2009 Wind-Diesel Workshop

Microgrid Control System Technology

GE Digital Energy, Markham Ontario

June 2nd, 2009

Digital Energy

we protect and connect the world's critical equipment to ensure safe, reliable power

Protection & Control
Multilin

Relays, Controllers, Meters, Fault Recorders

Communications
MDS, Lentronics

Wireless & Optical Network

Power Quality
Zenith Controls

Auto-Transfer Switches, UPS, Paralleling Switchgear, TVSS

Power Sensing
ITI

CTs, PTs, VTs, Test Switches and Control Switches

- Headquartered in Markham, Ontario
- Over 2,000 employees globally
- 10 manufacturing locations around the globe

Agenda . . .

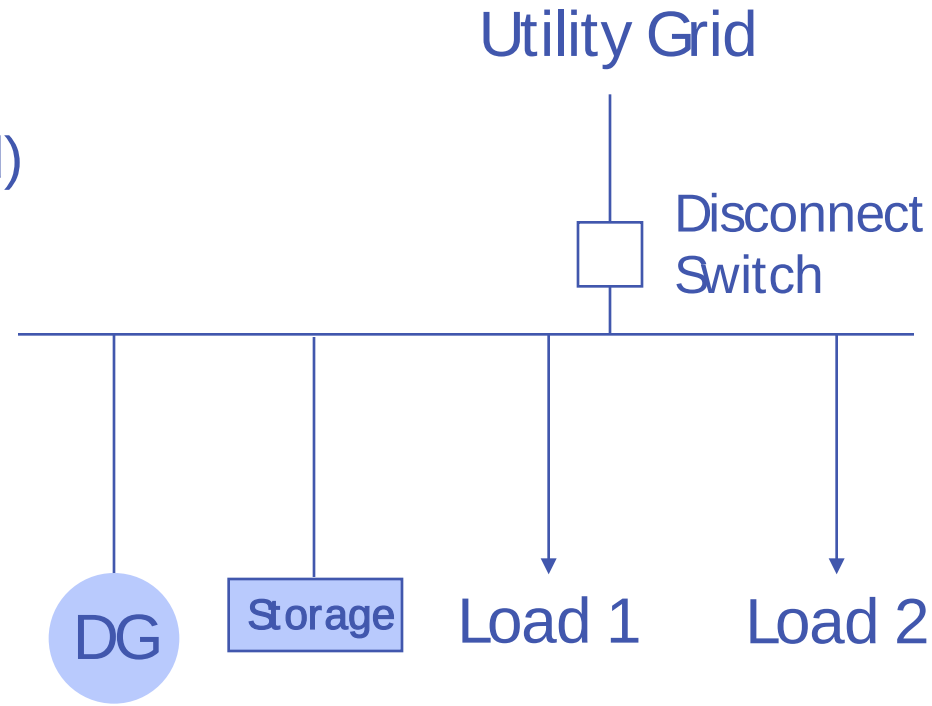
- ✓ What is a Microgrid?
- ✓ Typical Microgrid Architecture
- ✓ Introduction to Bellacoola Project
- ✓ Bellacoola Microgrid
- ✓ Microgrid Control System – Product Overview
- ✓ Technology Features
- ✓ Value Proposition
- ✓ Q & A

What is a Microgrid?

A Microgrid is a distribution network that includes **local (distributed) generation** and possibly energy storage; and can operate in an islanded mode (open grid connection)

Local Generation can include conventional (fossil fuel based) and/or renewable generation (PV, Wind, Hydro, Bio-mass)

Energy storage (H2/Fuel cell, Batteries, Pumped Hydro, Flywheel, Compressed Air)

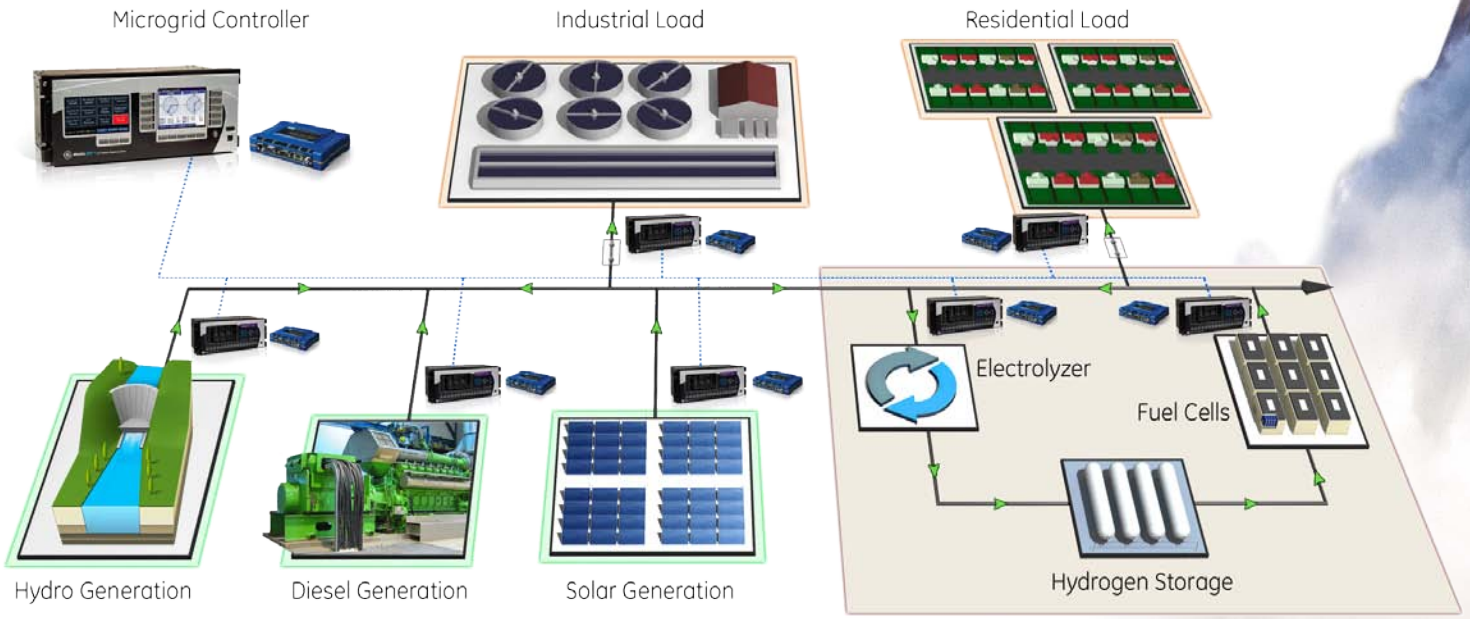


Typical Microgrid Architecture . . .

A Typical Microgrid features

- Combination of conventional and/or renewable on/off the grid energy sources
- Energy storage system to compensate for renewable intermittency
- Communication networking of all Microgrid elements including load clusters

Need for a Smart Control system to optimize and manage generators, energy storage and loads within the Microgrid

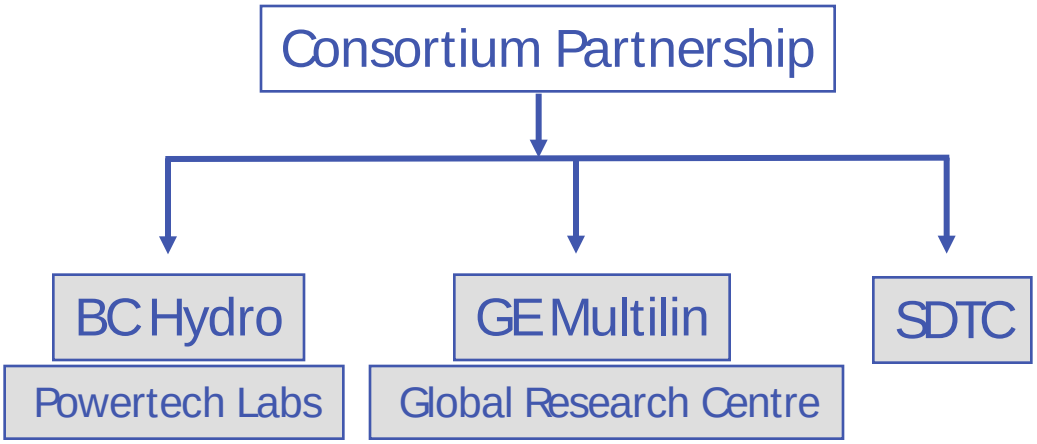


Bella Coola Project

Project Objectives

- Demonstrate the potential to reduce emissions from non-renewable power generation in remote communities
- Development of Microgrid Control System technology
- Increase utilization of the Clayton Falls hydro generation facility and reduce dependence on diesel generators at the community of Bella Coola

Project Consortium

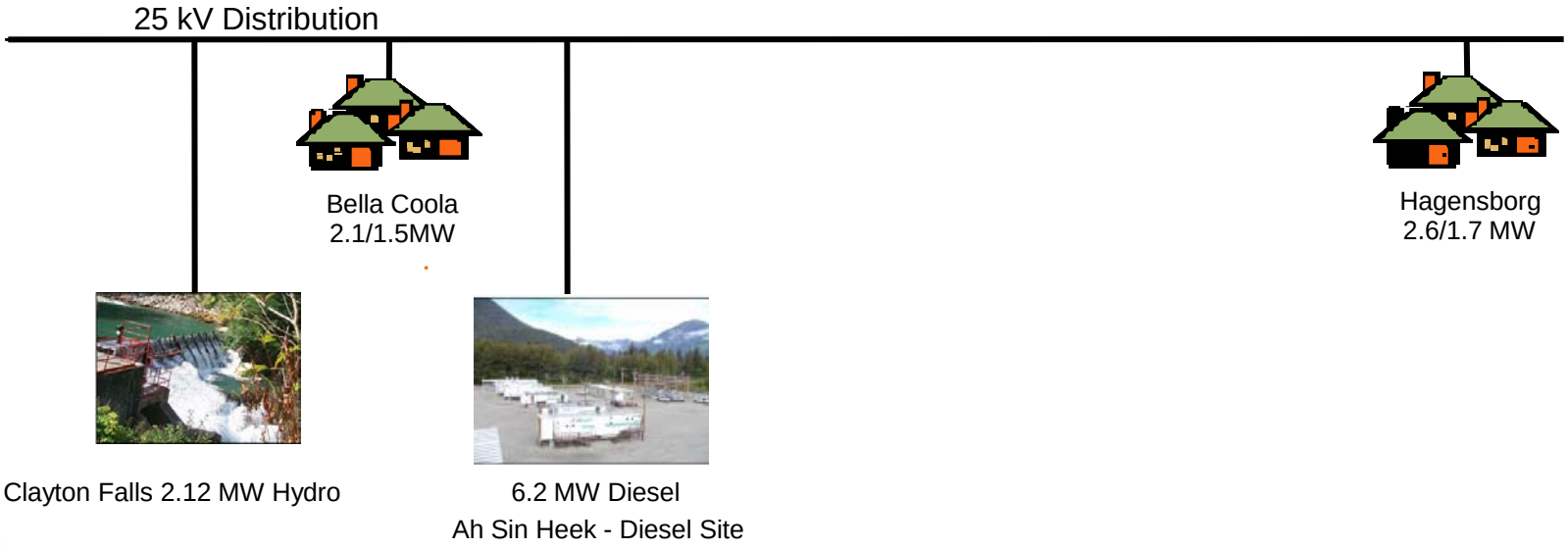


- Sustainable Development Technology Canada (SDTC) is a not-for-profit corporation created by the Government of Canada that supports development of clean technologies
- SDTC, BC Hydro and GE Multilin each contributed 1/3rd of the total project cost
- GE Multilin worked with GE Global Research Centre to develop Microgrid Control System (MCS) technology

Bella Coola Site

Existing Site:

- 439 km north of Vancouver, off-grid community
- Currently running on Diesel gensets and Hydro generators at Clayton falls
- Load profile: 4.7/3.2MW, Mostly residential loads
- 2 Hydro generators: 2.12MW
- 8 Diesel Gensets: 6.2MW
- Biggest challenge – Reduction of GHG emissions and cost of diesel transportation



Bella Coola Microgrid Control System

Microgrid Features:

- Centralized Supervisory control to optimize the use of renewables and minimize the use of diesel
- Wireless local area network
- Hydrogen based energy storage system
- Capability to connect, monitor and control the system remotely
- Interfaces to all Microgrid elements

Ah Sin Heek Diesel / Energy Storage Site

Local HMI

Microgrid Controller

Remote Monitoring

Ethernet Switch

MultiLink

Wireless Radio

25 kV Distribution

modem

Bella Coola 2.1/1.5MW

Hagensborg 2.6/1.7 MW

Storage 3.3 MW-hr

Hydro Generator Interface

Diesel Genset Interface

Electrolyzer 300 kW

Fuel Cell 125 kW

Battery Support 125 kW / 400 kW-hr

Clayton Falls 2.12 MW Hydro

6.2 MW Diesel

Utility Service Vehicle

Microgrid Control System - Overview

- Provides centralized management of distributed generators, energy storage and loads within a microgrid
- Implements a flat communication structure using Ethernet and/or wireless Ethernet Technology
- Applicable to **grid-tied** and **remote** microgrids

Key Features

- **Optimal Dispatch:** Makes the most efficient use of renewable, dispatchable and storage resources
- **Load Shedding:** Improves availability by dynamically arming loads based on system loading and available generation
- **Tie line control:** Consolidates the microgrid into a single, dispatchable resource

Optimal Dispatch

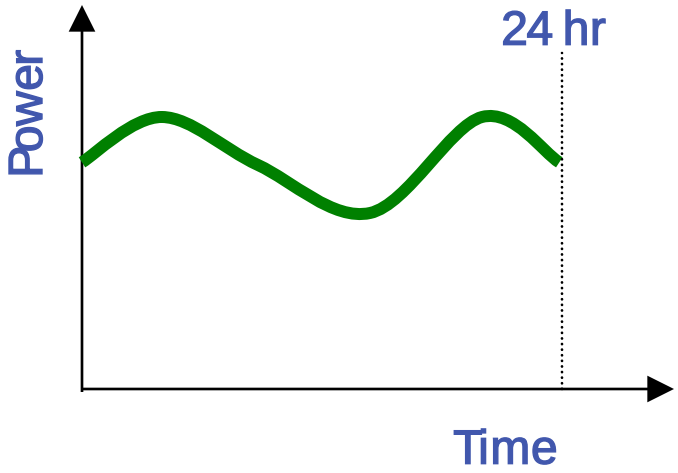
The process of allocating the required load demand between the available resources such that the cost of operation is minimized

- The energy output of renewable generators is variable and intermittent
- In order to make the best use of this energy it can be beneficial to incorporate energy storage technology
- Determining when to store energy and when to return it requires an advanced control strategy

Optimal Dispatch

The optimal dispatch algorithm Implements *Model Predictive Control* using:

- **Load** forecasts
- **Renewable** generation forecasts (wind, hydro, solar, bio-mass)
- and **Stored Energy**



Additional optimization constraints include:

- Min/max power/thermal output
- Generator Efficiency, Storage Efficiency
- Speed to ramp up/down output
- Electricity–to-thermal ratio in Combined-Heat-Power (CHP) source
- Market price of electricity (if connected to the utility grid)

Intelligent Load Shedding

An intelligent scheme that will arm the required amount of load to be shed in order to maintain system stability

- Prioritization of loads
- Dynamic load shedding based on potential generation deficit

Load shedding may be triggered by a fast message sent over communications or by a local measurement of frequency

Tie Line Control

- Treats the Microgrid as a dispatch able resource within the bulk system
- Utilizes Microgrid resources for control
- Microgrid Active Power Control
  - Enforce a microgrid power output/input at the tie-line
  - Enforce a power ramp rate limit
  - Respond to system frequency excursions
- Microgrid Reactive Power Control
  - Voltage regulation and power factor control at the tie-line
  - The voltage regulation includes voltage set point, steady state voltage response, and transient VAR response.

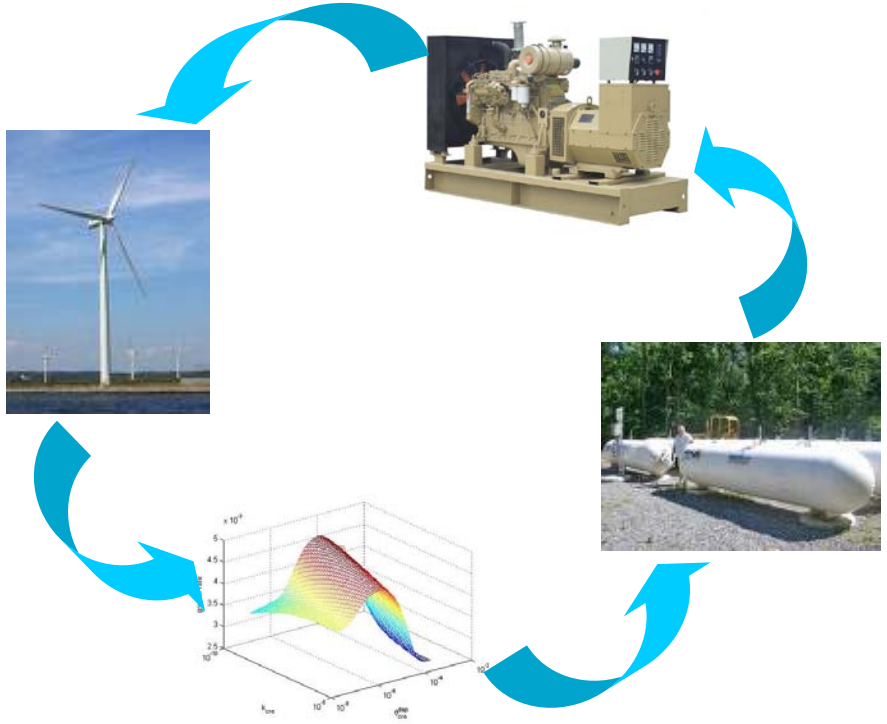
Microgrid Controller

Utility-grade substation IED based on the UR-Plus platform

Front Panel HMI: Annunciator, Mimic Diagram (control), Metering
Logic Engine: Boolean, Timers, Counters, Latches, Math, Time-Of-Day
Communication ports: Ethernet(3), Serial, USB, Irig-B
Protocols: DNP, Modbus, IEC61850
Recording: Transient Recorder, Disturbance Recorder, Data Logger, Sequence of Events
Metering: Voltage Current Power, Energy, Frequency, Sequence Components

Value Proposition . . .

- Enable efficient integration of traditional generators with clean power and energy storage
- Minimize energy cost via optimized dispatch of multiple Distributed Energy Resources
- Reduce operating cost by reducing manual operations and associated complexities



Thank you.

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