Practical considerations for remote microgrid design and energy management

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Presentation overview

1. Considerations with integrating renewable generation in remote communities
2. Opportunities through microgrid control and EMS design
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2. Opportunities through microgrid control and EMS design
Canadian context

Source: NRCan/AANDC
Technical issues/considerations

Safety

Utilities’ prime mandate is to provide safe, reliable power to their customers

Safety

• Voltage and frequency regulation, power quality
• Protection system analysis
  – nuisance tripping
  – non detection zones
  – protection coordination
Technical issues/considerations

Adequacy

Utilities’ prime mandate is to provide safe, **reliable** power to their customers

**Adequacy**

- Ability to supply the required power and energy without exceeding system ratings or operating limits, and with voltages and frequency within tolerances
  - Energy balance
  - Load flow analysis
Technical issues/considerations

Security

Utilities’ prime mandate is to provide safe, **reliable** power to their customers

**Security**

- Security is the ability to tolerate a credible event without loss of load, over-stress of equipment, or deviation from voltage and frequency tolerances
  - Large disturbance stability
  - Small signal stability
Remote challenges

System

- Lower system inertia
- High phase imbalance
- Low X/R ratio
- Legacy equipment
- High reliability requirement

Iqaluit, Nunavut, Canada
Remote challenges

Technology
Once you’ve seen one remote community…

You’ve seen one remote community
Presentation overview

1. Considerations with integrating renewable generation in remote communities

2. Opportunities through microgrid control and EMS design
MICROGRID ENERGY MANAGEMENT SYSTEMS
MARKET PERSPECTIVE AND VENDOR OFFERING

Farid Katiraei & Shadi Chuangpishit

Bucharest 2018 Microgrid Symposium
Outline

- Introduction
- Microgrid Energy Management Systems
  - Technical aspects & Standards
  - Structure and functional considerations
  - Market perspective - based on vendor surveys
- Summary and Conclusions

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- Yves Poisson
- David Turcotte
Canadian remote communities

**Challenge:**
High diesel fuel costs

**Solution:**
Renewable energy resources integration forming Mini-Grid / Microgrid

**Report Objective:**
Assess the availability of commercial microgrid controllers and communication interfaces for managing integration and utilization of renewable and sustainable energy resources in Canadian remote communities.
**Energy Management Systems (EMS)**

- **Primary control** (asset/device level controllers):
  - Performing the role of voltage and frequency regulation and power balancing

- **Microgrid / Mini-Grid EMS** (Supervisory controls or Master controller):
  - Performing the role of coordinating resource utilization and operation of various elements of the system. Different EMS types include varying levels of resource Optimization to achieve certain operational goals
EMS Key Requirements

- Managing connection/disconnection/dispatch of DERs
  - Coordinate operation of various assets in different modes of operation
- Reducing diesel (fossil) fuel consumption
- Increasing renewable energy penetration
- Managing voltage (power quality) across the microgrid
- Performing load management for enhancing efficiency

All of the above has to be achieved with better performance & reliability with respect to the existing grid !!!
IEEE 2030.7- Standard for the Specification of Microgrid Controllers

- To address the functions above the device-level control that are associated with the proper operation of a Microgrid and common to all microgrids, regardless of topology, configuration or jurisdiction

IEEE 2030.8- Standard for the Testing of Microgrid Controllers

- The common (core) functions are also defined in a way that they can be tested using a pre-defined test procedures and a set of performance metrics

Purpose:

- Achieve modularity and interoperability of interfaces to enable wide adaptation of the functions and controllers
- Focus on a modular approach that enables potential future expansion and new features.
IEEE 2030.7 - Functional Framework

Vendor Perspective | Standard Perspective

Advanced features

Basic features

Asset level features

Higher level functions
- Operator Interface
- Optimal dispatch
- Grid/Market communications

Core level functions
- Connect / Disconnect
- Dispatch (including simple rules)

Lower level functions
- Voltage/frequency controls
- Device level controls

Microgrid Controller functional view
Two types: **Centralized Vs. Distributed**

**Centralized Control**

**Distributed Control**

**Note:** primary controls are distributed by nature (at DER level)
Microgrid Control Systems

Market Perspective

- Who are the market players?
- What do they offer?
- At what price?
North American Market Players – Microgrid EMS

Note: Vendor survey was performed in Q1 2017
# Examples of EMS Deployment in Real World Projects

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<th>Vendor</th>
<th>Product</th>
<th>Customer/Project/Location</th>
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<td>IPERC (S&amp;C)</td>
<td>GridMasterTM</td>
<td>Department of Energy (DoE), Department of Defense (DoD), and Department of Homeland Security (DHS) - SPIDER Projects</td>
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<td><a href="#">Ameren Illinois Microgrid</a></td>
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<td><a href="#">“TransitGRID”</a> (New Jersey)</td>
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<td>Alstom (GE)</td>
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<td>ABB</td>
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<td>Ross Island Wind/Diesel (Antarctica New Zealand)</td>
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<td>Encorp</td>
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<td>Chowchilla and Red Bluff (California)</td>
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<td>Princeton Power</td>
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<td>Alcatraz Island Microgrid (San Francisco Bay)</td>
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<td>Annobon Island Microgrid (Equatorial Guinea)</td>
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<td>Siemens</td>
<td>SICAM Microgrid Controller Solution</td>
<td>IREN2 project (Wildpoldsried, Germany)</td>
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<td>SMA</td>
<td>Fuel Save Controller</td>
<td>PV-Diesel Hybrid System (Cojiba/Bolivia)</td>
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<td>University Hospital (Mirebalais, Haiti)</td>
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<td>Spirae</td>
<td>Spirae Wave</td>
<td>SDG&amp;E - <a href="#">Borrego Microgrid</a> (California)</td>
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<tr>
<td>SPS</td>
<td>Universal Microgrid Controller</td>
<td>San Nicolas Island Wind/Diesel Microgrid (California)</td>
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Vendor Comparison

**Product or Solution**
- Off the shelf with re-defined library of functions
- Or requires significant engineering by vendor

**Open source or Proprietary**
- User programmable
- Based on logical blocks and standard schemes

**Basic and Advanced features**
- Standardized functions for remote applications
- Reliability and robustness of solutions

**Price**
- Hardware/software cost
- Design/Engineering/Deployment cost
RFQ – System 1 & System 2

Remote Small Mini-grid

Diesel:
PV:
BESS:
Load:

Remote Micro-grid

Diesel:
PV:
BESS:
Load:

Note 1: CB is equipped with interconnection relay with protection settings for detection of grid outage, or power quality issues to disconnect and also with sync-check for re-connect.
Price Comparison: Microgrid Controller

Price Comparison

Vendor 1  Vendor 2  Vendor 3  Vendor 4  Vendor 5  Vendor 6  Vendor 7  Vendor 8

$-$  $50,000.00  $100,000.00  $150,000.00  $200,000.00  $250,000.00  $300,000.00  $350,000.00  $400,000.00  $450,000.00

System 1  System 2
EMS Controller: System 2 Prices

System 2 Price in $k

- Total price
- Engineering/Design
- Software configuration, user manuals and licenses
- Control, communications and monitoring hardware
Summary & Conclusions

- Great interest on integrating renewables in microgrid has created the vendor focus on Controller products and Solutions
- Major differences in vendor offerings (features and approaches) and therefore, large variations in pricing
- **Not off-the-shelf:** For many vendors, solutions require a great deal of engineering and customization
- The main focus would be to develop some baseline system requirements and RFQ template that can help system owners and developers narrow down on solutions and prices.
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