Planned Islanding and Energy Storage at BC Hydro

Workshop: International Smartgrid projects review
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Agenda

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

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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

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- 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

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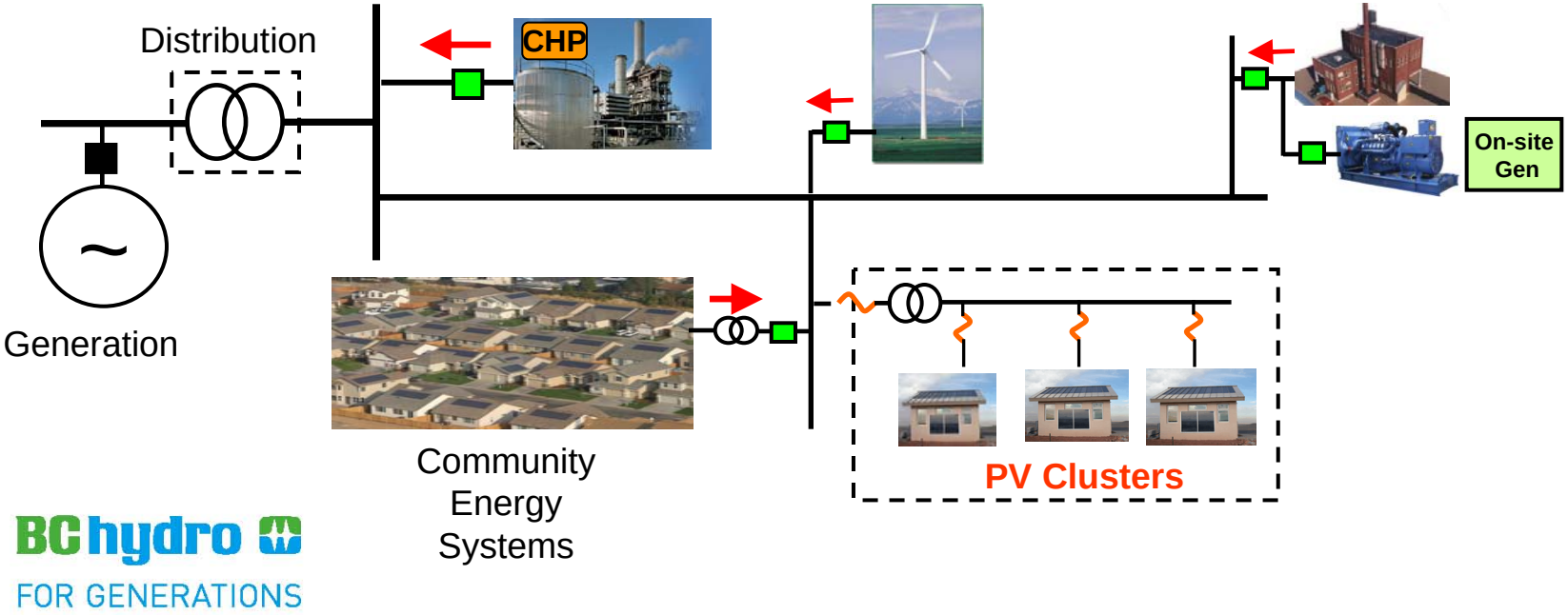
Emerging Trends

- 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)



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Planned Islanding

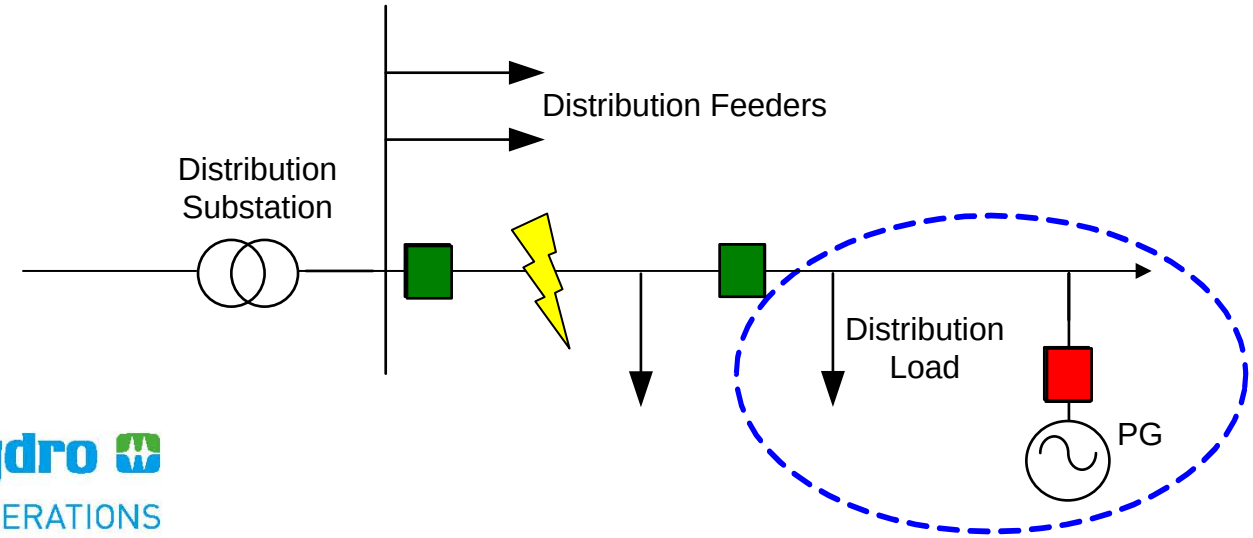
Two approaches for islanding:

- 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)



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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)

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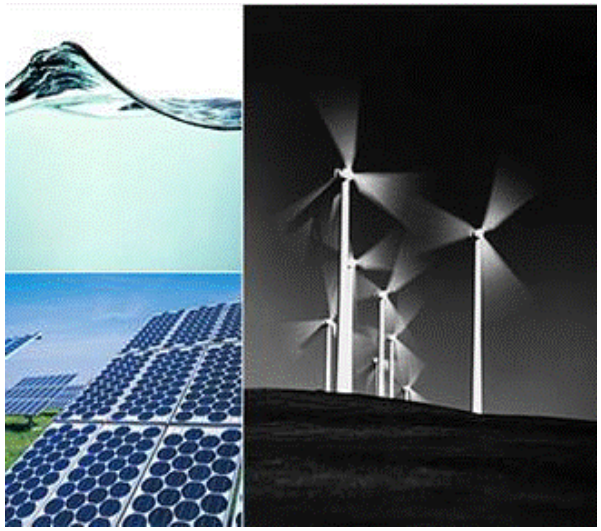
PG Islanding Assessment

- 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



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PGs Technical Requirements

- "Distribution Power Generator Islanding Guidelines", BC Hydro, June 2006
  - Load following capabilities
  - Generators with broader VAR control (power factor ±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)

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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

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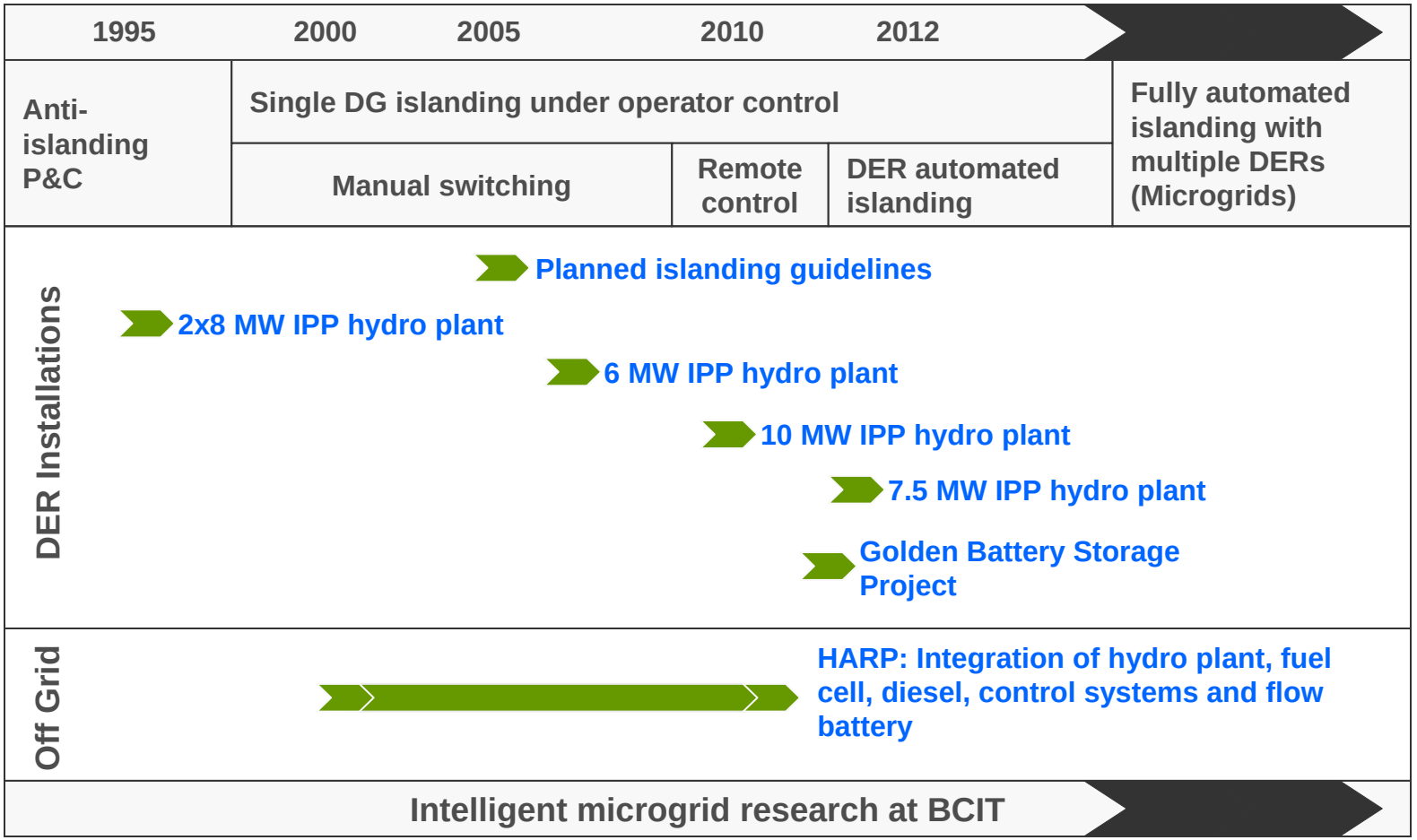
BC Hydro's Islanding Projects



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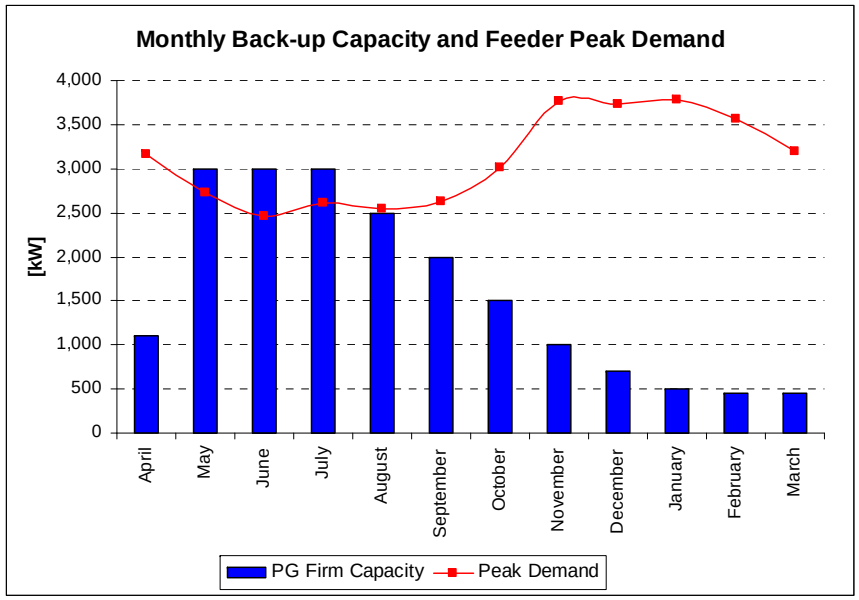
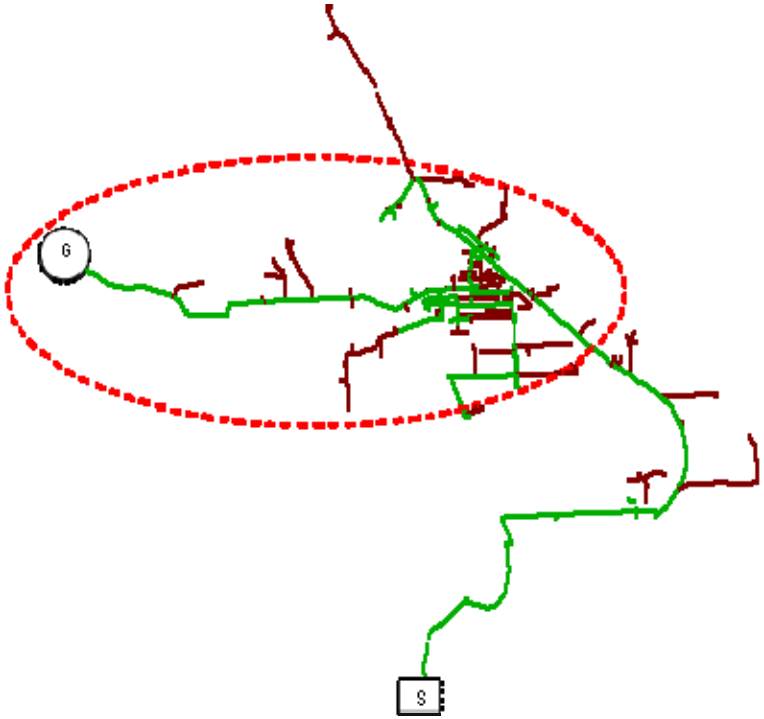
BC Hydro – Project 2, 2007

- 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





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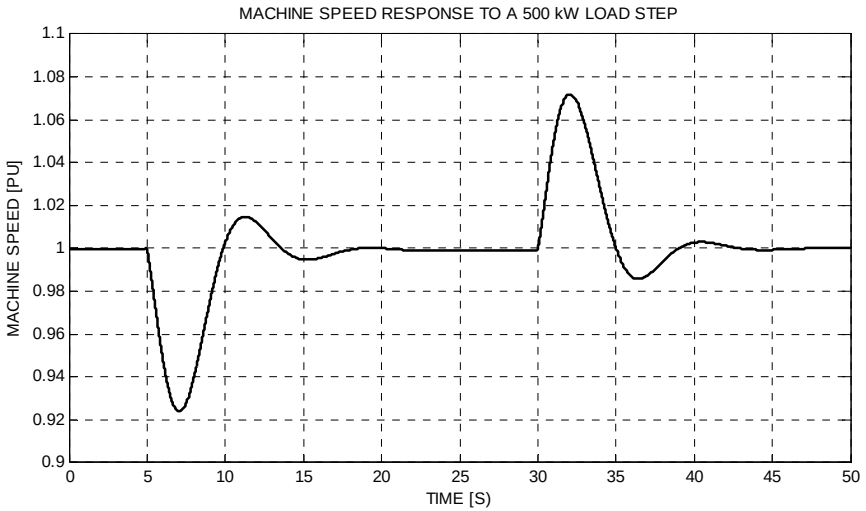
BC Hydro - Project 2, 2007

- 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



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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%)

BC Hydro Feeder	SAIDI	SAIFI	CAIDI
2008	3.77	5.05	0.75
2007	7.20	6.65	1.08
2006	34.16	8.87	3.85
2005	4.30	4.06	1.06

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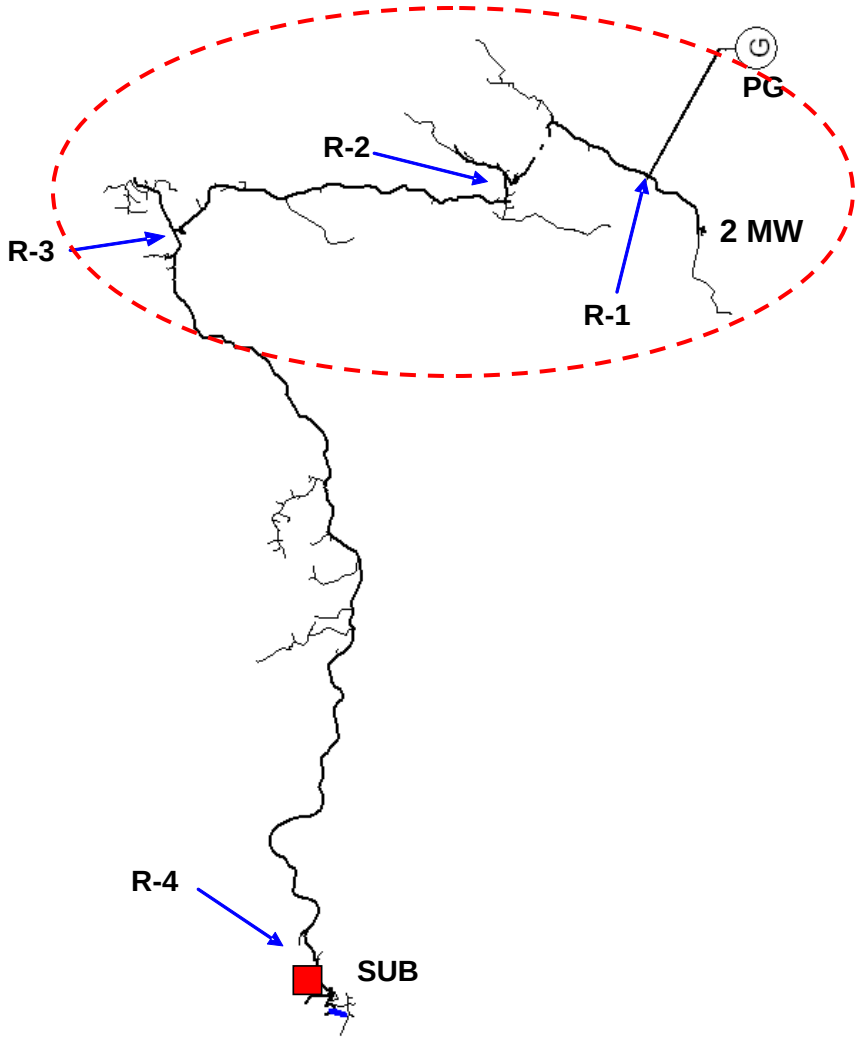
BC Hydro – Project 3, 2010

- 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)



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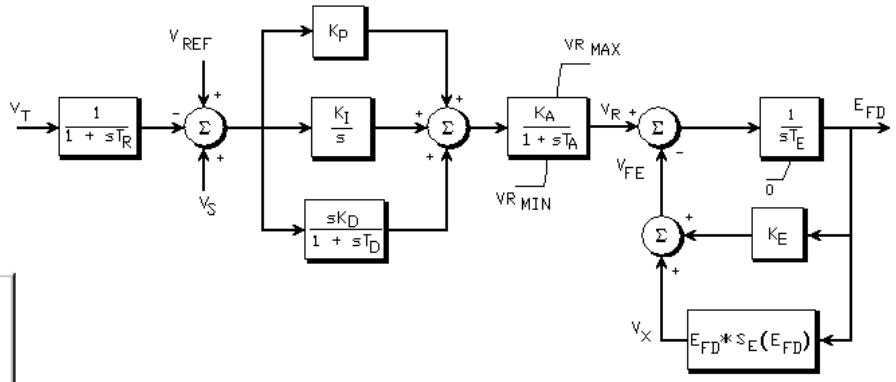
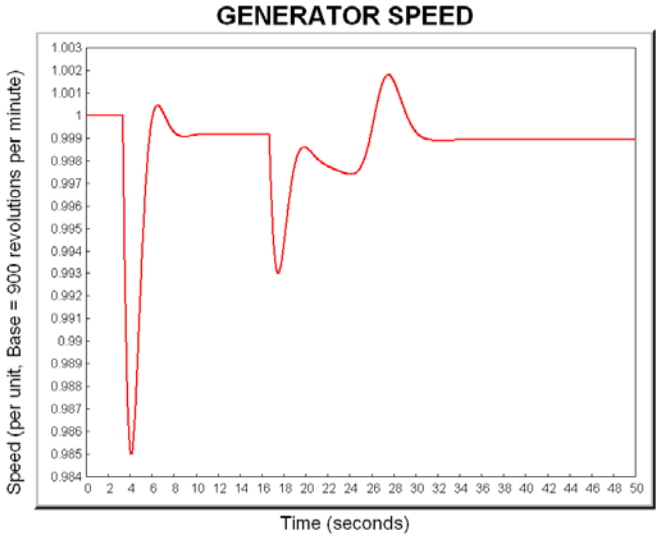
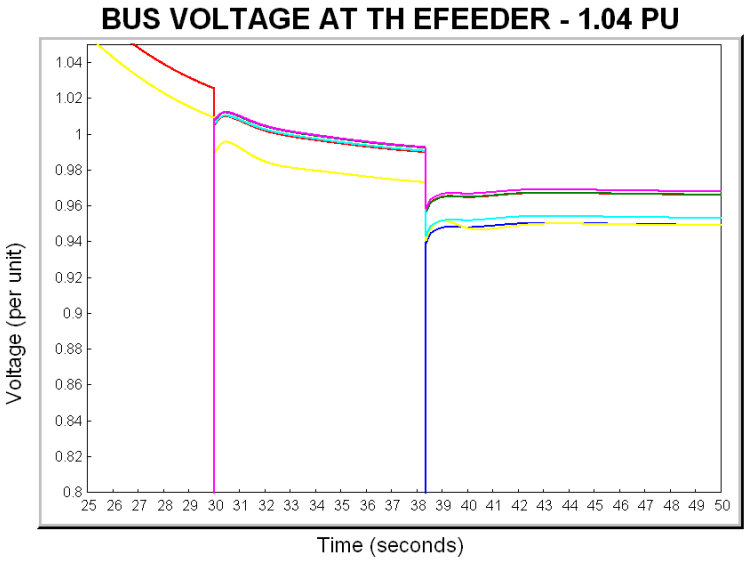
BC Hydro – Project 3, 2010

- Studies done in CYMDIST/CYMSTAB







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BC Hydro – Project 3, 2010

- Special PQ requirements for islanding conditions: V, f, harmonics

Voltage:

% of Nominal Voltage	Clearing Time Islanding Mode	Clearing Time Normal Mode
V < 50%	0.16 sec	0.16 sec
50% < V < 85%	5.0 sec	2.0 sec
85% < V <90%	60.0 sec	2.0 sec
90% < V <106%	Normal Operation	Normal Operation
106% < V < 110%	60.0 sec	1.0 sec
106% < V < 120%	5.0 sec	1.0 sec
V >= 120%	0.16 sec	0.16 sec

Frequency:

Under Frequency Limit		Minimum Time Islanding Mode		Minimum Time Normal Mode	
60.0-60.5	Hz	Continuous		Continuous	
60.6-61.5	Hz	10	minute	3	minutes
61.6-61.7	Hz	1	minute	30	seconds
61.8-62.5	Hz	1	minute	Instantaneous	
62.6-67.0	Hz	10	seconds	Instantaneous	
Greater then 67.0	Hz	Instantaneous		Instantaneous	

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

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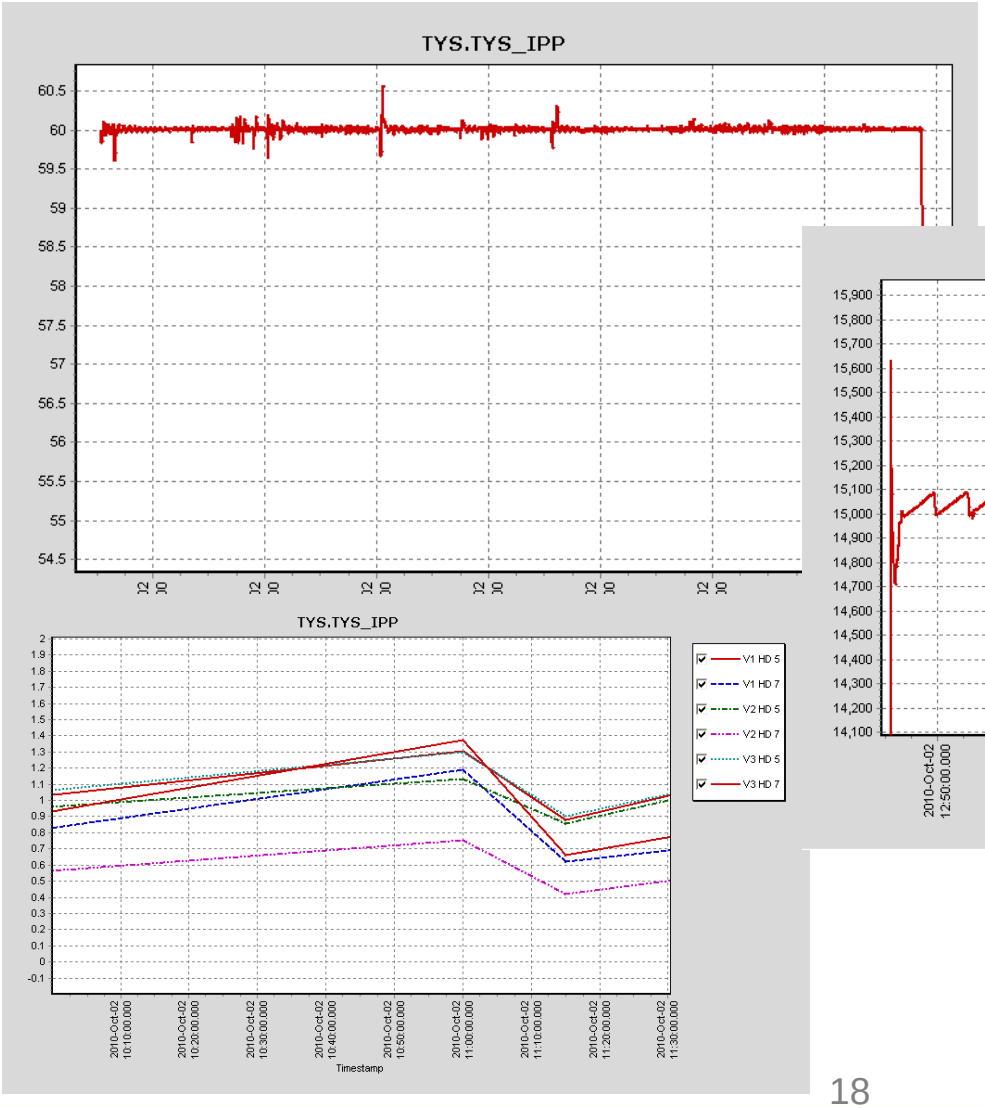
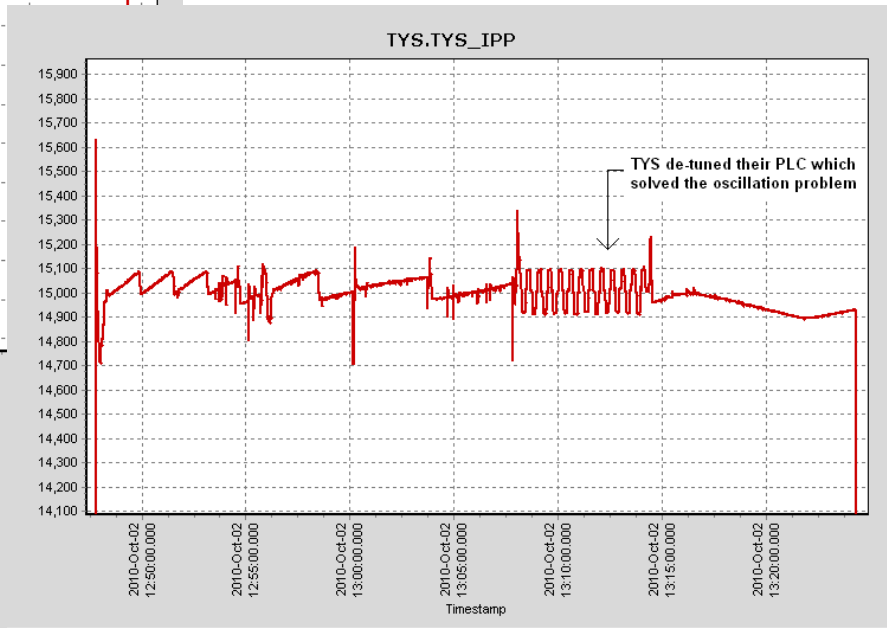
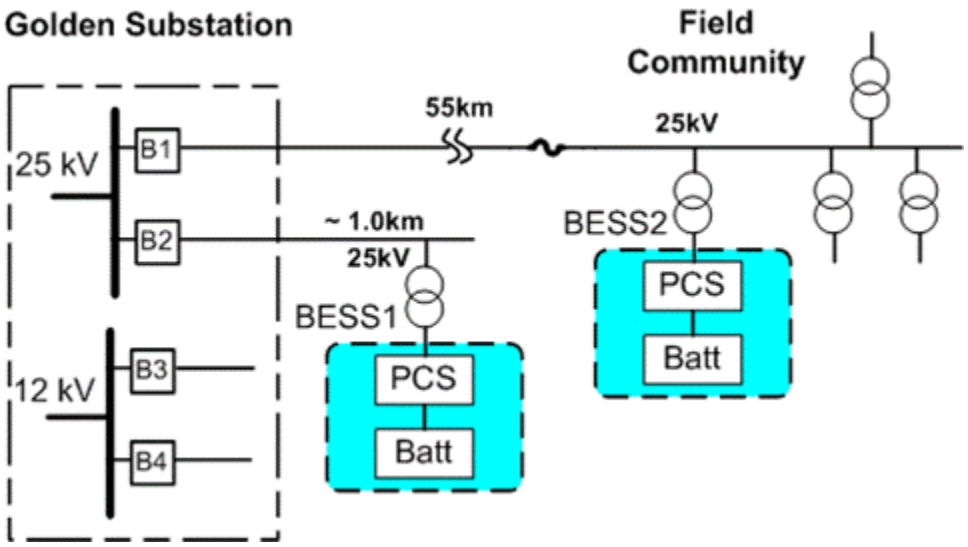
BC Hydro – Project 3, 2010





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



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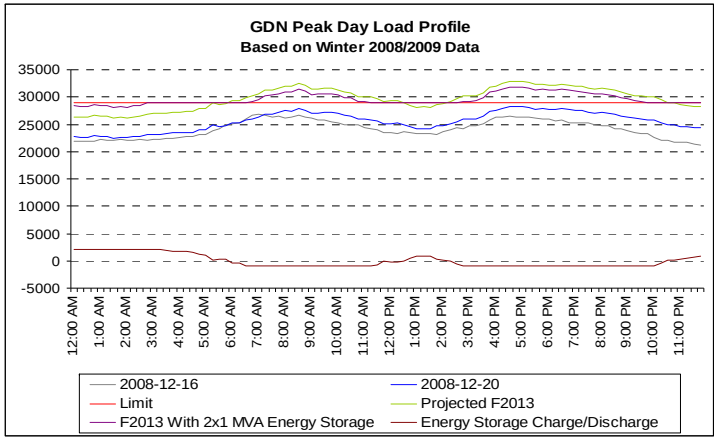
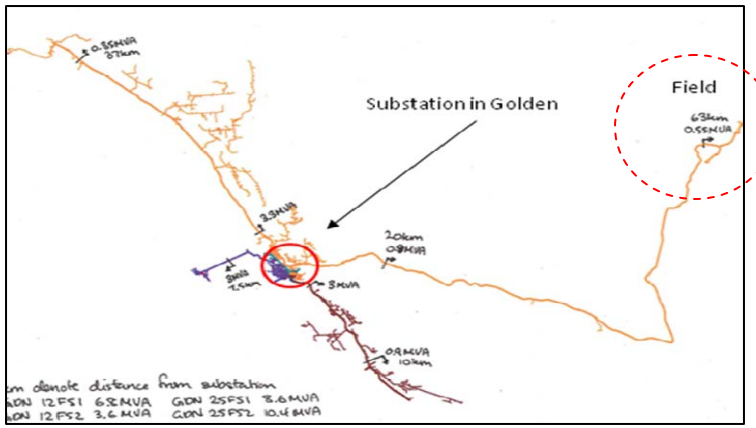
BC Hydro – Energy Storage Project





- Peak shaving to mitigate capacity risk at Golden substation, includes demand response (~2 MW).
- Islanding to relieve poor reliability metrics at Field (~ 500kW)

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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.

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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

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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

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BC Hydro – Energy Storage Project

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

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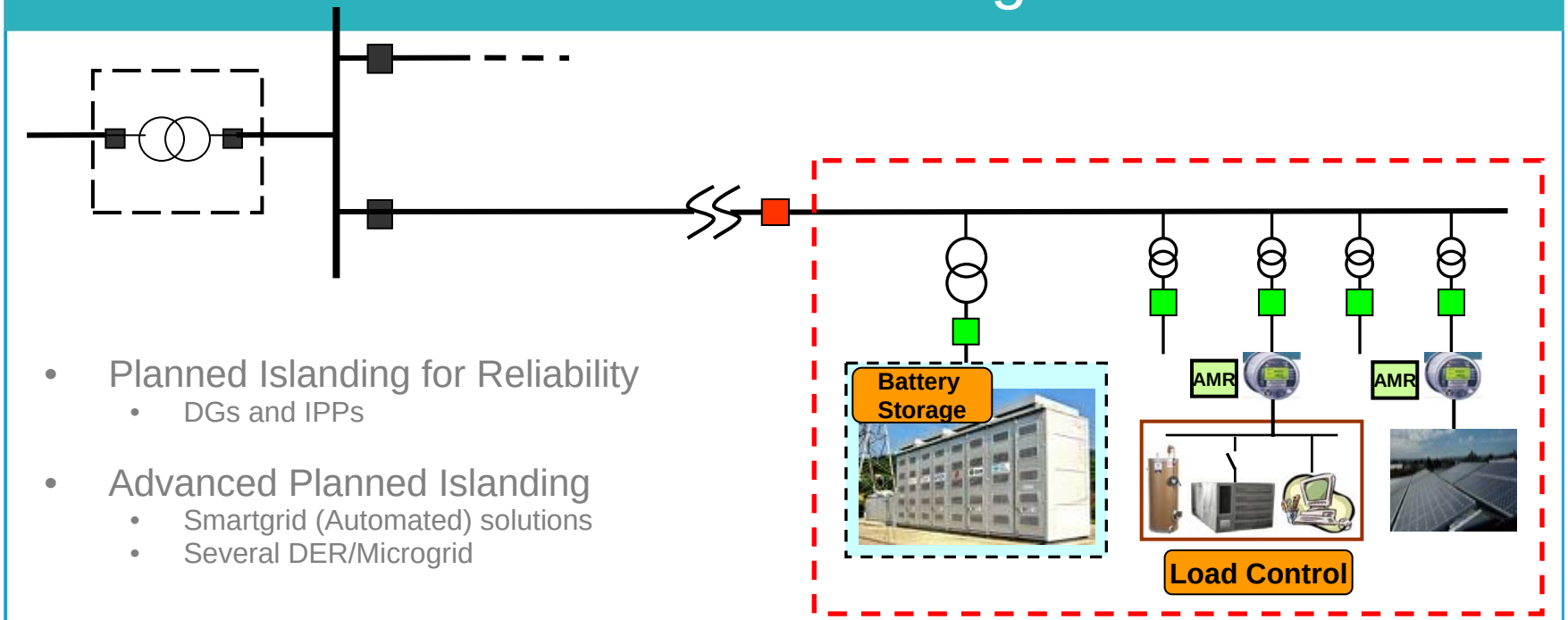
Conclusion and Future Challenges



- 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

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Questions?

Thanks!!

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