# Vancouver 2010 Symposium on Microgrids

Microgrid Symposium at Fairmont Pacific Rim, July 22nd, 2010

## Hydrogen Assisted Renewable Power (HARP) Project in British Columbia

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imagination at work

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# Outline

- About BC Hydro and Powertech Labs
- Background and Project Drivers
- The HARP Concept
- Project Objectives
- Bella Coola Microgrid
- HARP Project Components
- Testing & Integration
- Lessons Learned

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# About BC Hydro & Powertech

- **BC Hydro**
  - A Crown corporation owned by the Province of British Columbia
  - 1.8 million customers -serves about 95% of the province's population
  - Reliably generates 43,000 - 54,000 GWh of electricity annually
  - 11,300 MW installed capacity - 90% hydroelectric
- **Powertech**
  - A world-class leader in clean energy consulting, testing and solutions
  - Supports the Province of BC and BC Hydro in achieving their goals, as defined by the BC Energy Plan
  - Serves a global client base of Fortune 500 companies, utilities and governments

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# Background and Project Drivers

- Supply of reliable, clean, renewable power is a challenge facing over 300 remote communities in Canada
- BC Hydro serves isolated-grid communities
  - Today serves 9 remote communities, adding 34 more over 10-years
  - Strong interest in using renewable generation from local sources
- High price of diesel & impact of diesel generation
  - Price fluctuations expose remote communities to high fuel & electricity costs
  - Impact on the environment from fuel transportation and diesel operation
- Renewable Power is intermittent and has issues with dependability
  - HARP uses hydrogen to "firm up" the dependability of renewable generators
- Power usage in communities shows distinct peaks
  - Store off-peak energy from renewable sources for use during peak periods
  - Hydrogen and a "Smart Grid" has the potential to reduce peaks, increase efficiency and cost effectiveness of the system

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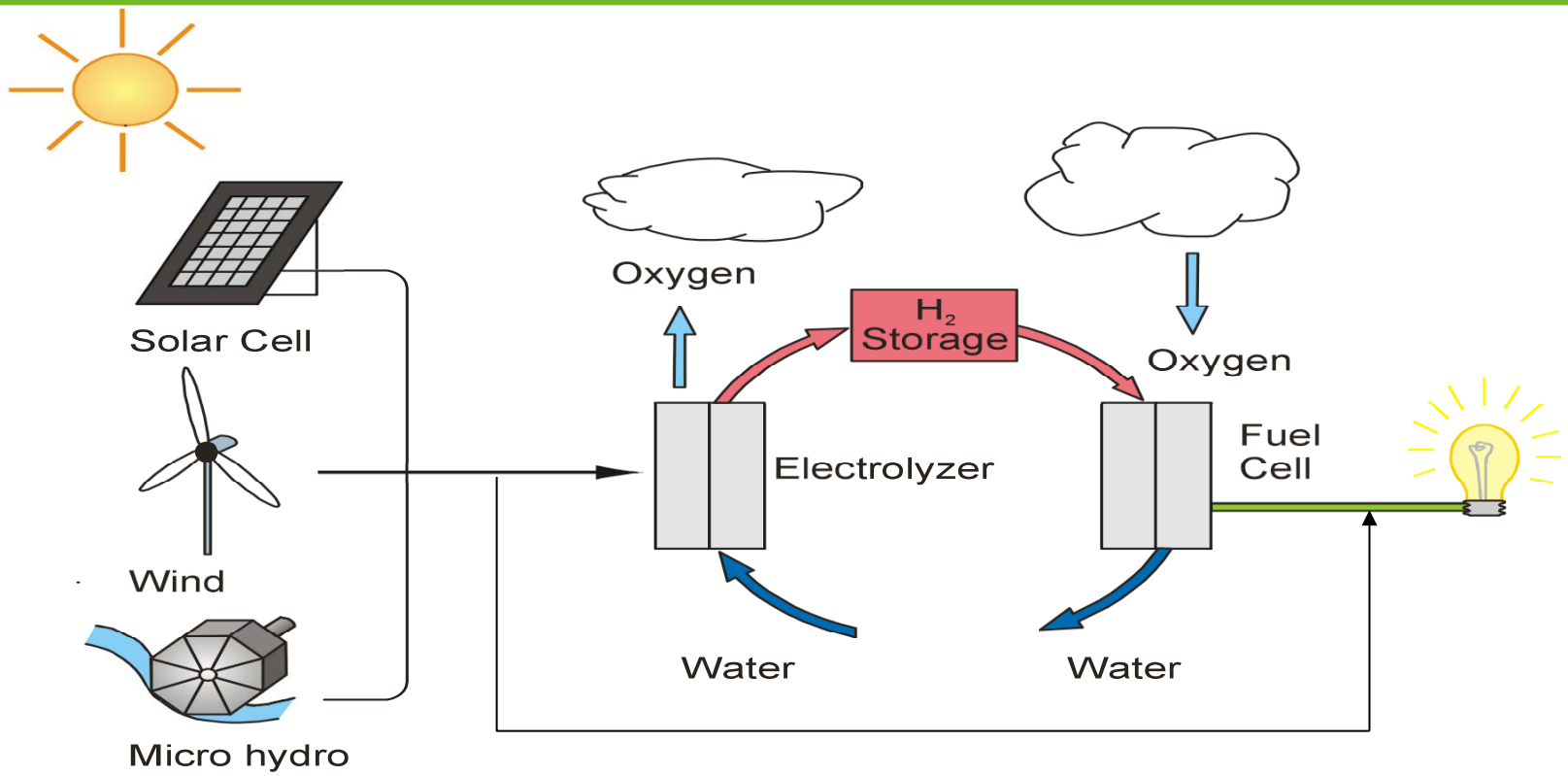
# The HARP Concept




- Generate hydrogen through electrolysis during periods of excess energy; hydrogen is stored as a compressed gas
- Generate electricity using fuel cells during times of peak or low power production

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# HARP Project - Objectives

- **Demonstrate**
  - the viability of energy storage in remote communities
  - the ability of the Smart Grid technology to optimize the operation of generation and storage
  - the reliability of different energy storage technologies
- **Identify best available technologies and equipment**
- **Use findings from this pilot project for future installations of hybrid renewable systems**

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# HARP Project Partners

- **BC Hydro** - Owner for the pilot project
- **Powertech** – Project manager
- **Sustainable Development Technology Canada**
- **BC Innovative Clean Energy (ICE) Fund**
  - Flow Battery
- **General Electric Canada**
  - GE Digital Energy – Control hardware
  - GE Global Research - Smart Grid development

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# Bella Coola

Bella Coola

- 450 km north of Vancouver
- Isolated grid

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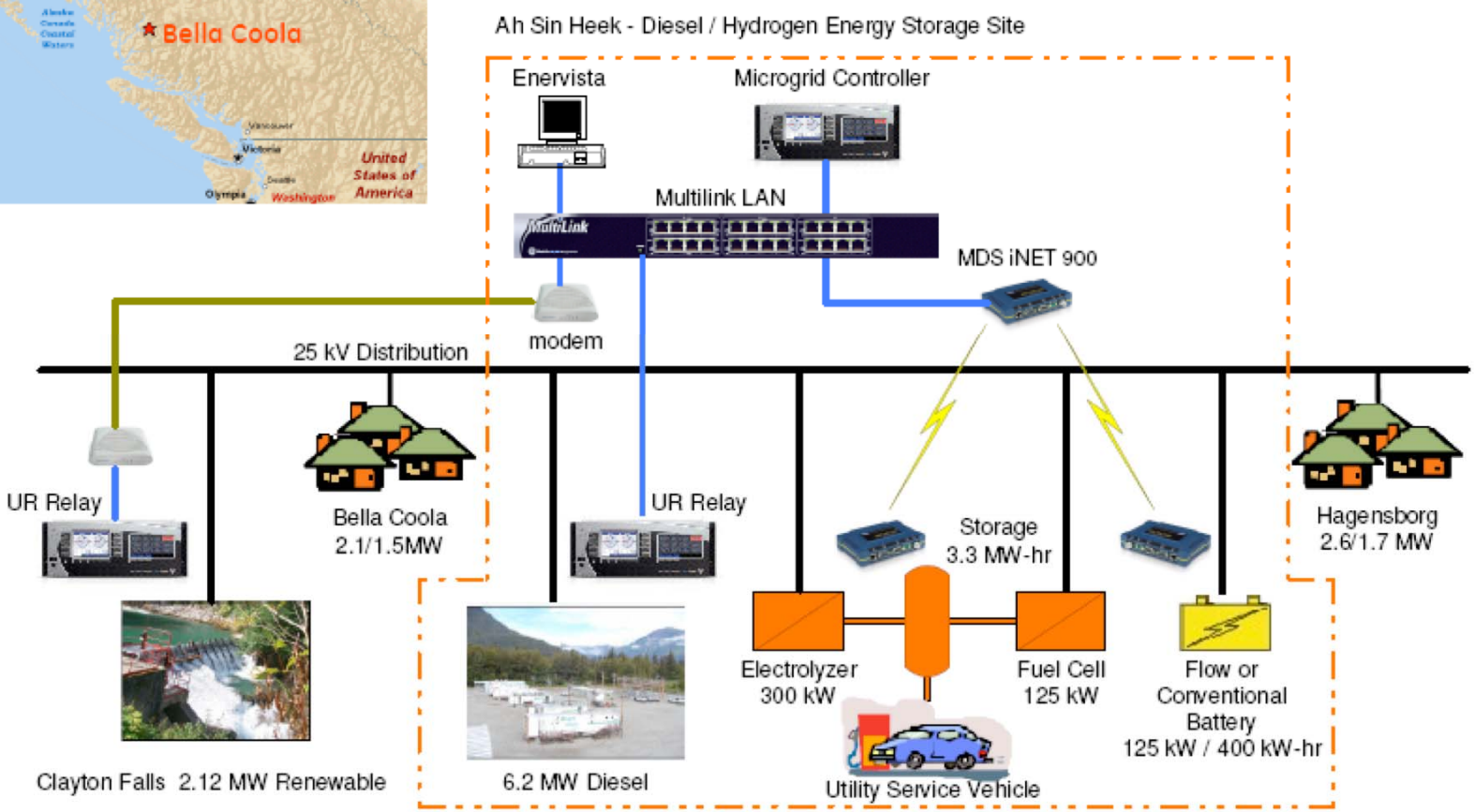
# Bella Coola Microgrid



# Bella Coola - Generation

Clayton Falls (CLA)

- Run of river
- 2.1MW Capacity

Ah-Sin-Heek (ASK)

- Diesel Generating Station
- Total Capacity 6.2MW

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# HARP Project Components

- Electrolyzer
  - production rate of 5 kg/h at ~200 psi
  - 320 kW power consumer
- Compressor
  - compresses gas from electrolyzer to store at higher pressure
  - 30kW power consumer
- Hydrogen Storage
  - 13970L (100 kg) at medium pressure (~2850 psi)
- Fuel Cell
  - 100 kW power output
  - modular design of 10kW fuel cell modules for system redundancy
- Flow Battery
  - 100 kW power output capacity
- Smart Grid: GE Microgrid Controller
- Hydrogen Truck

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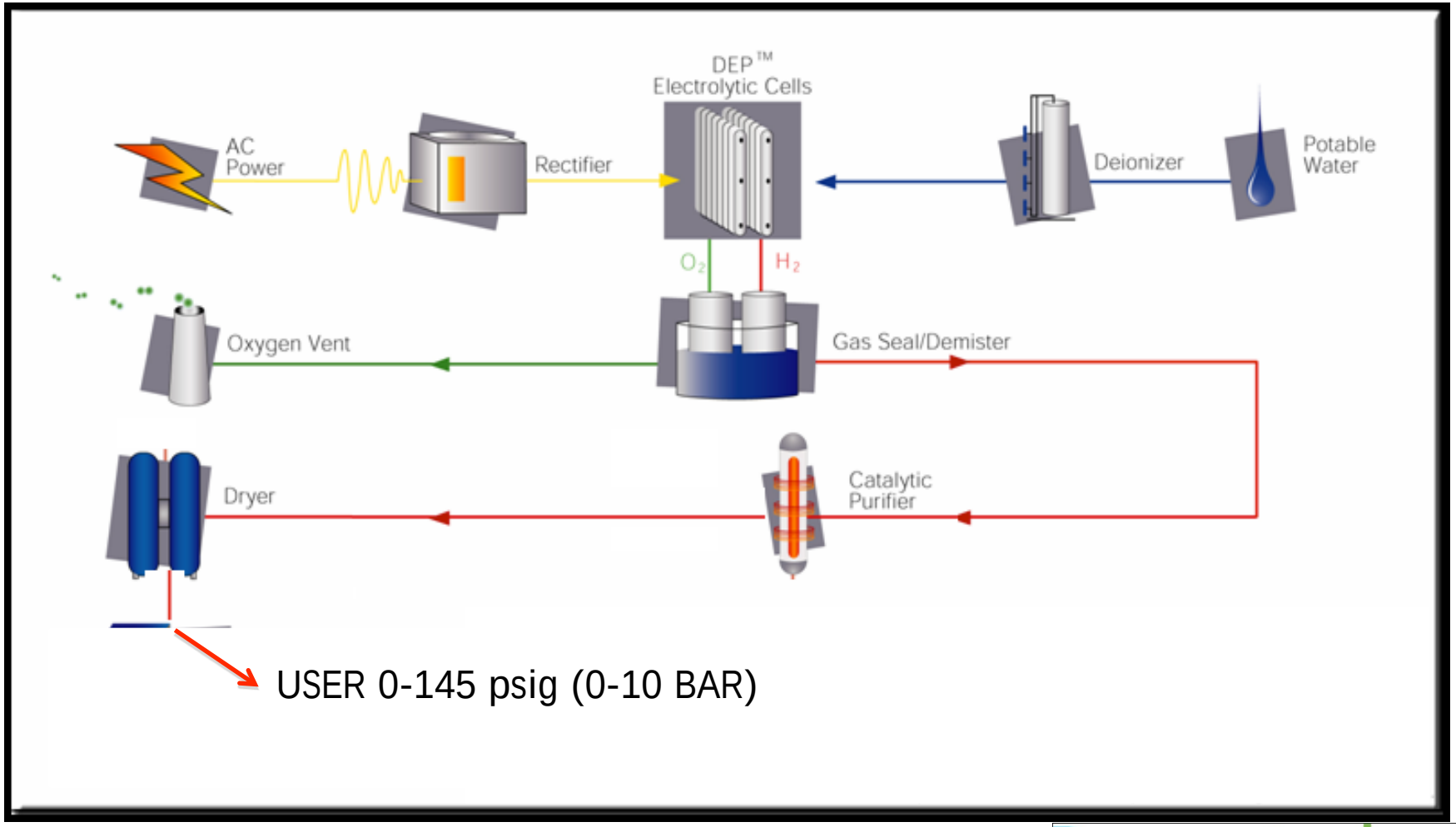
# ELECTROLYSER - Simplified Process Flow

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# ELECTROLYSER – HYDROGENICS HYSTAT60

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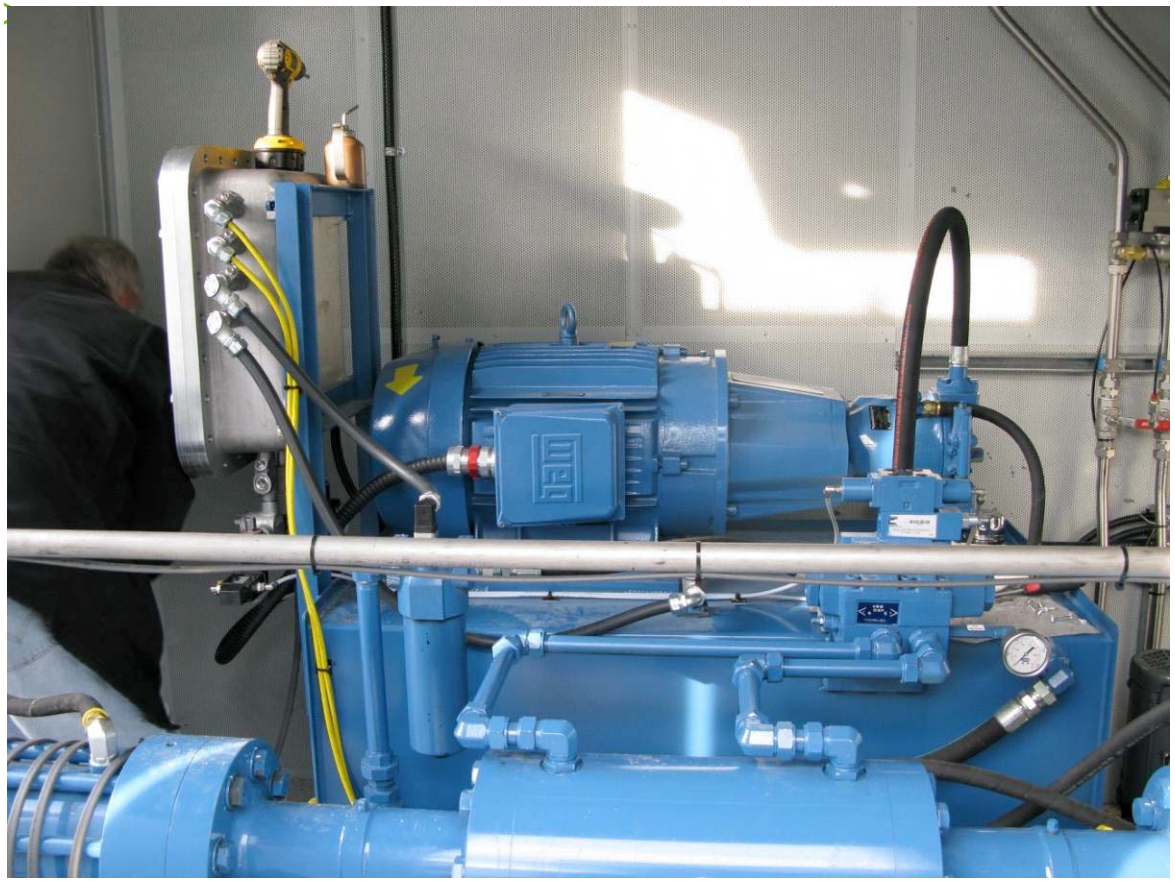
# HIGH PRESSURE HYDROGEN COMPRESSOR



Compresses hydrogen to 200 atmospheres

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# HIGH PRESSURE HYDROGEN STORAGE

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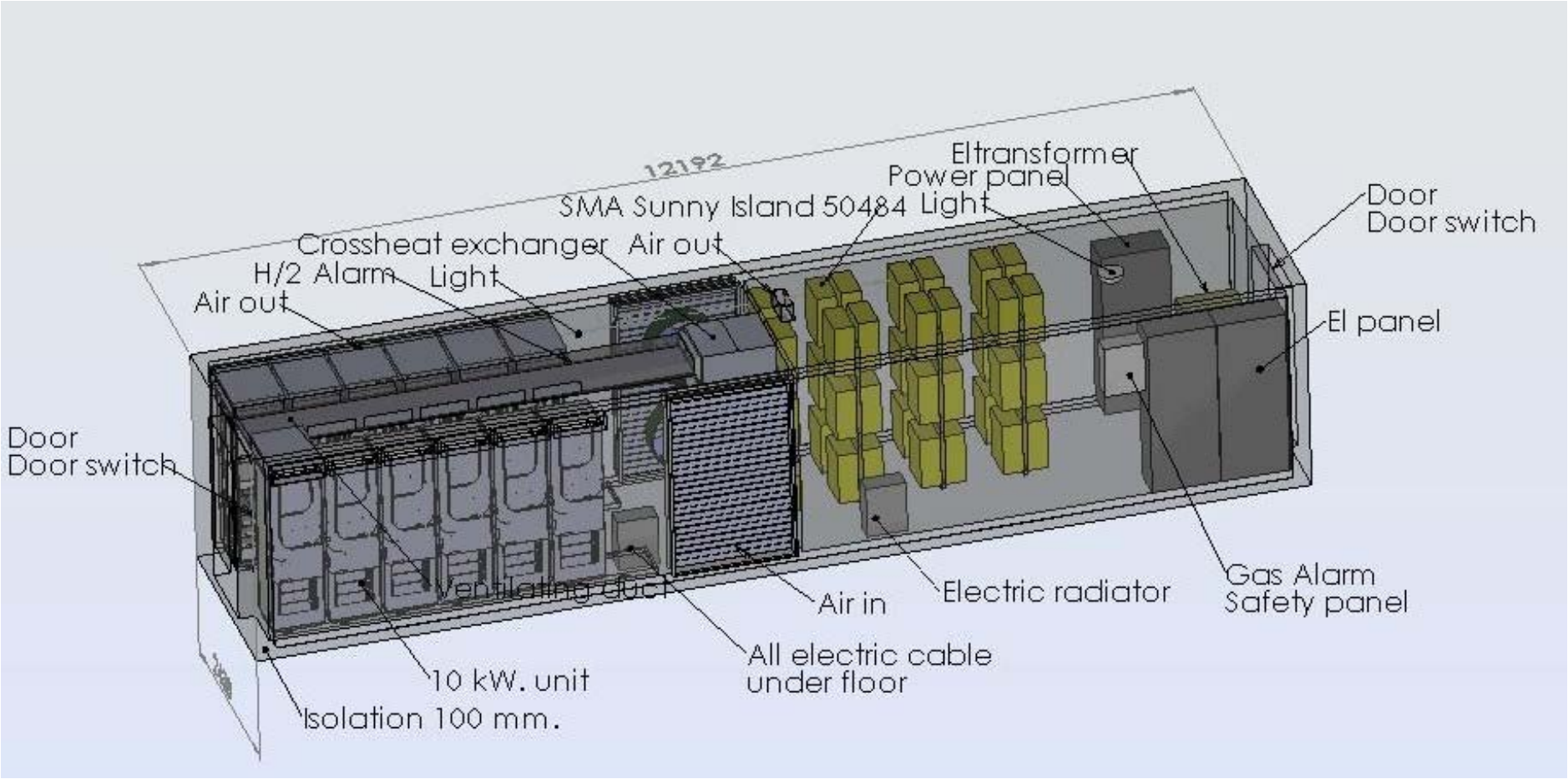
# FUEL CELL - DANTHERM

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# FUEL CELL - DANTHERM -Fuel Cell Room

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# FUEL CELL - DANTHERM - Inverters

>

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# FLOW BATTERY - ZBB

- The ZBB Zinc Energy Storage System (ZESS) is a proprietary and patented regenerative fuel cell based on zinc/bromide technology.
- The ZESS 50 holds 50 kWh, and includes three cell stacks, each containing 60 cells. The module dimensions are 4’ x 4’ x 6.5’, weighing 3,200 pounds.
- The ZESS offers 2 to 3 times the energy density (75 to 85 watt-hours per kilogram) with associated size and weight savings over existing lead/acid batteries.

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# FLOW BATTERY - ZESS 500 in modular configuration

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# Microgrid Control System - Optimal Dispatch

# Optimal Dispatch

- Allocating the required load demand between the available resources to minimize total cost of operation
  - Advanced storage system required for increased utilization, as energy output of renewables is intermittent
  - The GE Microgrid controller is generic and scalable to allow for use in remote communities of various sizes
  - Optimized operation of the Bella Coola system will reduce diesel fuel consumption and increase utilization of run-of-river hydro

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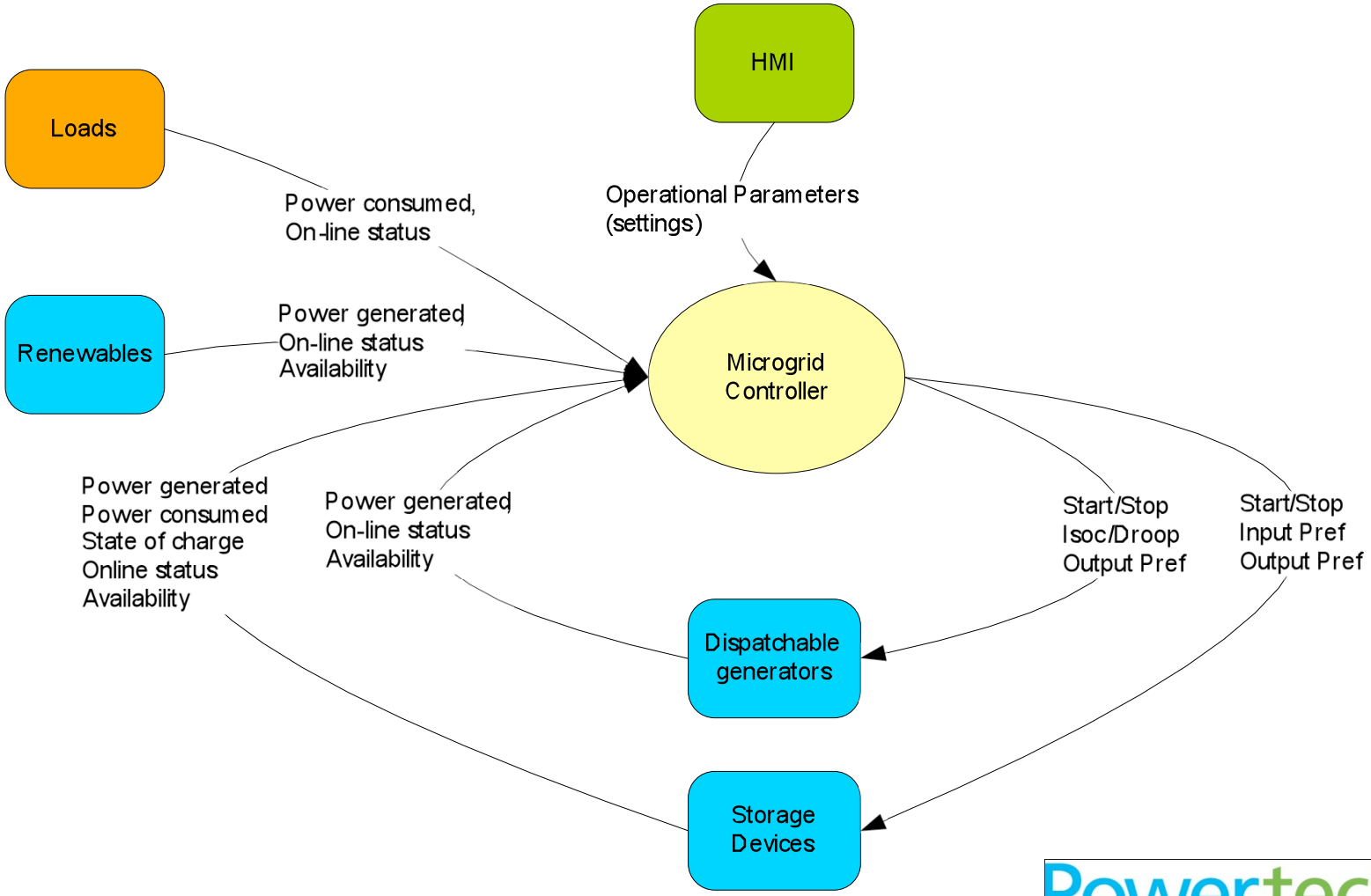
# MCS Data Flow

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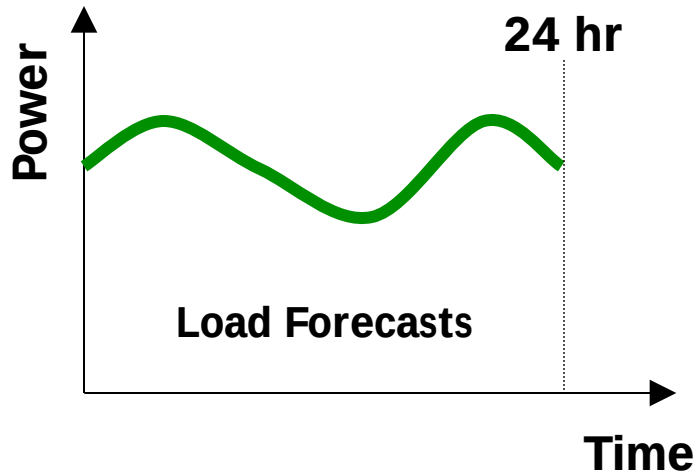
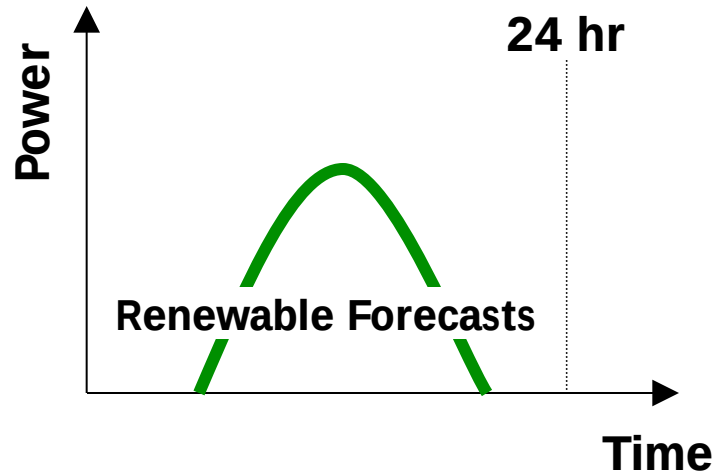
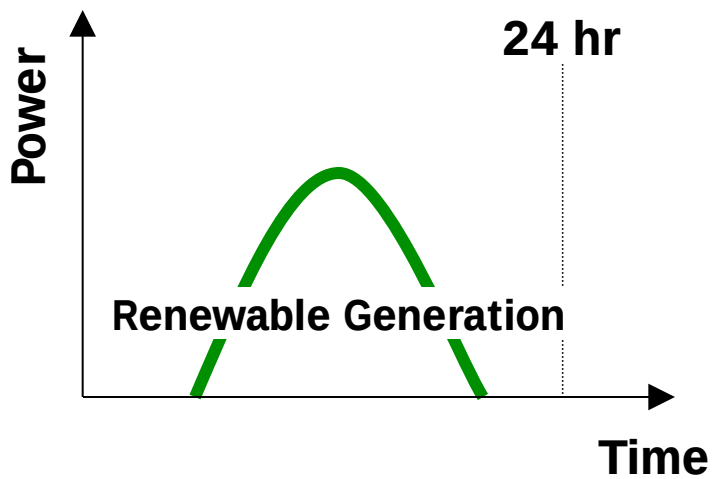
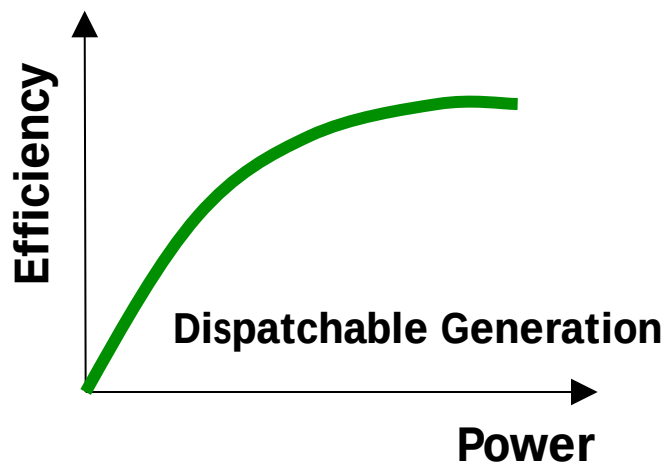
# Optimal Dispatch

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

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# HYDROGEN TRUCK

> To familiarize Bella Coola staff with hydrogen handling, stored hydrogen was used to fuel an internal combustion engine company truck (GMC Sierra)

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# Testing & Integration Plan

- Test HARP system in Powertech Labs
- Deploy HARP system in Bella Coola
- All components containerized

- HARP system must integrate with existing Bella Coola grid
- HARP system must interface with existing Bella Coola generating control system

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# Hydrogen Energy System – Testing at Powertech

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# Hydrogen Energy System – Installed in Bella Coola

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# Hydrogen Energy System – Installed in Bella Coola

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# Lessons Learned - Technical

- Pre-testing should be carried out on integrated system prior to deployment
  - Address difficulties in making all components work together
  - Work out implementation issues close to home
- Communications between generators, control systems and other components is challenging
  - One month for the electrolyzer
  - Two months for the Ah Sin Heek diesels and Clayton Falls hydro plant
  - GE MDS Ethernet Radios work very well
- Ensure equipment is designed for the site environment
  - Significant rainfall in Bella Coola – sills on containers needed to keep out the rain
- System component models impact the control system algorithms
  - Generation of H2 takes 30 minutes to ramp up

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# Lessons Learned - Logistics

- They are called *remote* communities for a reason
  - Moving in a 55T crane and 6 flatdeck trucks of heavy equipment is both challenging and costly
  - Bella Coola 'hill' has a 17% grade with 7 switchbacks; 1450M elevation over 3km
- Full set of spares needed on site
  - You won't find a metric fastener, spare cable or "O" ring in a remote community; plan the spares storage with or inside the equipment
- Use plywood templates for equipment footprints
  - Send to site when pouring foundations to ensure mounts and conduit line up with the equipment
- Always pull extra cables into a conduit or leave room for extra cables
- Consider timing
  - Don't deploy equipment during the Olympics
- Safety training required and must be planned in advance
- Equipment must be mothballed if left sitting idle for months

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# Lessons Learned – People + User Reactions

- People support the project
  - The right people are key – they run the machines in remote communities
  - Extensive operator training is required – this isn't diesel anymore
  - Overcoming fears – H2, high pressure, KOH caustic; plan emergency readiness
- View project as "the future"
  - As commented by locals "Makes you want to believe in UFO's"
- Hydrogen-fueled truck popular with the workers
- Running the Microgrid controller in "advisory" mode and collecting data until operators are comfortable with the system's solutions for diesel and hydro generator dispatch
  - Microgrid controller will soon be running all machines
  - Flow battery is under construction

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imagination at work

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