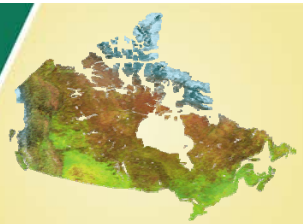


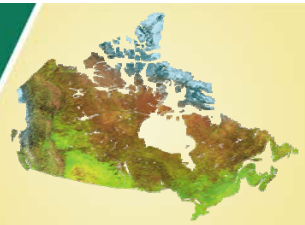
IEEE 1547.4 Guideline for Intentional Islanding of Distributed Generation and BC Hydro's Planned Islanding Experience

Chad Abbey[1] Susan Tang[2]

1 – Natural Resources Canada - CETC-Varennes

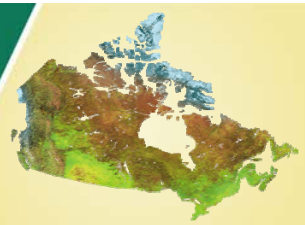
2 – BC Hydro

Overview



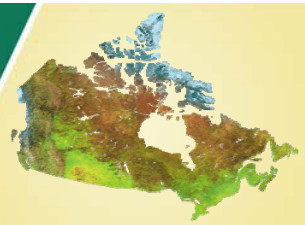
- Canadian microgrid research
- IEEE 1547.4
  - History
  - Document overview
  - Technical issues
- BC Hydro planned islanding
  - Islanding strategy
  - Boston Bar case study
- Summary

General



- History
  - IEEE 1547.x series – IEEE 1547.4
  - Meetings: biannual meetings since August 2004.
  - Structure of document defined
  - Content is being integrated
- Next Meeting
  - Aug. 2006 – Las Vegas
- Project end date
  - Guide scheduled to be balloted and approved by December 2007
- Chair: Ben Kroposki, National Renewable Energy Laboratory (NREL)

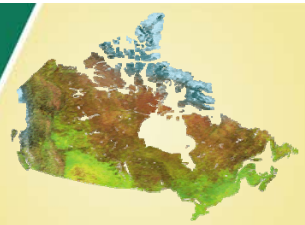
Document content



1) Overview
2) References
3) Definitions and Acronyms
4) Electrical System Characteristics
5) Functionality of the DR Island System
6) Design and Integration of DR Island Systems
7) Operation and Management of DR Island Systems

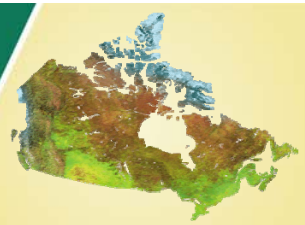
- Appendices
  - Bibliography
  - Case studies
  - Short circuit calculations

DR island functionality



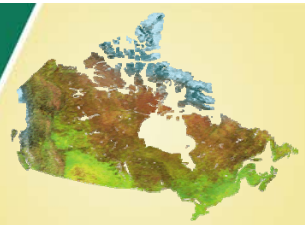
- EPS connected mode (normal parallel operation)
- Transition mode
- Island mode
  - Load and generation management
  - Voltage and frequency control
  - DR control
  - Stability – steady-state dynamic stability
  - Protection issues – coordination, out-of phase reclosing, configuration
  - Cold load pickup
  - Monitoring and communication
- Reconnection mode

Design and integration



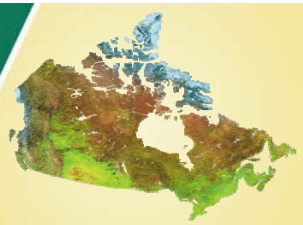
- Types
- Engineering considerations
- EPS planning
  - Studies – compatibility, load flow, short circuit studies
  - Operating practices
  - Interferance of parallel operation settings – anti-islanding, under / over frequency and voltage

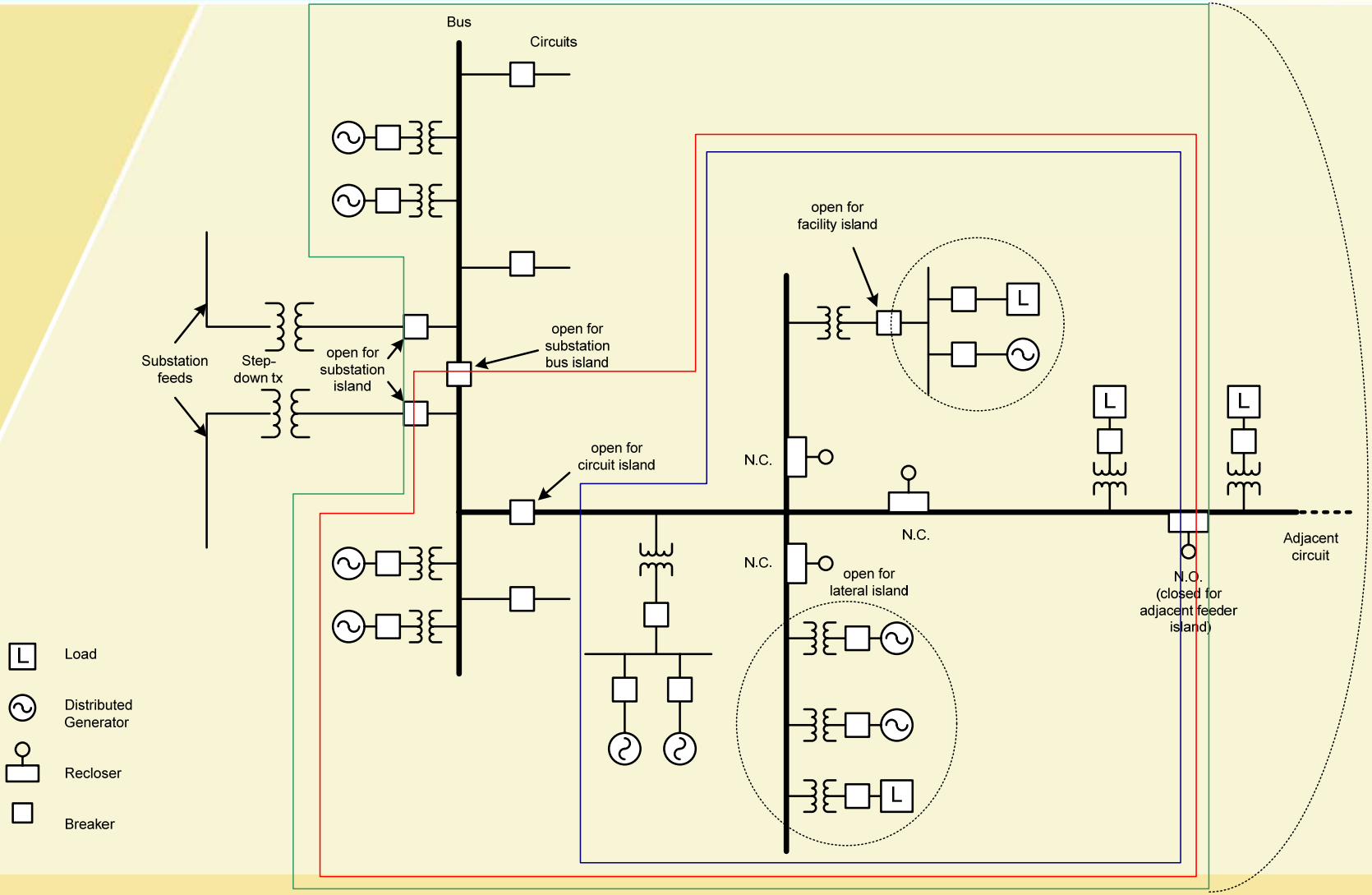
Operation and Management



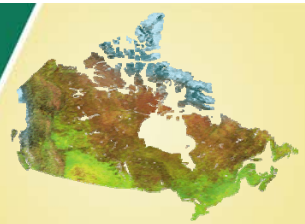
- Power dispatch
  - Central dispatch control
  - Distributed dispatch
- Communication and information exchange
- Real time operation considerations
- Time length of operation

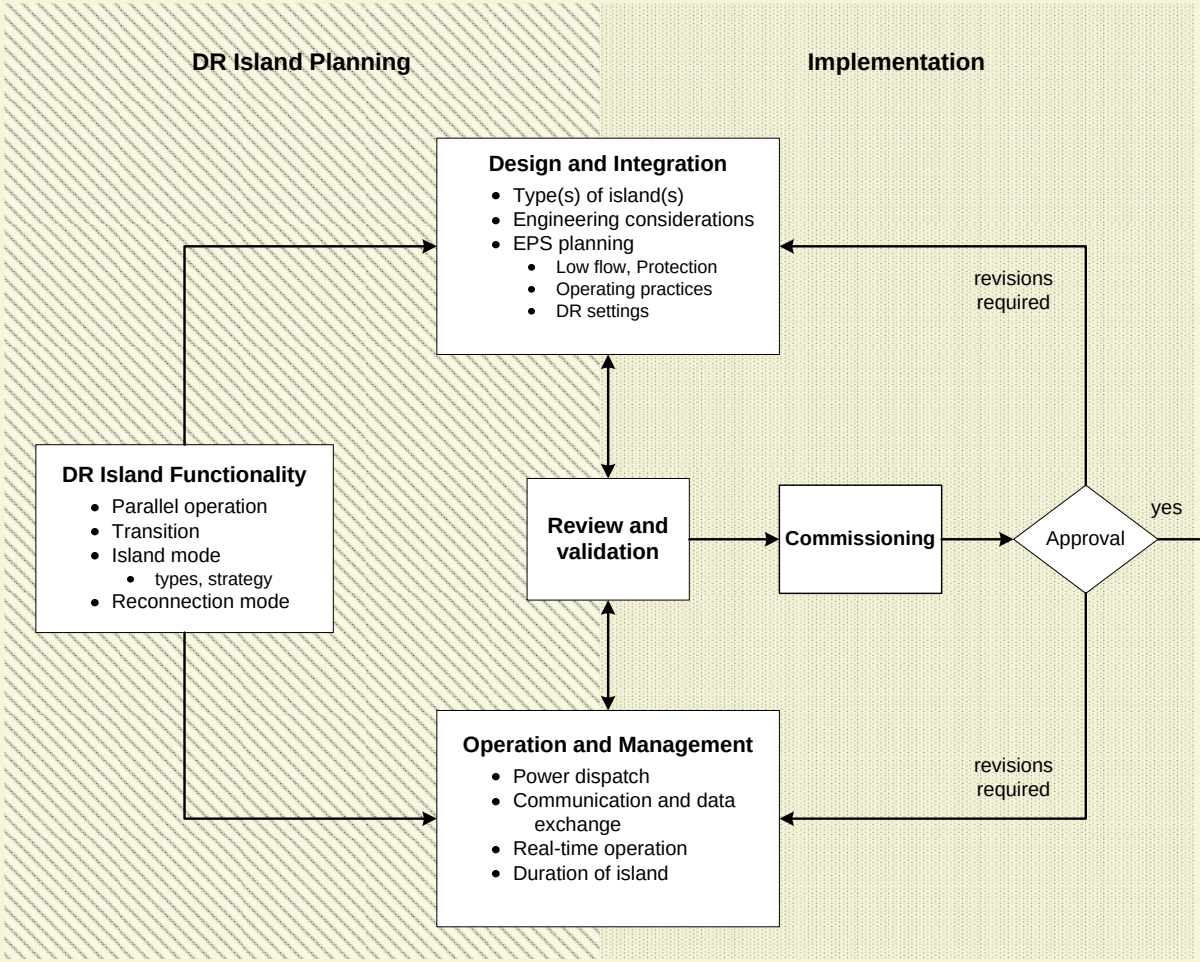
DR islands



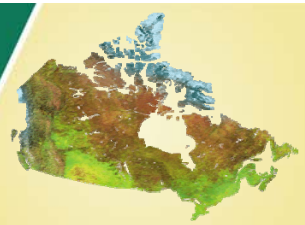

Bus
Circuits
Substation feeds
Step-down tx
open for substation island
open for substation bus island
open for facility island
open for circuit island
N.C.
N.C.
N.C.
open for lateral island
N.O. (closed for adjacent feeder island)
Adjacent circuit
L
Load
Distributed Generator
Recloser
Breaker

Design process



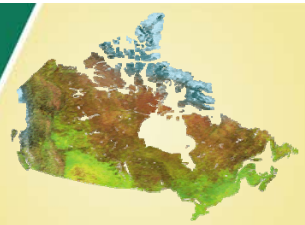


BC Hydro – planned islanding



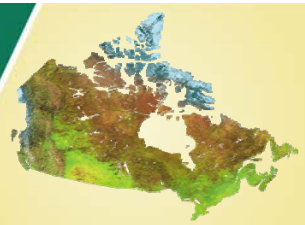
- Reliability concern
  - D customer reliability was below customer expectations
  - If a power generator (PG) islands BCH loads on same or nearby feeder – reliability improvement
    - Transmission supply is unsecure – single radial supply
    - Feeder is long and subject to frequent outages – trees, storms, motor vehicles
- Islanding study
  - Inadvertent islanding & planned islanding of BCH customer load
  - the island is all or part of a distribution feeder
  - the island excludes the distribution substation LV bus and the substation transmission supply

Islanding study



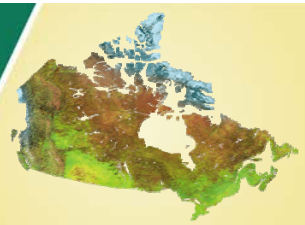
- Existing PG Interconnection Requirements
  - Review existing BCH PG Interconnection Requirements for treatment of inadvertent islanding
- System Reliability
  - Determine criteria for reliability impact under inadvertent islanding, planned islanding, future planned islanding
- Power Quality
  - Define PQ considerations for frequency & V variations, low fault levels, harmonics, etc
- BC Hydro System Requirements
  - Define requirements on BCH side for PG planned islanding, e.g. telecom, P&C, with incremental costs

Islanding study



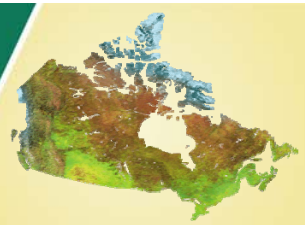
- Power Generator System Requirements
  - prime mover & generator
  - exciter, governor & AVR
  - generator lag/lead power factor rating
  - load follow capability
  - protection & coordination requirements
  - black start capability
  - Commissioning tests for V & frequency performance in grid connect, island and dead-load pickup
  - costs for added requirements

Islanding study



- Operation and Safety
  - Define Area Control Centre & line crew requirements for islanding operation, e.g.
  - Added PG monitoring at Area Control Centre
  - Line crew training
  - Local Operating Order
  - Safety issues for line crews, tree trimmers & substation personnel

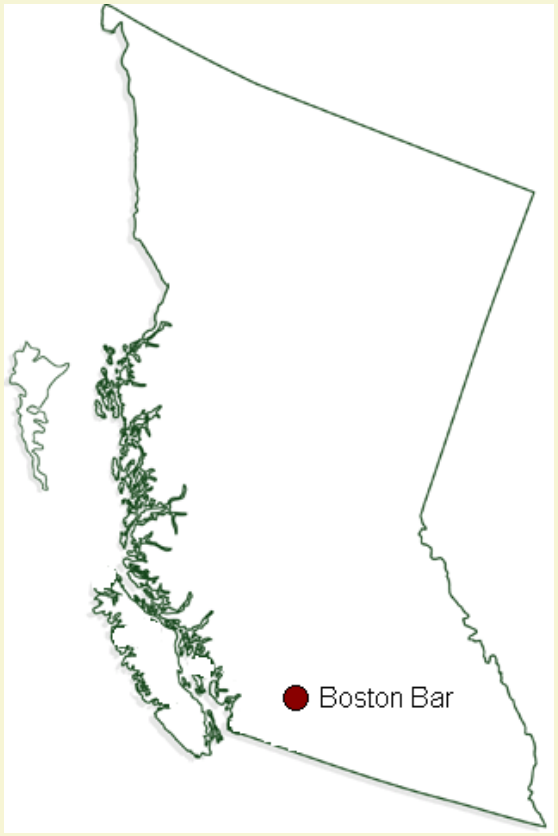
Islanding study



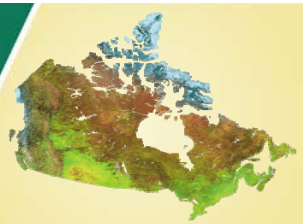
- Commercial
  - Define commercial terms/conditions & economic principles for PG planned islanding
- Economic Analysis of Investment Alternatives
  - Perform cost comparisons on 3 cases:
    - short outage on urban distribution feeder
    - short outage on rural distribution feeder
    - long outage on rural distribution feeder

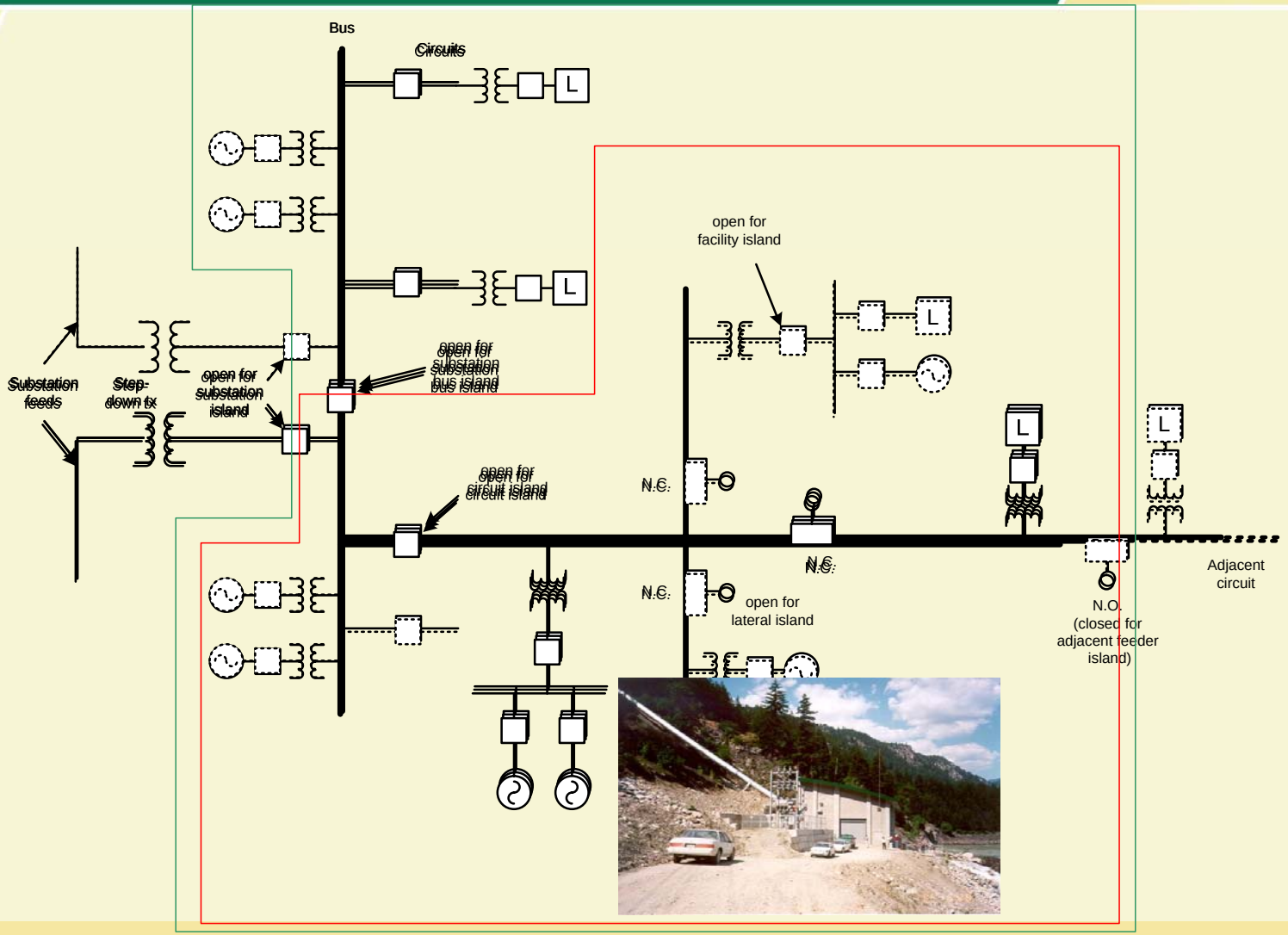
Case study - Boston Bar Hydro

- Run-of-river hydro - April 1995
  - 200 km NE of Vancouver
  - 25 kV feeder
  - 3.0 MVA peak load
- Generators:
  - 2 x 3.45 MW (8.6 MVA)
  - 4.16 kV
  - IPP remote operator
- Agreement with IPP
  - $44/MWh in 1995
  - Bonus for islanding

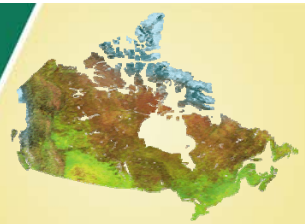


System configuration



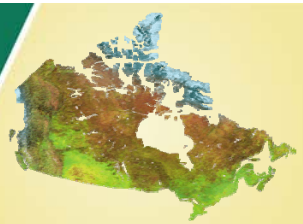


Lessons learned



- PGs of interest for feeder planned islanding are likely:
  - rated 3-10 MVA
  - new sites
  - MVA rated > 2x peak load - to hold load on opening of substn feeder CB & for dead-load pickup IPP
- Retrofitting IPPs - not likely economic
- Spending $ to rehabilitate an existing IPP during a BCH supply emergency is fruitless
  - (Valemount 138 kV line burned down in Aug 2003)
- Incremental capital cost
  - Expected to be small for quality designs & quality equipment

Comparison

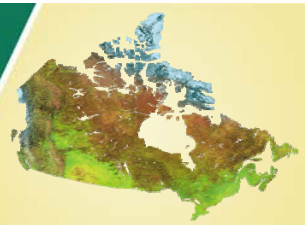


	DR island functionality	Parallel	Transition	Island	Facility	Lateral	Circuit	Substation	Adjacent feeder	Reconnection mode	Design and integration	Types of islands	DR - number and type	DSM	Storage	Engineering considerations	Cold load pick-up	Blackstart capability	DR settings	Protection coordination	Operation and Management	Power dispatch	Centralized	Decentralized	Communication and data exchange	Real-time operation	Duration	Short-term	Indefinite
Facility island	1	1	2	1	✓	-	-	-	-	2	2	1	✓	-	-	2	-	✓	-	✓	2	3	-	✓	2	3	2	✓	-
Boston Bar	4	5	3	4	✓	✓	✓	✓		4	3	3	✓	-	-	4	✓	✓	✓	✓	4	3	-	✓	4	3	4	-	✓
IEEE 1547.4	5	5	5	5	✓	✓	✓	✓	✓	5	5	5	✓	✓	✓	5	✓	✓	✓	✓	5	5	✓	✓	5	5	5	✓	✓

1 3 5

Simple Moderate Complex

Summary



- Microgrids
  - Technically feasible – however – must be industry friendly
  - Structured process is required to move beyond pilot projects
- Application guide
  - Powerful tool
  - Formalize the design process
- BC Hydro
  - Canadian leader in planned islanding
  - Initiative in analysis of islanding
  - Technical assessment vs. business case