Planned Islanding and Energy Storage at BC Hydro

Workshop: International Smartgrid projects review
December 10, 2010

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Distribution Planning
T&D Asset Investment Management
BC Hydro
Agenda

- BC Hydro
- Emerging Trends
- Planned Islanding
- Islanding Assessment & Tech. Req.
- BCH Islanding Projects
- Energy Storage
- Conclusions & Future Challenges
BC Hydro

- Gov't Owned Crown Corp.
- 1.8 Million Customers
- 10 GW Domestic Peak Load
- Serves 94% of British Columbia
- Integrated G, T, & D Utility
- Aprox. 5,600 Employees
- 18,286 km transmission lines
- 225 Substations
- 1,300 Feeders
  - Overhead 48,000 km
  - Underground 8,500 km
- Voltages
  - D: 12, 25 kV
  - T: 60kV-500kV

F2010 Normalized Reliability

- SAIFI=1.52 Target = 1.27
- CAIDI=2.28 hrs Target = 2.15 hrs
- CEMI>=4 =13% Target = 8.5%

Two-Step Residential Rate

- Step 1 (up to 1,350 kWh)  5.91 cents/kWh
- Step 2 (> 1,350 kWh)     8.27 cents/kWh
- Calculated per billing cycle (typically 2 months)
BC Hydro’s business environment

- Ageing utility infrastructure ➔ reliability
- Changing demographics ➔ knowledge retirement
- Customer expectations ➔ access to information, reliability
- Technology advances ➔ IEDs, telecom, data management, automation
- Climate change ➔ introduction of Clean Energy Act 2010 in BC
  - Vertical integration of BC Hydro with Transmission (BCTC)
  - Self-sufficient by 2016
  - Reduce future incremental demand by 66% through DSM
  - Meet remaining demand through 93% clean or renewable
  - Encourage fuel switching to reduce GHG
  - Key projects not subject to BCUC ruling
  - Encourage economic development through Clean Technology

BC hydro
FOR GENERATIONS
Emerging Trends

- Going from Centralized Generation to Decentralized Gen.
- Distributed Generation: Customer Owned Generation
- High Penetration of DERs (multiple DGs, IPPs, PV clusters, wind farms, etc.)
- Active Network (Community Energy Storage, Planned Islanding, Microgrids)
Planned Islanding

Two approaches for islanding:

- **Current practice – Protection against islanding**
  Disconnect DG subsequent to fault or any other switching event and loss of grid, IEEE 1547

- **Planned (intentional) islanding**
  Supervised transitions to an island condition in order to allow DG continue operation and serve the local load (Ride-through – Scheduled/Black-start)
Planned Islanding

• Why “Planned” Islanding?
  • To avoid safety concerns, and power quality issues

• When Planned Islanding?
  • Source is not secure: long transmission lines, long-duration interruptions
  • Opportunity to defer capital investments for reliability improvement
  • Special levels of reliability performance required by large customers

• PG Islanding Capability
  • Is the ability of a PG to continuously supply part of the distribution system that is separated from the rest of T/D system
  • Electric supply must be safe, controlled, reliable, and provide acceptable power quality (V, Hz)
PG Islanding Assessment

• Feasibility of PG Islanding:
  • PG islanding capability
  • Cyclic generation output
    PG output > feeder/area peak load (>4 months)
  • Planned islanding strategy
    Ride-through vs. black-start
  • Significant reliability improvement (SAIDI)
  • No power quality issues
  • Reasonable system upgrades and costs
  • No operation and safety concerns
  • Special commercial, or contractual considerations
PGs Technical Requirements

• “Distribution Power Generator Islanding Guidelines”, BC Hydro, June 2006
  • Load following capabilities
  • Generators with broader VAR control (power factor $\pm 0.8$)
  • Fast acting speed governor and exciter
  • Inertia and controls to pick up dead-feeder load
  • Black-start capability (scheduled islanding)
  • PG with sufficient excitation current to allow fault detection
  • Dual overcurrent protection settings (for parallel and islanded operation)
  • Capability to maintain power quality (Machines with large inrush current or cyclic loads)
  • Operating data/status telemetry (no SCADA)
BCH Upgrades & Requirements

- Feeder/area load > PG MVA rating/output ➞ if not, feeder sectionalization plan required
- Bi-directional line voltage regulators and fault detection elements
- Voltage supervision at feeder substation CB (out-of-phase reclosing)
- Reclosers upgrade (disable/delay reclosing function, replace to electronic)
- Line fuses upgrade (replace/relocate/remove)
- PG real-time operating data/status at Control Centre and inter-operator communications
- PG commissioning tests for both grid-connected and islanded mode
- System impact study (steady-state and dynamic) for islanding operation, and DOO
## BC Hydro’s Islanding Projects

<table>
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<tr>
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<tbody>
<tr>
<td>Anti-islanding P&amp;C</td>
<td>Single DG islanding under operator control</td>
<td>Manual switching</td>
<td>Remote control</td>
<td>DER automated islanding</td>
<td>Fully automated islanding with multiple DERs (Microgrids)</td>
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<tr>
<td>DER Installations</td>
<td></td>
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<td></td>
<td>Planned islanding guidelines</td>
</tr>
<tr>
<td></td>
<td>2x8 MW IPP hydro plant</td>
<td>6 MW IPP hydro plant</td>
<td>10 MW IPP hydro plant</td>
<td>7.5 MW IPP hydro plant</td>
<td>Golden Battery Storage Project</td>
</tr>
<tr>
<td>Off Grid</td>
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<td>HARP: Integration of hydro plant, fuel cell, diesel, control systems and flow battery</td>
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**Intelligent microgrid research at BCIT**
BC Hydro – Project 2, 2007

- 6 MW run-of-river IPP connected to a 25 kV feeder
- Outages > 6 hours, from May to Sept. & affect 1,000 customers
- Black-start, manual switching
BC Hydro - Project 2, 2007

- Islanding study and test results:
  - Technical study performed by IPP consultant and BCH
  - Load-bank used to test PG's islanding capability.
  - Load following and load pick-up capability
  - EMTP simulations confirmed test results
  - Load blocks (500-800kW) may be picked up by PG
  - Installation of switches at BCH feeder. Load-isolation switching points
  - BCH prepared PIR and DOO which includes an islanding plan

![MACHINE SPEED RESPONSE TO A 500 kW LOAD STEP](chart.png)
BC Hydro – Project 2, 2007

- Major Achievements:
  - BCH successfully contracted an agreement with an existing IPP to provide emergency back-up
  - Very few modifications and upgrades were required to implement the project
  - One successful islanded operation occurred in 2008 (6hrs, 1000 customers)
  - Significant customer reliability improvement (~50%)

<table>
<thead>
<tr>
<th>BC Hydro Feeder</th>
<th>SAIDI</th>
<th>SAIFI</th>
<th>CAIDI</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008</td>
<td>3.77</td>
<td>5.05</td>
<td>0.75</td>
</tr>
<tr>
<td>2007</td>
<td>7.20</td>
<td>6.65</td>
<td>1.08</td>
</tr>
<tr>
<td>2006</td>
<td>34.16</td>
<td>8.87</td>
<td>3.85</td>
</tr>
<tr>
<td>2005</td>
<td>4.30</td>
<td>4.06</td>
<td>1.06</td>
</tr>
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BC Hydro – Project 3, 2010

- 10 MW run-of-river IPP connected to a 25 kV feeder
- Large industrial customer (~2 MW + 1 MW BCH customers)
- Black-start & ride-through, automated switching (reclosers)
BC Hydro – Project 3, 2010

- Studies done in CYMDIST/CYMSTAB

**Generator Speed**

**Bus Voltage at TH Efeeder - 1.04 PU**
**Voltage:**

<table>
<thead>
<tr>
<th>% of Nominal Voltage</th>
<th>Clearing Time Islanding Mode</th>
<th>Clearing Time Normal Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>V &lt; 50%</td>
<td>0.16 sec</td>
<td>0.16 sec</td>
</tr>
<tr>
<td>50% &lt; V &lt; 85%</td>
<td>5.0 sec</td>
<td>2.0 sec</td>
</tr>
<tr>
<td>85% &lt; V &lt; 90%</td>
<td>60.0 sec</td>
<td>2.0 sec</td>
</tr>
<tr>
<td>90% &lt; V &lt; 106%</td>
<td>Normal Operation</td>
<td>Normal Operation</td>
</tr>
<tr>
<td>106% &lt; V &lt; 110%</td>
<td>60.0 sec</td>
<td>1.0 sec</td>
</tr>
<tr>
<td>106% &lt; V &lt; 120%</td>
<td>5.0 sec</td>
<td>1.0 sec</td>
</tr>
<tr>
<td>V &gt;= 120%</td>
<td>0.16 sec</td>
<td>0.16 sec</td>
</tr>
</tbody>
</table>

**Frequency:**

<table>
<thead>
<tr>
<th>Under Frequency Limit</th>
<th>Minimum Time Islanding Mode</th>
<th>Minimum Time Normal Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>60.0-60.5 Hz</td>
<td>Continuous</td>
<td>Continuous</td>
</tr>
<tr>
<td>60.6-61.5 Hz</td>
<td>10 minute</td>
<td>3 minutes</td>
</tr>
<tr>
<td>61.6-61.7 Hz</td>
<td>1 minute</td>
<td>30 seconds</td>
</tr>
<tr>
<td>61.8-62.5 Hz</td>
<td>1 minute</td>
<td>Instantaneous</td>
</tr>
<tr>
<td>62.6-67.0 Hz</td>
<td>10 seconds</td>
<td>Instantaneous</td>
</tr>
<tr>
<td>Greater than 67.0 Hz</td>
<td>Instantaneous</td>
<td>Instantaneous</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Over Frequency Limit</th>
<th>Minimum Time Islanding Mode</th>
<th>Minimum Time Normal Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>60.0-59.5 Hz</td>
<td>Continuous</td>
<td>Continuous</td>
</tr>
<tr>
<td>59.4-58.5 Hz</td>
<td>10 minute</td>
<td>3 minutes</td>
</tr>
<tr>
<td>58.4-57.9 Hz</td>
<td>1 minute</td>
<td>30 seconds</td>
</tr>
<tr>
<td>57.8-57.5 Hz</td>
<td>1 minute</td>
<td>7.5 seconds</td>
</tr>
<tr>
<td>57.4-56.9 Hz</td>
<td>10 seconds</td>
<td>45 cycles</td>
</tr>
<tr>
<td>56.8-56.5 Hz</td>
<td>10 seconds</td>
<td>7.2 cycles</td>
</tr>
<tr>
<td>56.4-53.0 Hz</td>
<td>10 seconds</td>
<td>Instantaneous</td>
</tr>
<tr>
<td>Less than 53.0 Hz</td>
<td>Instantaneous</td>
<td>Instantaneous</td>
</tr>
</tbody>
</table>

- Special PQ requirements for islanding conditions: V, f, harmonics
TYS de-tuned their PLC which solved the oscillation problem.
BC Hydro – Energy Storage Project

- 2x1MW ESS in Golden/Field, 25 kV DS
- Constraint substation (peak shaving) and reliability (islanding)
- Contribution from NRCan through CEF
- ISD Sept. 2011
• Peak shaving to mitigate capacity risk at Golden substation, includes demand response (~2 MW).

• Islanding to relieve poor reliability metrics at Field (~ 500kW)
BC Hydro – Energy Storage Project

Business Case Development

• Major costs:
  • Battery units, Integration (PCS), P&C, Telecom

• Major benefits
  • Financial
    • Savings of from deferred transformer upgrade costs
    • Avoided cost of 2 MW equivalent diesel generation for peak shaving and outage support
    • Leverage from Clean Energy Fund
  • Non-financial
    • Improve reliability for the community of Field (eliminate estimated 80% of outages)
    • Mitigate risk of demand exceeding capacity at Golden substation
    • Avoid GHG emissions from use of emergency diesel generator back-up
  • Long-term potential
    • Further benefit from deferred upgrade costs by relocating energy storage to another capacity constrained substation
    • Gain critical knowledge in the use of storage technologies: for purposes of peak shaving, reliability, integrating renewables, and managing multiple distributed resources.
BC Hydro – Energy Storage Project

Procurement Process

- **Battery RFP**
  - Challenging to develop a specification given the lack of experience in this area
    - Used external expertise, Quanta Technology
    - Developed the spec based on functional requirements: Peak shaving & Islanding
  - Received 5 responses with 5 different technologies
    - Lead-acid, Lithium Ion, Vanadium Flow batteries, NAS batteries, Zinc-air

- **Integrator RFP**
  - Schedule: Originally unable to post RFP for systems integrator until the battery contract is complete.
    - One proponent

- **Lessons learned**
BC Hydro – Energy Storage Project

Project Challenges

• Non-technical
  • Site selection: geotechnical instability, flooding risk, footprint
  • Parks Canada property
  • Community relationship and engagement
  • Whether conditions: extreme winter conditions challenge battery technologies
  • Environmental permitting
  • Internal (BHC) change management

• Technical
  • Telecommunications: remote location
  • Lack of standards: safety
  • P&C, difficult in a long feeder with several reclosers. Low fault contribution from the battery PCS
  • Smooth remote restoration (re-synch) from islanding operation
  • Batteries heating and cooling
Project Outcomes

- **Performance measurement**
  - Project implementation metrics
  - Load profile data at batteries and Golden substation
  - Battery metrics: Efficiency, charge/discharge profiles
  - Reliability metrics for Field: CAIDI, SAIFI

- **Deliverables**
  - BC Hydro Storage Deployment and Integration Guideline 2013
  - BC Hydro Case Study Report 2014
  - Knowledge dissemination

- **Potential project extensions**
  - Demand response pilot programs
  - Integration of renewable distributed generation
  - Integration of energy management systems
Conclusion and Future Challenges

- Planned Islanding for Reliability
  - DGs and IPPs
- Advanced Planned Islanding
  - Smartgrid (Automated) solutions
  - Several DER/Microgrid
- Utility-scale Energy Storage
  - Islanded operation for reliability
  - Peak shaving
  - Integration of renewable generation
- Planned Islanding guidelines/IEEE1547.4

BC hydro
FOR GENERATIONS
Thanks!!

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