
Contact: F. Goodman, EPRI (Chair)
Liaison: K. Mauch, Mauch Technical Serv.

IEEE P1547.4 - Draft Guide for Design, Operation, and Integration of Distributed Resource Island Systems with Electric Power Systems
Contact: B. Kroposki, NREL (Chair)
Liaison: Chad Abbey, NRCan/CETC-V

IEEE P1547.5 - (NEW) Draft Technical Guidelines for Interconnection of Electric Power Sources Greater than 10MVA to the Power Transmission Grid
Contact: (TBD)
Liaison: Sylvain Martel, NRCan/CETC-V

IEEE P1547.6 - (NEW - Still unamed) Draft standard for DG on networked (as opposed to radial) distribution systems
Contact: (TBD)
Liaison: Sylvain Martel, NRCan/CETC-V

International Electrotechnical Commission (IEC) Standards

IEC TC8 - System Aspects of Electrical Energy Supply

Contact: G. Valtorta, Italy (Secretary)
Canadian Committee Chair: D. Desrosiers, HQ

Ad-Hoc Group 2 (PT1) - Connection to Electricity Supply System

Contact: A. Bower, UK (Convenor)
Liaison: S. Martel, NRCan/CETC-V
A. Garg, Hydro-One

IEC TC57 - Power Systems Management and Associated Information Exchange

Chair: T. Lefebvre, France
Canadian Committee Chair: M. Toupin, HQ

Working group 17 - Communication Systems for Decentralized Energy Resources

Contact: F. Goodman, EPRI, USA (Convenor)
Liaison: J. Goulet, IREQ/HQ
L. Dignard, NRCan/CETC-V

Canadian Activities

CSC / IEC TC8 - System Aspects of Electrical Energy Supply (CSA TC C508)

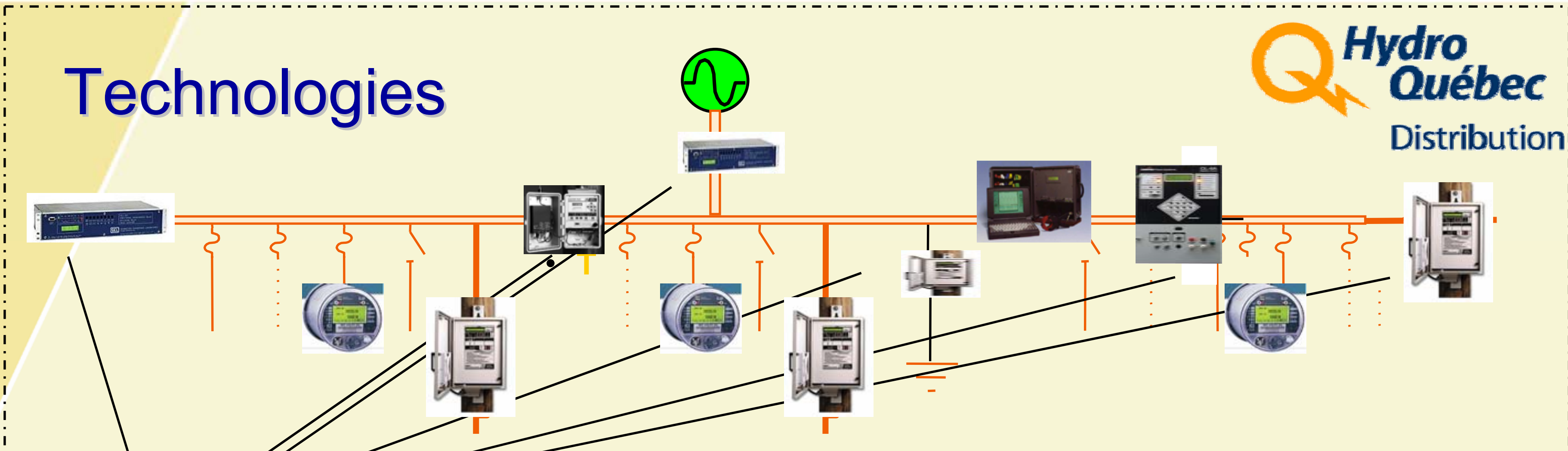
Technical Committee

Daniel Desrosiers, Hydro-Quebec (Chair)
John O'Neill, CSA (Secretary)
Sylvain Martel, NRCan/CETC-Varennes
Jean Bertin-Mahieu, Hydro-Quebec
Kai Cheng, Manitoba Hydro
Ajay Garg, Hydro One
John Petras, Toronto Hydro
Angela Di Lollo, Canadian Electricity Ass.
Helen Sam, Canadian Electricity Assoc.
Romano Sironi, Toronto Hydro

CSA Technical Sub-Committee

Romano Sironi, Toronto Hydro (Chair)
John O'Neill, CSA (Secretary)
Sylvain Martel, NRCan/CETC-V
Richard Bahry, Fortis Alberta
Serge Bernard, Hydro Quebec
Ken Brightwell, ESA
Daniel Desrosiers, Hydro-Quebec
Tim Eckel, SaskPower
Ajay Garg, Hydro One
Eric LeCourtois, Hydro Quebec
Glenn Paskaruk, Manitoba Hydro
Wayne Ruhnke, Ruhnke Consulting Inc.
Helen Sam, CEA
John Savage, Ministry of Energy
Bert Dreyer, ENMAX
Larry Haffner, BCTC

Advanced Distribution System-Strategic Planning



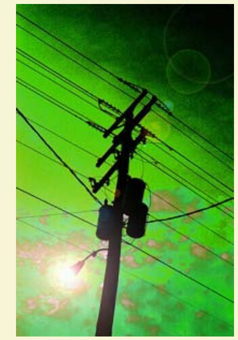
Data
- Voltages
- Load currents
- Fault currents
- Temperature
- Operations monitoring

Functionalities
- Voltage control
- Optimised load flow
- Fault location
- Equipment failure detection
- Power Quality evaluation

Business needs
- Improving reliability
- Reduce costs
- Energy efficiency
- Customer satisfaction…

Source: G. Simard, Hydro Québec Distribution

International R&D effort



- International Collaboration
  - ✓ CIGRE Taskforces
  - ✓ IEA collaborations
  - ✓ Microgrid R&D Symposium series
  - ✓ Next Microgrid meeting: December 2006

Conclusion

Encourage multidisciplinary R&D collaboration in technology research, development, demonstration:

- Cost effectiveness through shared knowledge on early stage demonstration projects
- More effective communication of results and opportunities to decision makers and stakeholders (government, regulators,policy advisors)

* * Formalize international Microgrid R&D collaboration