Microgrid R&D at BC Hydro

Golden Energy Storage Project

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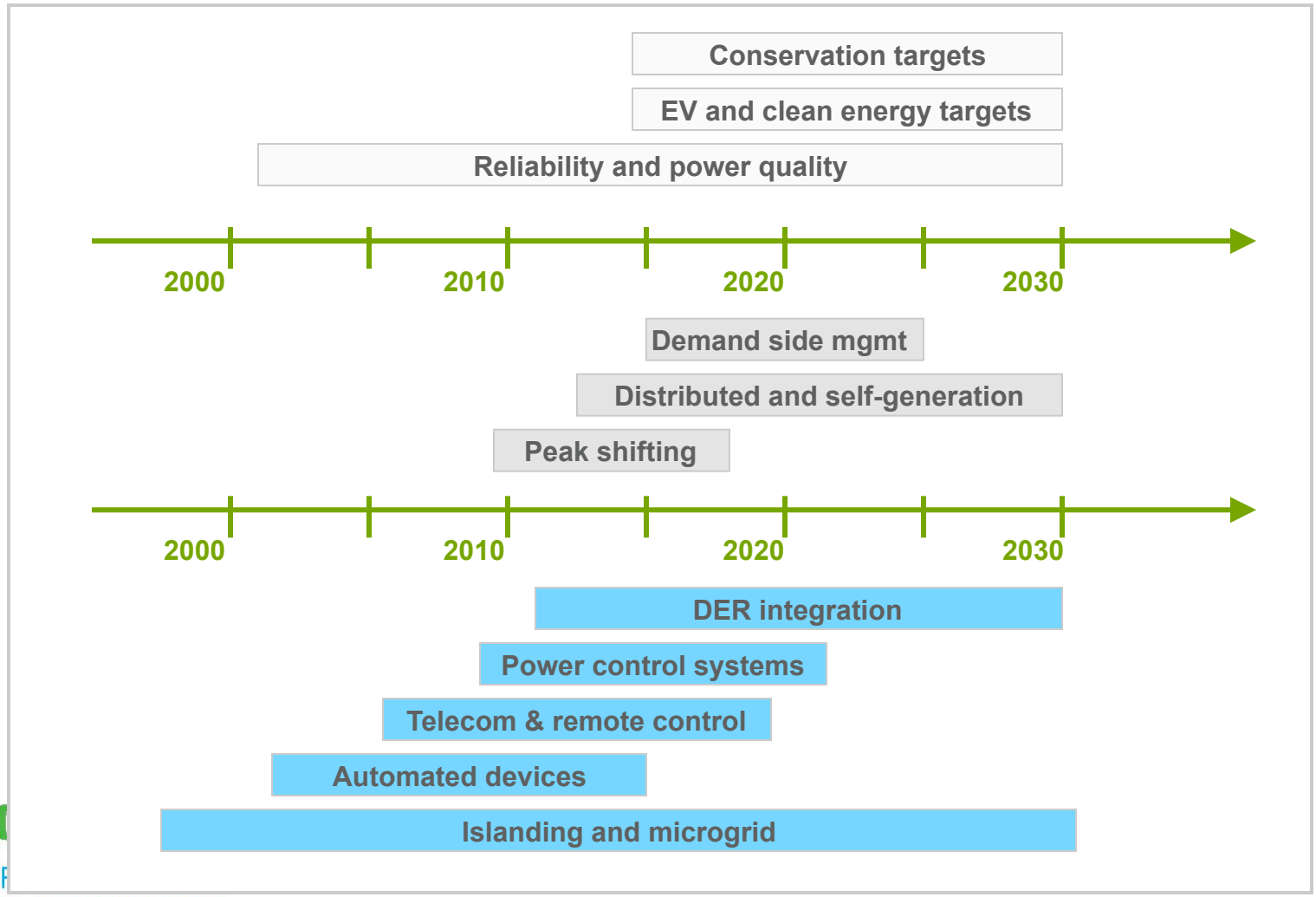
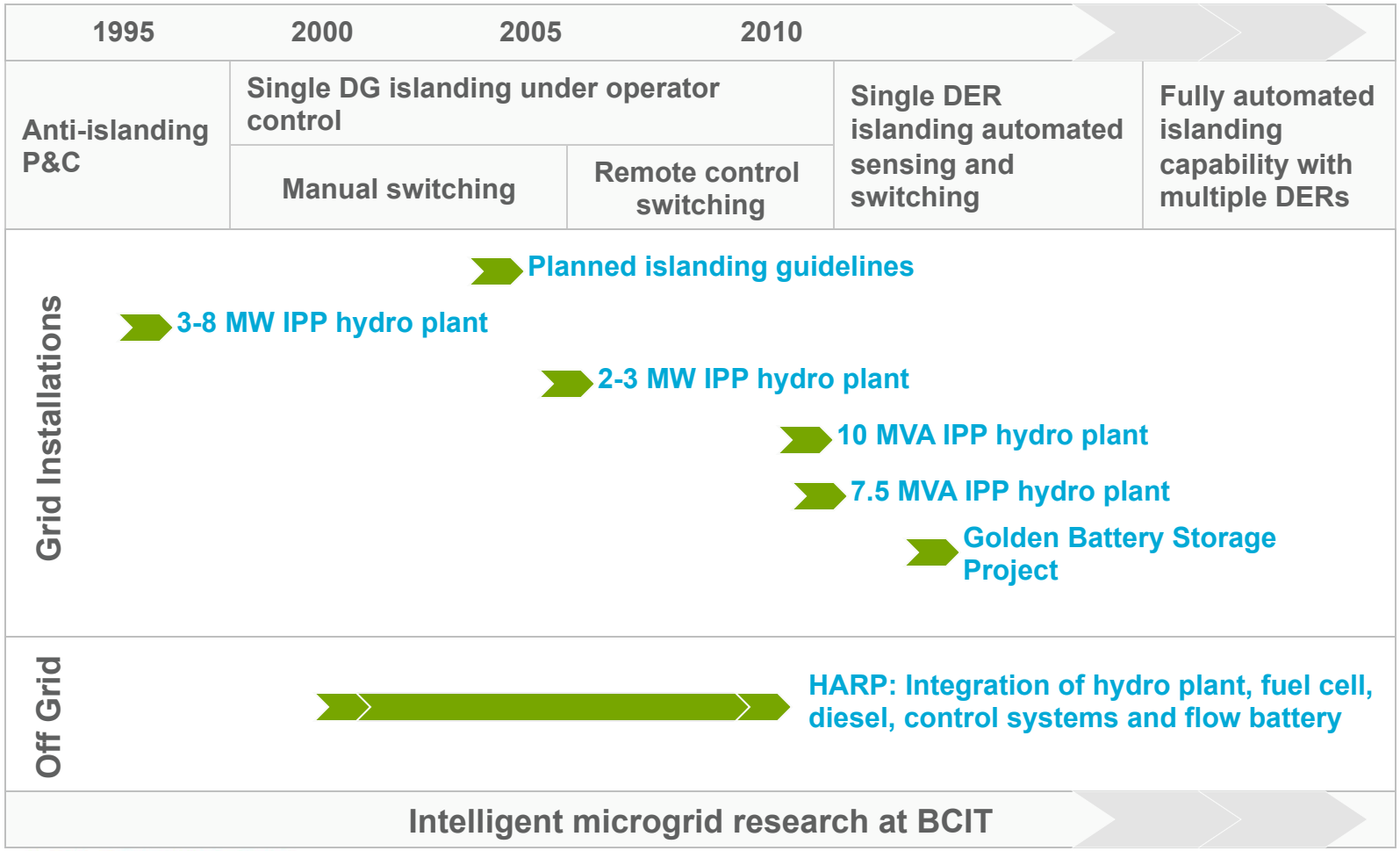
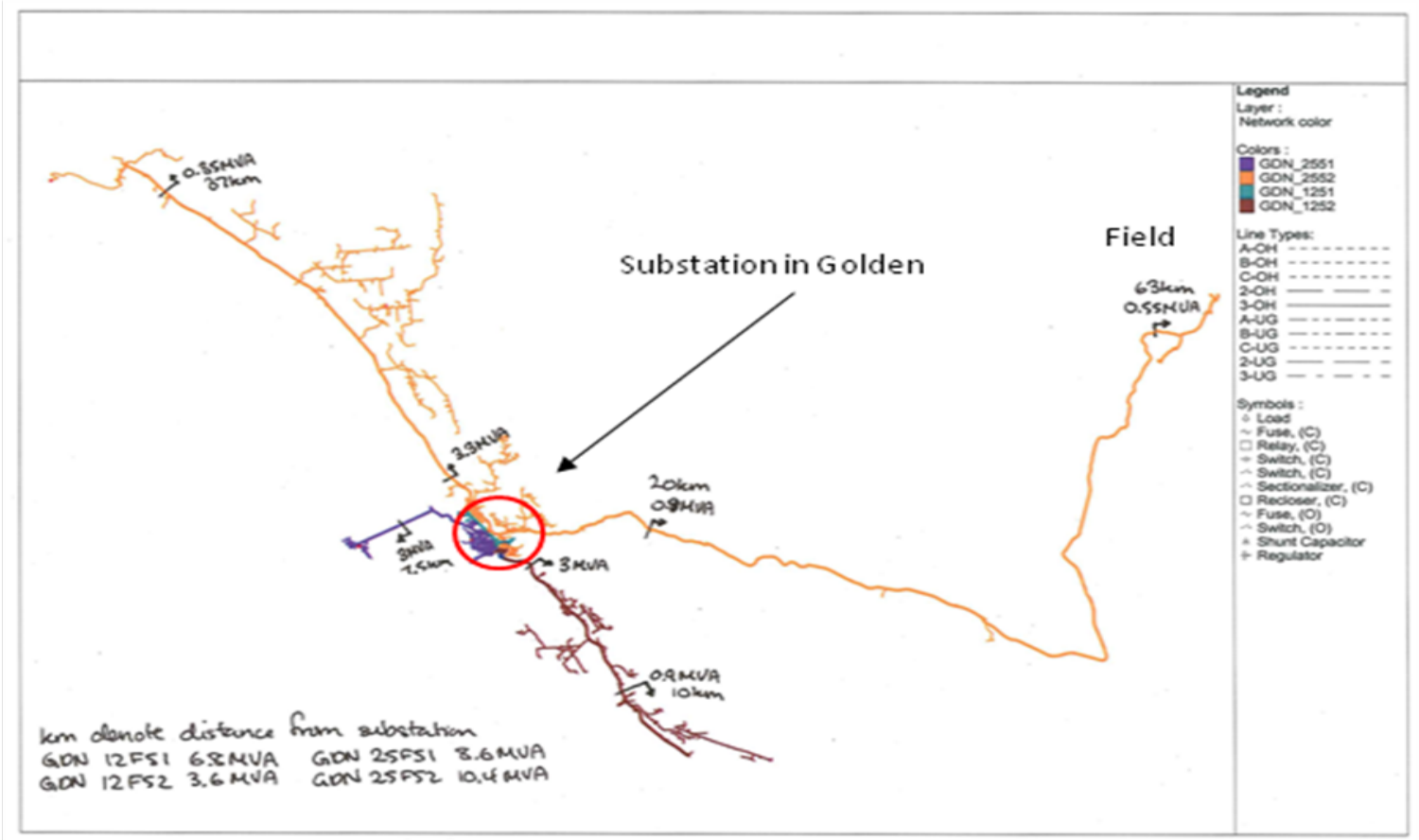
BC Hydro objectives



BC Hydro microgrid R&D



Golden substation and feeder network



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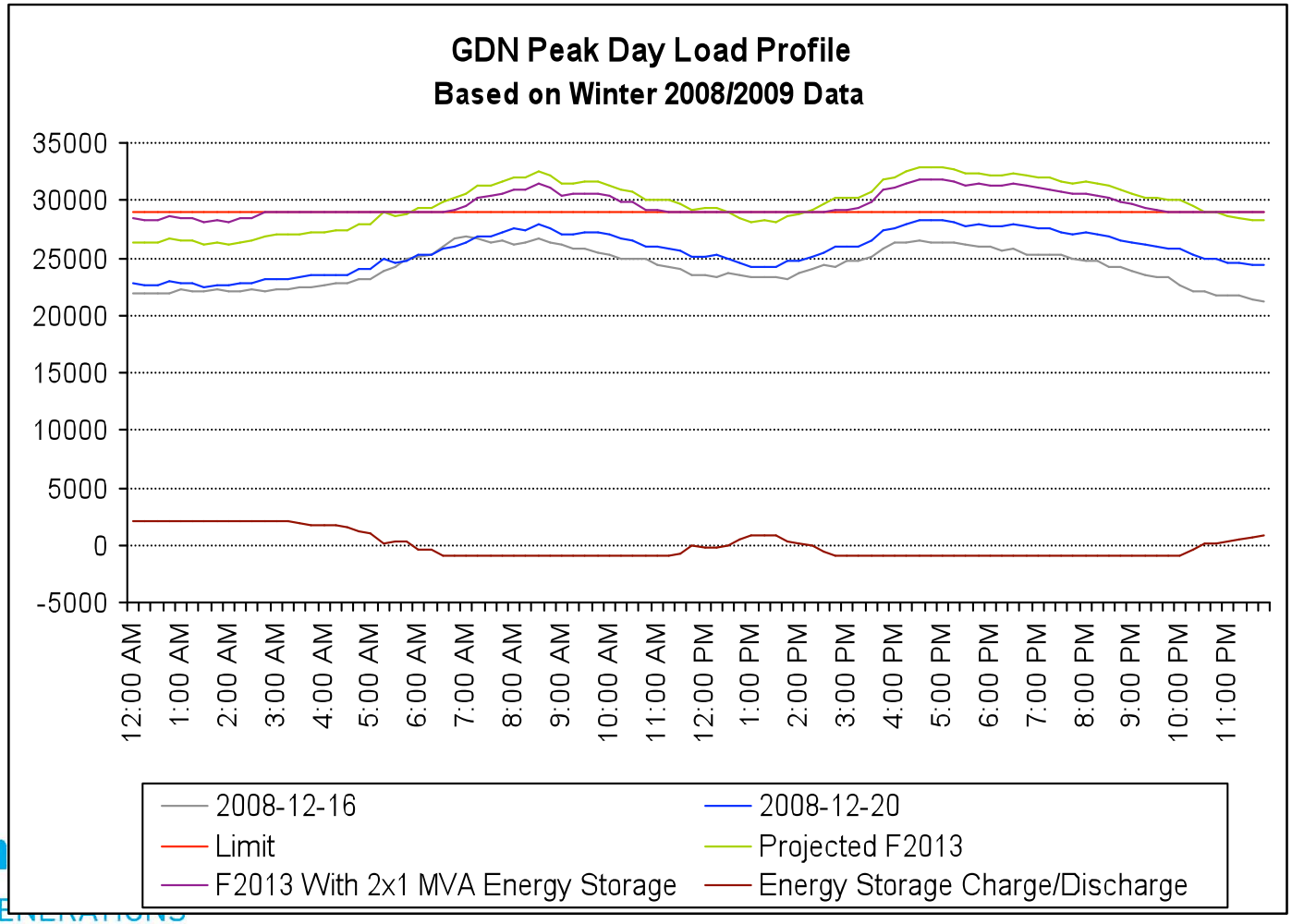
Golden substation peak load profile



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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

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Reliability numbers for Field

Reliability	Fiscal Year 2007	2008	2009	BC Hydro average (F2007 – F2009)
Average **duration** of customer interruptions (in hours)	5.2	3.6	3.3	2.29
Major Events		0.8		+0.98
Average **number** of Interruptions per customer	7.1	10.2	6.9	1.51
Major Events		0.8		+0.69

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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

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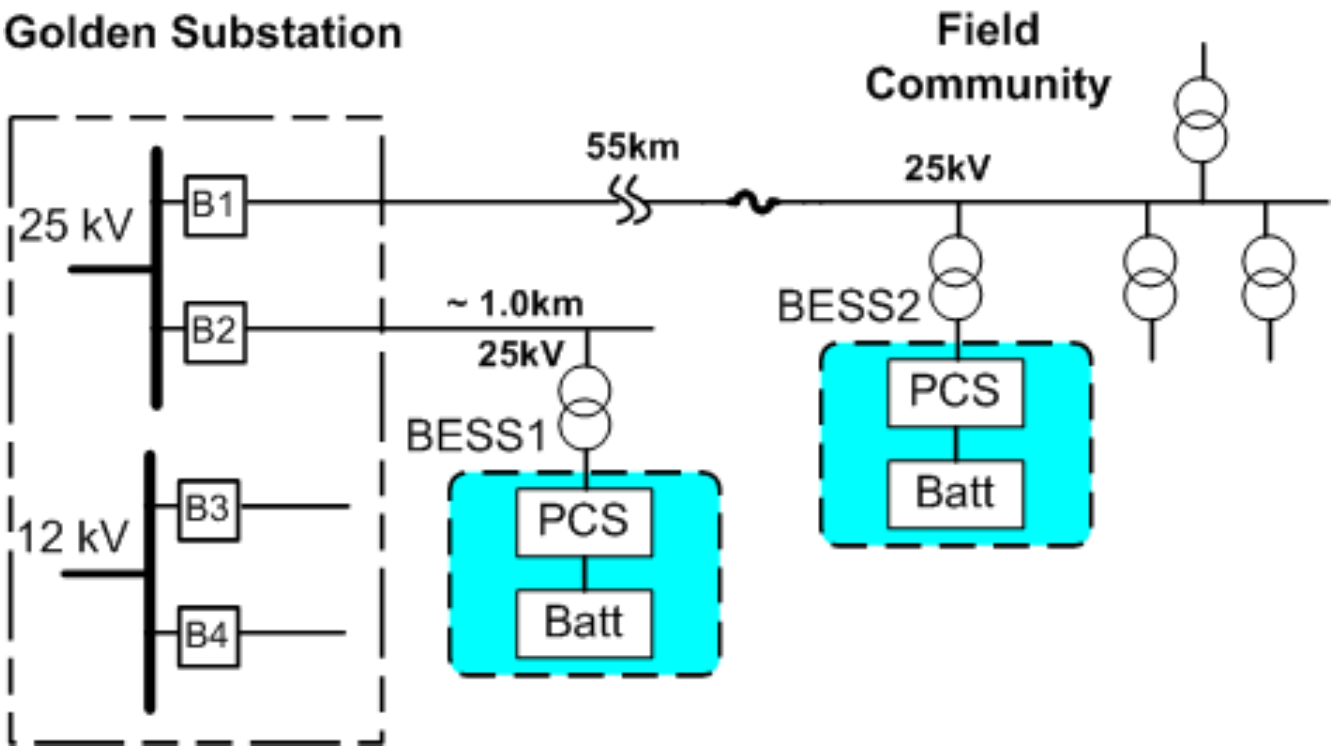
Golden substation and feeders schematic



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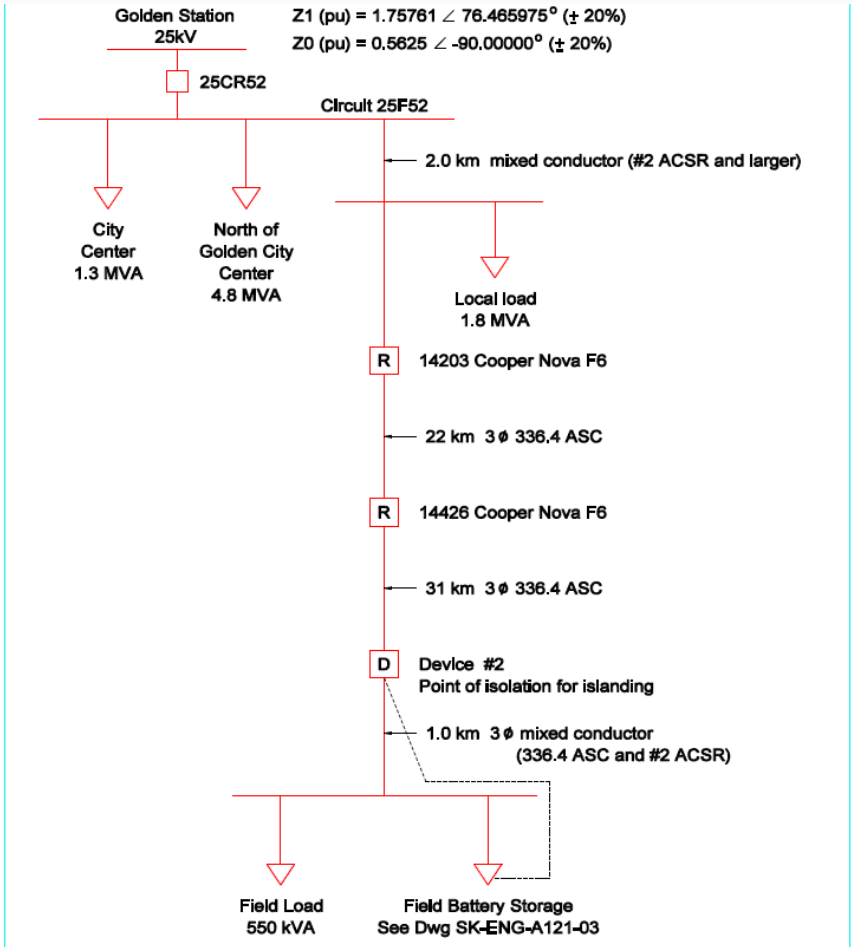
Schematic showing point of isolation for islanding



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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

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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

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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

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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

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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

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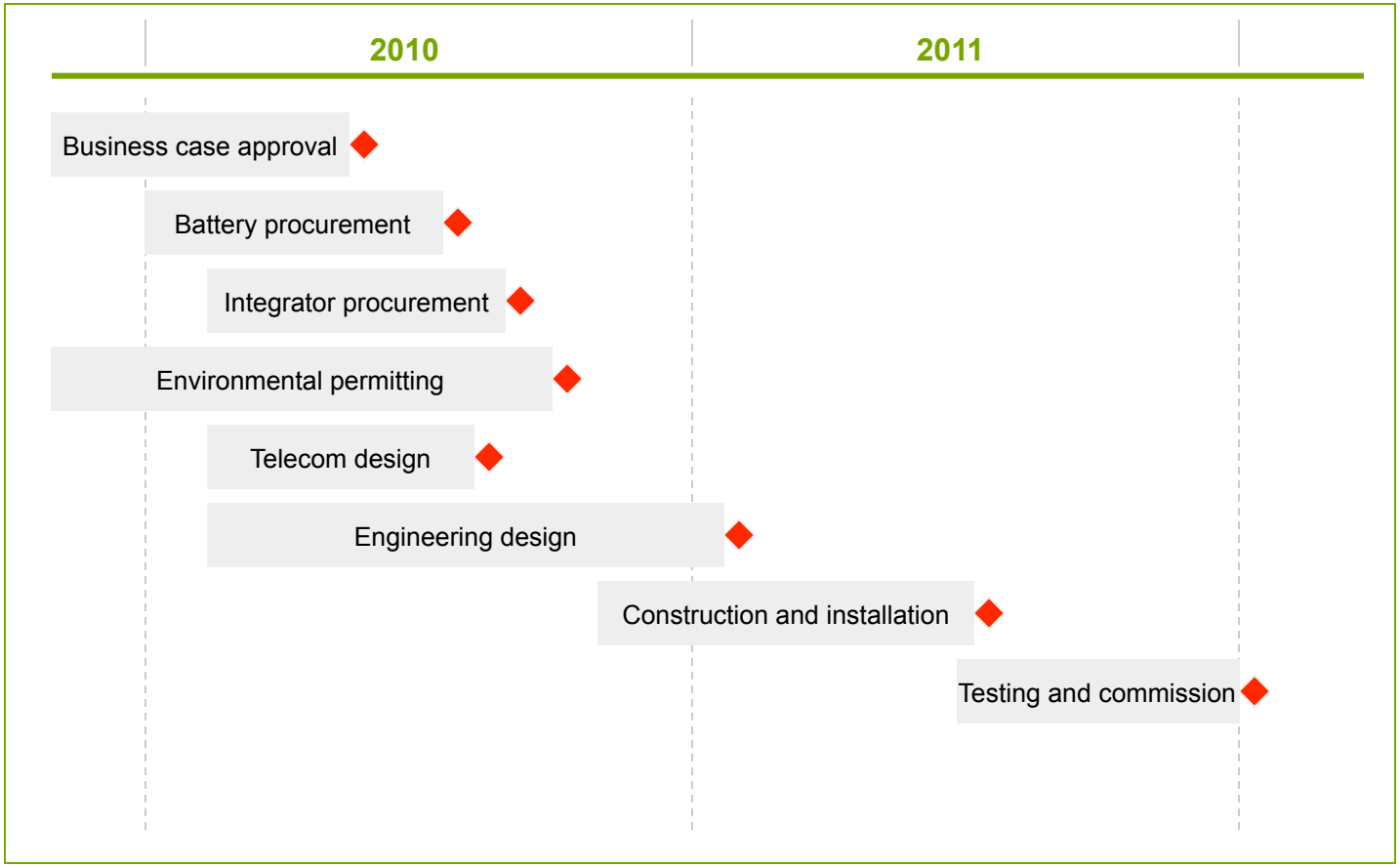
Project timeline



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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

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