The National Academies of Science, Engineering and Medicine QER *Workshop on:*

Electricity Use in Rural and Islanded Communities - Microgrids

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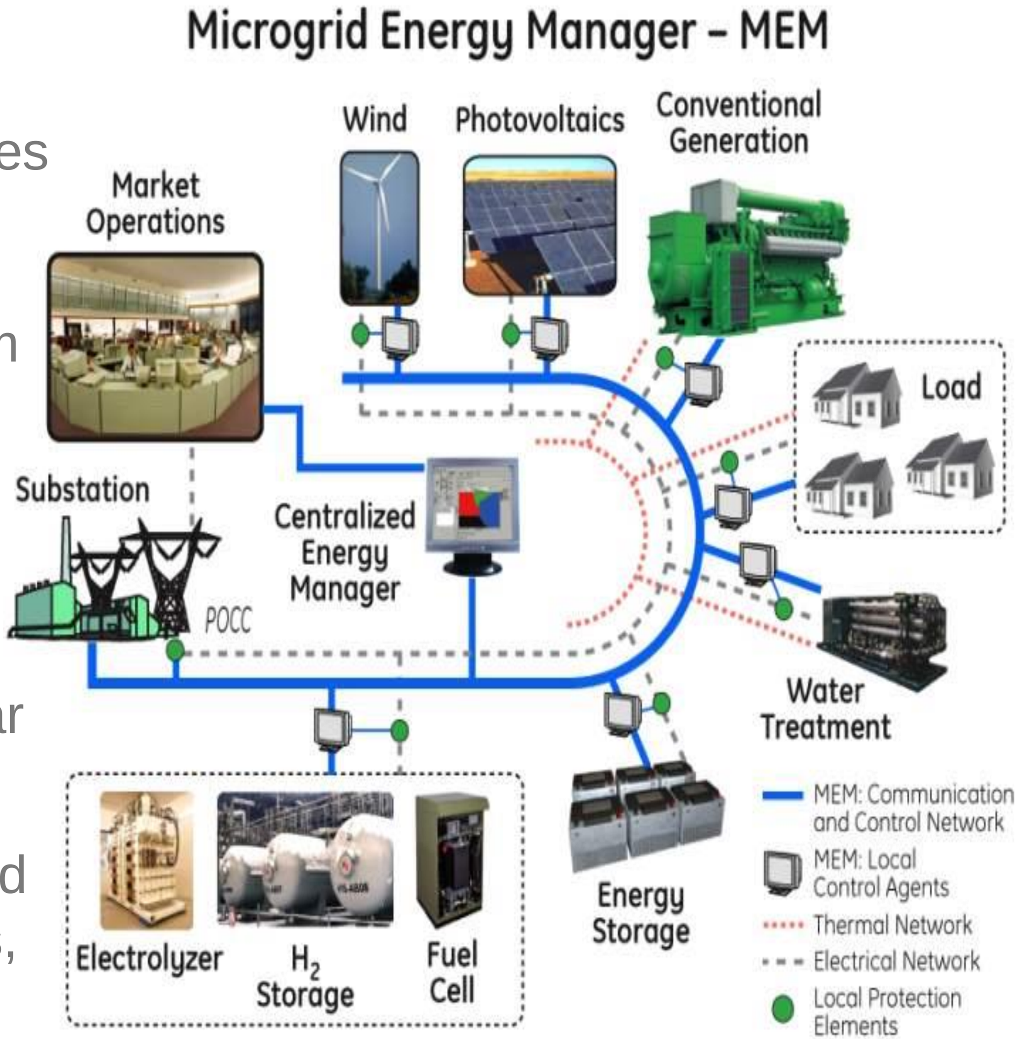
What is a microgrid?

A Microgrid is an integrated energy system consisting of interconnected loads and distributed energy resources (DERs); and can operate as an integrated system **parallel with the grid** or in an intentional island system (off-the grid mode)



Microgrids enable:

- Integration & optimization of high penetration renewables such as solar & wind
- Integration & optimization of demand resources such as commercial loads, energy storage, & water treatment

Microgrids enable high-penetration renewables

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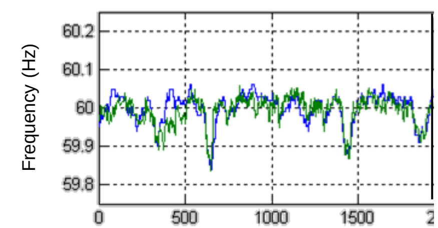
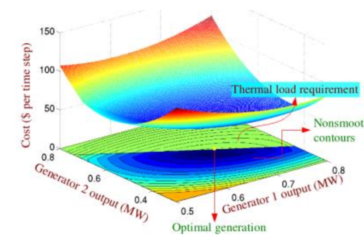
Challenges to Integrating Distributed Renewables

- Integration of non-conventional energy resources
  - Intermittency of renewables can impact grid stability
  - Desire driven by fuel costs and logistics
  - Low overload, short circuit ratings
  - Power rate limits
  - Rapid frequency changes due to lack of inertia

- Distribution protection and controls inadequate for distributed generation
  - Bi-directional power flows
  - Unit level voltage and VAR support
  - Fault current contribution
  - Island operation



- Supervisory controls needed to realize full operating potential
  - System-level energy optimization (electrical, thermal, loads)
  - Unit commitment and dispatch
  - Aggregation and system performance

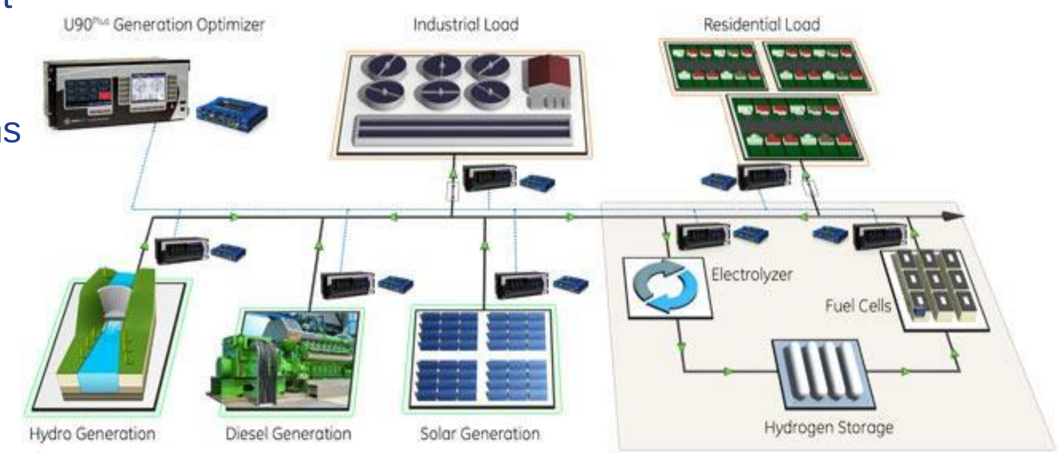


Design of a Microgrid – Potsdam, NY

Design of a resilient, community microgrid in the NY North Country to improve disaster response and Construct a National Grid underground distribution system for power and communications

Work Scope

- Site Survey Data Questionnaire Development
- Site Data Collection & Tabulation
- Homer/ DERCAM Modeling
- Conceptual Architecture + One-Line Diagrams
- Generation Size & Location
- Functional Scheme for MG Controller
- Dynamic interactions
- Fault simulation
- Protection coordination
- Synchronization
- Islanding and Black Start
  - ETAP and/or Aspen for Protection and Grounding
  - CymDIST Distribution Analysis Package
  - PSLF for Dynamics
  - PSCAD for transients



Potsdam Microgrid:
Interconnect more than 12 entities, including National Grid service facility, Clarkson University, SUNY Potsdam, Canton-Potsdam Hospital, Village of Potsdam buildings, plus commercial providers of fuel, food, and other essential emergency services.

Rural (Coastal) Microgrid – Boothbay Maine

Key Facts:

- Central Maine Power serves Boothbay Peninsula
- Served by single 34.5kV line (typical of coastal towns)
- Summer tourist season resulted in system overloads
- CMP proposed upgrading line for cost of $18 million
- In 2012 the Maine PUC approved a Pilot Project - Non Transmission Alternative (NTA)
- MPUC named Grid Solar LLC as “Smart Grid Energy Services Operator for NTA pilots

Rural (Coastal) Microgrid – Boothbay Maine

Key Actions/Results:

- In 2012, Grid Solar LLC issued RFP for ~2MW of local energy resources: energy efficiency, demand response, smart grid technologies, and small scale, clean distributed generation
- Grid Solar awarded contracts for 1,677kW of Projects:
  - Energy efficiency -lighting(243 kW)
  - Solar photovoltaics (PV) (308 kW)
  - Back-up diesel generation (500 kW)
  - Demand response and peak load shifting (252 kW)
  - Lithium Ion battery energy storage (500 kW)
- Dispatched by Grid Solar from their Portland control center
- Net cost of ~$6MM – Savings of over $12MM to ratepayers

Barbados Wind & Solar Integration Study

The Barbados Light & Power Company (**BL&P**), as with all Emera companies, **is committed to finding clean energy solutions and developing renewable energy sources** for Barbadians. Indeed, BL&P continues to work with the Government and people of Barbados towards the national goal of 29 percent renewable energy by 2029.

To this end, in 2014 BL&P commissioned GE Energy Management Consulting to **analyze the technical and economic impact of intermittent renewable energy sources,** namely wind and solar PV, on the Company's generation, transmission and distribution system. The study sought to **determine the extent of changes**, if any that were **necessary to accommodate the sustained integration** of intermittent renewables on the grid, with a view to providing suitable recommendations

http://www.blpc.com.bb/watts-new/302-barbados-wind-and-solar-integration-study-the-barbados-light-power-company-bl-p.html

Barbados Wind & Solar Integration Study

The Study Objective:

The objective of the study was to **analyze the technical and economic impact** of intermittent renewable energy (RE) sources, namely **wind and solar PV**, on the generation, transmission and distribution **system** of The Barbados Light & Power Company Limited (BLPC). Using detailed power system modeling, **the study assessed** numerous aspects of the BLPC system related **to planning, design, renewable integration, grid operation, and reliability with the objective of providing recommendations on**:

- **Changes**, if any, to the requirements and standards for interconnecting intermittent renewable energy resources
- **Maximum allowable intermittent renewable energy limit** that can be accommodated on the existing system without mitigation measures
- **Mitigation measures** (including energy storage technologies) and associated costs to accommodate renewable energy for the scenarios presented

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Barbados Wind & Solar Integration Study

Key Findings:

The **penetration levels** of wind, central PV, and distributed PV investigated in this study **can be accommodated** on the BLPC grid, **provided certain mitigation measures are incorporated.**

The **only major risk** from increased renewable energy penetration **is associated with dynamic response of distributed PV resources**. The study findings conclude that:

- Without mitigation measures and under operating conditions studied, the existing grid can accommodate up to
  - 20 MW of distributed PV
  - 15 MW of Wind
  - 20 MW of Centralized PV

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Barbados Wind & Solar Integration Study

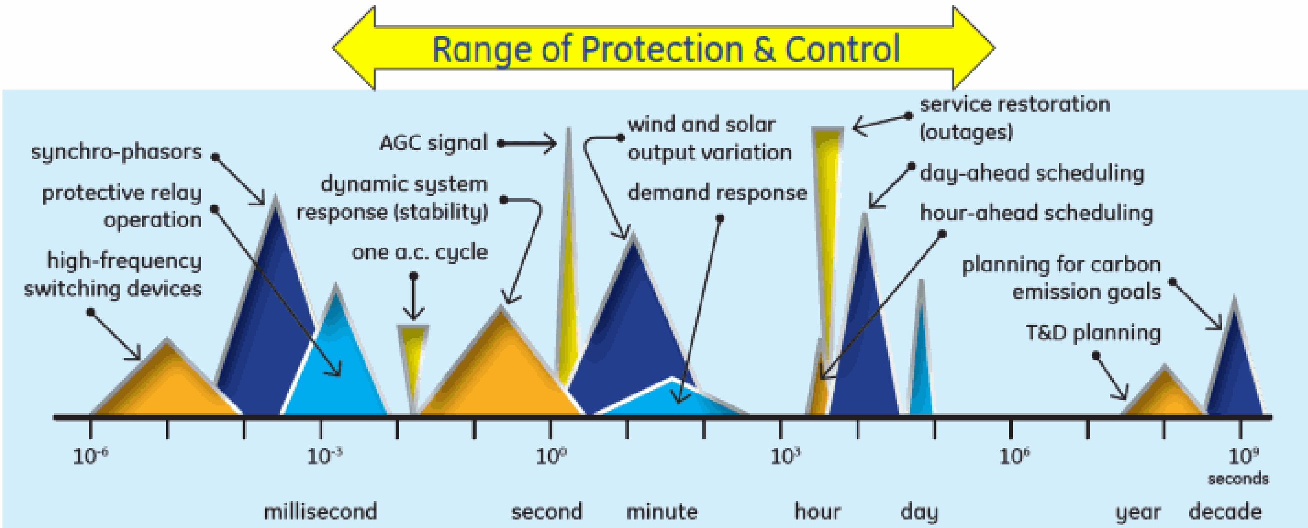
Key Findings (cont):

- The following mitigation measures are required to maintain the BLPC grid reliability and security under the examined renewable energy penetration limits:
  - Increased spinning reserves to counteract variability of wind and solar
  - Automatic generation control for improved frequency regulation
  - Frequency and voltage ride through capability on all renewable energy plants
  - Governor droop response from thermal and renewable plants
  - Improved voltage control on distribution feeders

- Voltage and frequency ride through capability on all new distributed PV systems is especially critical for Barbados, since independently owned distributed PV is likely to be the dominant type of Renewable energy resource on the island.

Focus

Electric Power System Time Scale



15 Orders of Magnitude

Source: Adapted from Alexandra von Meier, ACC2011 Workshop on SG

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