Microgrid Research

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Outline

- Motivation and objectives
- Projects:
  - Modeling and simulation
  - Optimal dispatch and control
  - Optimal planning
- Current status and next steps

Motivation and Objectives

- Many communities in Canada and remote communities in the rest of the world are not connected to the grid and are dependant on other means to supply electrical energy to their community.
- Remote communities in Northern Canada have no road access.
- The dominant source of electrical energy for these communities is through diesel fuel burning gen sets.
- Diesel fuel must be supplied to these communities.
- All of the community supply comes from brief winter road access or by air.

Motivation and Objectives

- Need for clean, reliable renewable electricity in remote communities of Canada and other parts of the world (e.g. India, Chile).
- Reduce energy costs and cost uncertainty (fuel and transportation).
- Energy costs in remote Canadian communities can be many times greater than a grid connected community.
- Reduce potential damage to environment from fuel transportation and emissions (gases and other emissions).

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Motivation and Objectives

- Determine local renewable energy sources (wind, hydro, biomass, geothermal, solar) most appropriate economically and technically for climatic conditions of the remote community.
- Develop microgrid controller technologies to properly integrate and control multiple energy sources and storage, considering a possible eventual connection to the grid.

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Example: Kasabonika

Kasabonika Lake

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Example: Kasabonika

- Existent system:
  - Three Diesel Generators 1000, 600, 400 kW
  - Wind turbines: existent 3x10kW + new Wenvor 30kW being installed
  - Diesels have worked well for many years and are a well-known technology.
  - Many are familiar and comfortable with operational aspects.
  - Require regular attention (maintenance, service, replacement).
- Currently under load growth restrictions since 2008 until a new 2MW generator is added, but funds are not available for 5 years and community is “desperate” for alternative options.

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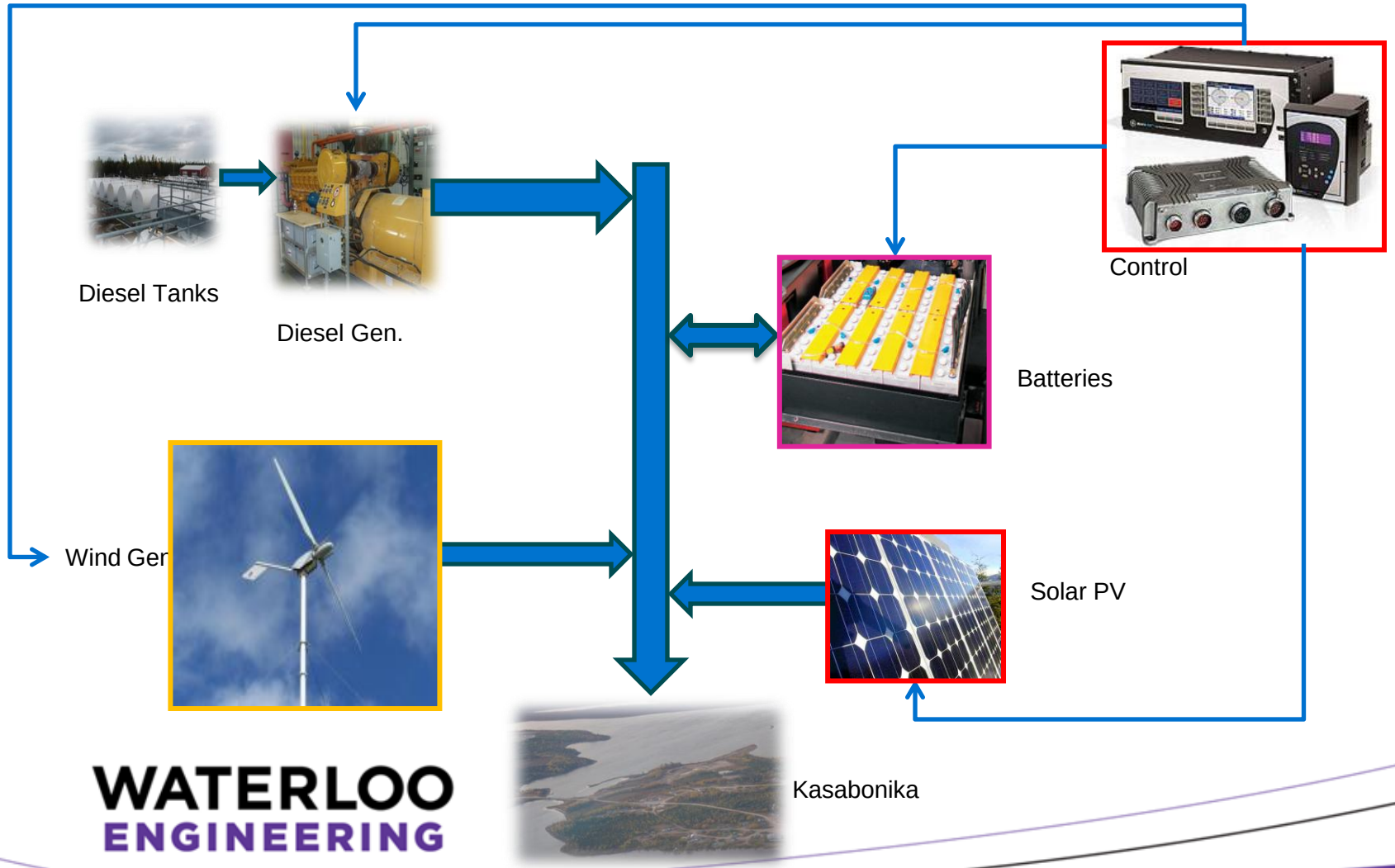
Example: Kasabonika



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Microgrid Modeling and Simulation

- Models:
  - Components, particularly DG units.
  - Integrated system.
- Simulations and studies:
  - Power flow.
  - Voltage stability: regulation and loadability.
  - Eigenvalue analyses.
  - Transient stability.

Optimal Operation and Control

- Voltage and frequency regulation and control.
- Optimal dispatch.
- Interaction with main power system for grid-connected microgrids.
- Improve existent power management algorithms.
- Develop and test algorithms that can be included in a “real” system controller.

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Optimal Planning

- Determine best microgrid design technically and economically.
- Consider:
  - Local resources.
  - Type of equipment.
  - Sizes.
  - Costs: purchase, installation, operation and maintenance.

Current Status

- PhD students working on these projects:
  - Ehsan Nasr:
    - ABB-MITACS project with Prof. Kankar Bhattacharya.
    - DG modeling, simulation, analysis and control of microgrids.
    - Has just finalized his PhD proposal and is preparing a conf. paper on DG modeling and stability analysis and comparison.
  - Daniel Olivares:
    - Chilean scholar, co-supervised with Prof. Mehrdad Kazerani.
    - Optimal “automatic” dispatch of microgrids.
    - Has just finalized his PhD proposal and has presented a conf. paper on optimal centralized dispatch of microgrids.
  - Mariano Arriaga:
    - NSERC scholar, co-supervised with Prof. Mehrdad Kazerani.
    - Optimal microgrid planning.
    - Preparing a presentation on microgrid planning for Kasabonika and working on a paper on planning for remote community microgrids.

Next Steps

- Continue with PhD students' research work.
- Planning to apply for NRCan's ecoENERGY Innovation Initiative:
  - Demo (RD&D) and R&D projects.
  - Microgrid integration in remote communities:
    - R&D microgrid at uWaterloo
    - Demo at Kasabonika: development, integration and control of existent diesel + existent wind + new wind + solar PV + batteries + load management, with significant and relevant community involvement.
  - Possible industry partners:
    - Kasabonika Lake First Nation: remote community
    - Hydro One: microgrid operation and maintenance?
    - Mahindra: system integration and microgrid control
    - SANYO: solar PV and batteries?
    - Schneider: microgrid protection and control?
    - Wenvor: wind?

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