Microgrid R&D at BC Hydro
Golden Energy Storage Project

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Helen Whittaker MBA, PMP
Office Chief Technology Officer
e: helen.whittaker@bchydro.com

Jaime Peralta MSc, PEng
Distribution Planning
e: jaime.peralta@bchydro.com
BC Hydro objectives

- Conservation targets
- EV and clean energy targets
- Reliability and power quality
- Demand side mgmt
- Distributed and self-generation
- Peak shifting
- DER integration
- Power control systems
- Telecom & remote control
- Automated devices
- Islanding and microgrid
**BC Hydro microgrid R&D**

<table>
<thead>
<tr>
<th>Year</th>
<th>1995</th>
<th>2000</th>
<th>2005</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anti-islanding P&amp;C</td>
<td>Single DG islanding under operator control</td>
<td>Single DER islanding automated sensing and switching</td>
<td>Fully automated islanding capability with multiple DERs</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Manual switching</td>
<td>Remote control switching</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Grid Installations**

- **1995**: Planned islanding guidelines
- **2000**: 3-8 MW IPP hydro plant
- **2005**: 2-3 MW IPP hydro plant
- **2010**: 10 MVA IPP hydro plant, 7.5 MVA IPP hydro plant, Golden Battery Storage Project

**Off Grid**

- **HARP**: Integration of hydro plant, fuel cell, diesel, control systems and flow battery

**Intelligent microgrid research at BCIT**
Golden substation and feeder network

Substation in Golden

Field

km distance from substation
GDN 12F51 6.2 MVA
GDN 25F51 3.5 MVA
GDN 25F52 3.6 MVA
GDN 25F52 10.4 MVA

Legend
Layer:
Network color
Colors:
GDN_2551
GDN_2552
GDN_1251
GDN_1252
Line Types:
A-UG
B-UG
C-UG
D-UG
E-UG
F-UG
G-UG
H-UG
I-UG
J-UG
K-UG
L-UG
M-UG
N-UG
O-UG
P-UG
Q-UG
R-UG
S-UG
T-UG
U-UG
V-UG
W-UG
X-UG
Y-UG
Z-UG
Symbol:
Load
Fusing (C)
Relay (C)
Switch (C)
Sectionalizer (C)
Recliner (C)
Fuser (C)
Switch (C)
Shunt Capacitor
Regulator

FOR GENERATIONS
Golden substation peak load profile

GDN Peak Day Load Profile
Based on Winter 2008/2009 Data

- 2008-12-16
- Limit
- Projected F2013
- F2013 With 2x1 MVA Energy Storage
- Energy Storage Charge/Discharge
Risk mitigation against exceeding capacity

• Voltage conversion 12kV circuits to 25kV
  • Increases transformer capacity from 31.2 MVA to 36 MVA
• Columbia Valley Transmission 230kV to Kicking Horse substation
  • 69kV ring bus to Golden removes transmission capacity constraint
• Customer curtailment agreement
  • Addresses peak issues on 12F51 but not on 25 kV circuits
• Energy storage (2 MW)
• Upgrade to transformers
  • Demand expected to exceed 36 MVA by FY2015 without storage, FY2017 with storage
• Customer Standing Offer Program (SOP)
  • Potential to provide additional energy – does not address capacity
## Reliability numbers for Field

<table>
<thead>
<tr>
<th>Reliability</th>
<th>Fiscal Year</th>
<th>BC Hydro average (F2007 – F2009)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2007</td>
<td>2008</td>
</tr>
<tr>
<td>Average <strong>duration</strong> of customer interruptions</td>
<td>5.2</td>
<td>3.6</td>
</tr>
<tr>
<td>(in hours)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Major Events</td>
<td>0.8</td>
<td></td>
</tr>
<tr>
<td>Average <strong>number</strong> of interruptions per customer</td>
<td>7.1</td>
<td>10.2</td>
</tr>
<tr>
<td>Major Events</td>
<td>0.8</td>
<td></td>
</tr>
</tbody>
</table>
BC Hydro opportunity

- **Solution to near-capacity substation at Golden**
  - Proposed use of 2 x 1 MW battery storage (at Golden and Field) to bridge capacity gap prior to transmission upgrade (peak shaving)

- **Solution to poor reliability indices for Field**
  - Proposed use of 1 MW battery storage at Field and demand response to provide back-up energy source (islanding)

- **Use knowledge for future initiatives**
  - Defer capacity (transmission or generation) in other locations
  - Support for intermittent generation from renewable sources
  - Energy management of distributed energy resources
  - Alternative energy source to diesel generation as back-up
Golden substation and feeders schematic
Schematic showing point of isolation for islanding

Golden Station 25kV

Z1 (pu) = 1.78761 < 76.465975° (± 20%)
Z0 (pu) = 0.56253 < -90.000000° (± 20%)

25CRS2

Circuit 25FS2

City Center 1.3 MVA

North of Golden City Center 4.8 MVA

2.0 km mixed conductor (#2 ACSR and larger)

Local load 1.8 MVA

R 14203 Cooper Nova F6

22 km 3 φ 336.4 ASC

R 14426 Cooper Nova F6

31 km 3 φ 336.4 ASC

D Device #2
Point of isolation for islanding

1.0 km 3 φ mixed conductor
(336.4 ASC and #2 ACSR)

Field Load 550 kVA

Field Battery Storage
See Dwg SK-ENG-A121-03

Note: This sketch is a simplified representation of the circuit GDN 25FS2. Distances are approximate and loads are based on Winter 08/09 peak.
## Project challenges: Business case

- **Business case approval**
  - Based on deferred transformer upgrade and avoided cost of diesel
  - CEF award required to make case

- **Major costs**
  - Battery units
  - Integration services (PCS)
  - Protection, Control & Telecom
  - Upgrades to distribution network

- **Major benefits**
  - Immediate benefits
    - Improved reliability for the community of Field
    - Ability to mitigate exceeding capacity of substation
    - Avoided cost of diesel
    - Deferred transformer upgrade costs
  - Future benefits
    - Potential to relocate the BESS – defer future upgrade costs
    - Gain critical knowledge in the use of storage for islanding and integration of renewables
    - Storage technologies will form an integral part of BC Hydro’s future asset base for the purposes of peak shaving, integrating renewables and managing multiple distributed resources
Project challenges: Procurement

- Battery procurement
  - Challenging to develop a specification given the lack of experience in this area
    - Used external expertise
    - Developed the spec based on functional requirements
      - Peak shaving
      - Islanding
  - Posted RFP for batteries and received 5 responses with 5 different technologies
  - RFP criteria included technical specifications, references showing proof of performance, cost, safety and environmental aspects
  - Currently negotiating with lead-proponent

- Risks
  - Schedule: Unable to post RFP for systems integrator until the battery contract is complete
  - Performance: Canadian extreme winter conditions challenge battery technologies
  - Operations: Lack of safety standards
Project challenges: Site selection

• Original preferred site in Field
  • Close to load centre
  • Potential to share resources with waste water treatment plant
  • High visibility from road requiring masking
  • Limited space for building
  • Geotechnical study showed possibility of instability

• Moved to 2nd option site
  • Advantages in extra space and good geotech
  • Disadvantage in distance from load centre (about 5km)

• Environmental permitting
  • Proceeding as planned
  • Footprint increased to allow for building due to potential cold weather conditions
Project challenges: Telecom design

- Remote, mountainous location of Field
  - No microwave
  - Satellite is difficult
  - Potential to use lease line
  - PLC subject to outage
- Continuous monitoring of battery requirement
  - Lease line disadvantage if running along the same poles as the distribution line
- Local communications between PCS and isolation devices (switch)
  - Wimax or 220 radio considered
  - Proposal for fibre continuous link – concern is outage
Project challenges: Engineering design

- Protection Coordination and control of PCS and feeder switching devices
- Automation of switching sequences for islanding and re-synch
- Ensuring protection of equipments and stability of system

- Risk mitigation
  - Steady State and Dynamic simulation studies
  - Testing during commissioning
  - Use of experienced power system integrator resources
  - Lessons learned from AEP and others
Project timeline

- Business case approval
- Battery procurement
- Integrator procurement
- Environmental permitting
- Telecom design
- Engineering design
- Construction and installation
- Testing and commission
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
  - System metrics: Response time, reliability of automation

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

- Knowledge dissemination