Microgrids
Technology Selection

Presented by

CHA Consulting, Inc.
William John Joyce, PEng
Senior Project Manager

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CHA design/construction solutions

Agenda

- History of Power Generation in North America
- Microgrids - A Review in Brief
- Generation Technologies for Consideration
- Technology Analysis & Modeling
- Questions & Answers

Look

Listen

Beware of the hazards surrounding you!

- Waterfront
- Crossing Lights
- Trip Hazards

History of Power Generation – N. America

- Centralized Generation - Base load on thermal/nuclear power with mix of hydro power (by Region)
- Embedded cogeneration helped increase generation efficiency
- Renewables – PV and Wind in West → East
- Reduction in thermal (specifically coal) & expansion of renewables & micro-renewable projects
- Distributed generation - microgrids

What is a Microgrid?

- Microgrid is a localized group of electricity sources & loads that normally operate connected to & synchronous with traditional centralized electrical grid (macrogrid)
- Can also disconnect to "island mode" & function autonomously as physical and/or economic conditions dictate

Why a Microgrid?

- Platform to integrate renewable energy sources (environmental)
- Enhances the macrogrid - handle sensitive loads & supplies power in areas of constrained transmission or distribution
- Promotes integration of DER to increase resiliency & system efficiency
- Promotes integration of Smart Grid Technologies

Microgrid Types

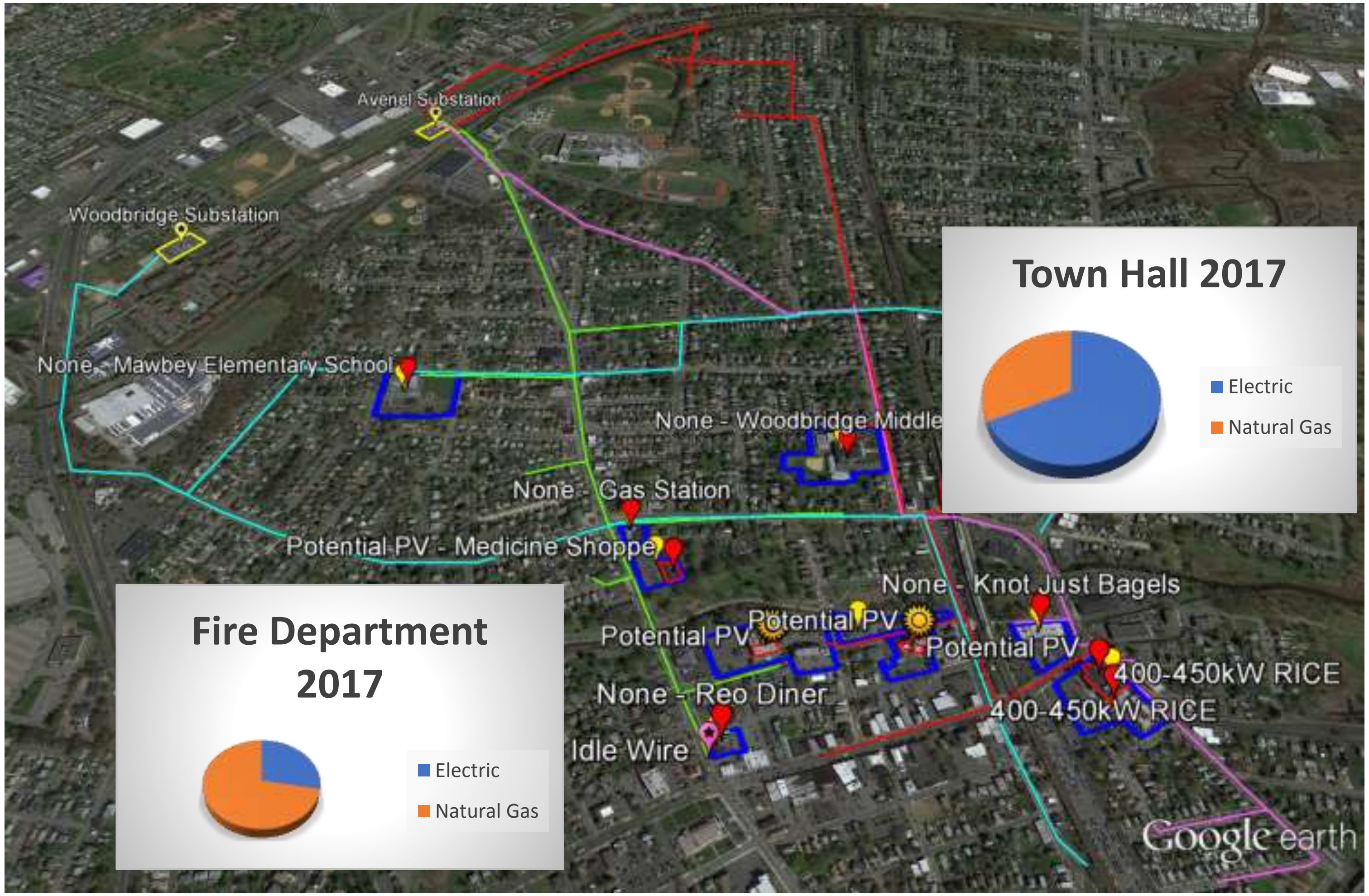
- **Customer Microgrid** - Self governed, down stream of PCC
  - Examples: Municipality, institutional or industrial campus, hospital facilities
- **Utility Microgrid** - Segmented boundary of the macrogrid
- **Remote Microgrid** - Serves respective connected thermal & electrical load(s); often with unique challenges in handling step-loads & load shedding
  - Examples: Arctic mine-site or high altitude community

DER Technology Selection

- Distributed Energy Resources (DER) are small-scale thermal & electrical power generation sources located in a defined boundary to serve respective connected load(s)
- **Electrical** generation technologies include:
  - Gas Generators – Reciprocating & turbine engines (including microturbines)
  - Photovoltaic (PV) and Battery Energy Storage Systems (BESS)
  - Fuel cells
  - Small wind turbines
- **Thermal** generation technologies include:
  - Renewable power technologies (DG, bio fuels, bio mass)

Application of DER Technologies

- **Step 1** – Determination of thermal & electrical load profile of facilities or defined boundary to be served (define: min/max/base)
- **Step 2** – Define design/evaluation criteria of project
  - Financial, environmental, spatial, availability, redundancy, simplicity/operability
- **Step 3** – Align array of (thermal:electrical) outputs for selected technologies to efficiently satisfy dynamic profile of loads served considering constraints of respective connection to macro grid (feeder) & host facility


Avenel Substation
Woodbridge Substation
None - Mawbey Elementary School
None - Woodbridge Middle
None - Gas Station
Potential PV - Medicine Shoppe
None - Knot Just Bagels
Potential PV
Potential PV
Potential PV
400-450kW RICE
400-450kW RICE
None - Reo Diner
Idle Wire
Town Hall 2017
Electric
Natural Gas
Fire Department 2017
Electric
Natural Gas
Google earth

Generation Technologies

- **Electrical** - Gas Generators - Reciprocating Engines
  - Availability - Typically >95%
  - Black-start - Battery or compressed air
  - Capacity - 10kWe → 18MWe
  - Degradation - Relatively flat output profile with rebuilds at 40k/80k OH
  - Emissions - Most prime units can achieve EPA Tier 4 levels. Noise mitigation required
  - Functionality - Fast response to step-load; “efficient” > 50% MCR
  - Generates - Electricity (eff <44%), hot water, low pressure steam & chilled water (using absorption chiller)

- **Electrical** - Gas Turbine and Microturbines
  - Availability - >96% for 1-5MWe; <95% for machines >5MWe
  - Black-start - Require aux generator (micro units can start off battery bank)
  - Capacity - 500kWe → ~500MWe
  - Degradation - Altitude & ambient temperature effects are predominant. Cycling & ambient air (& fuel) quality dictate rebuild at 25k-50k OH
  - Emissions - Can achieve low levels of NOx & CO, within combustion process or treat TEG with CO Catalyst, SCR, etc.. Noise mitigation required.
  - Functionality - Fast response to step-load; electrical efficiency degrades linearly at reduced load. E.g. Solar Mars 100 (100→60)%MCR Response: (32→23)% Elec Eff.
  - Generates - Electricity (eff ~ 26-38%), ideally suited for steam production due to high-temperature exhaust

- **Electrical** - Photovoltaic (PV) & Battery Energy Storage Systems (BESS)*
  - Availability - Vary by geographical location, time of day, weather conditions
  - Black-start - N/A; BESS can discharge to prescribed VA when dispatched
  - Capacity - 100 We → N (size of array) (Capacity Factor ~ <25%)
  - Degradation - Minimal degradation of substrate; eff >80% after 20 years
  - Emissions - As good as sustainability measures to produce/dispose of cells
  - Functionality - BESS provides rapid response to step-load and load rejection
  - Generates - Electricity (eff ~ 35-45%), represents maximum achievable efficiency of PV material. Actual efficiency is influenced by output voltage, current, junction temperature, light intensity & spectrum
  - *Similar to attributes of small wind turbines (1-300kWe) c/w BESS

Generation Technologies

- **Electrical** - Fuel Cells (Natural Gas)
  - Availability - 99.9%
  - Black-start - Yes
  - Capacity - >200kWe for economics of CHP
  - Degradation - Minimal degradation of cell or array (output) over economic life
  - Emissions - Associated with fuel stock reformer (CO_2)
  - Functionality - Processor/reformer converts natural gas to H_2; long start-up time; MINIMAL operational supervision & related OPEX. Biogas compatible.
  - Generates - Electrical efficiency (>40-<60%); with waste heat <~85% (limitations on grade of waste heat, suitable for space heating, DHW, etc.)

Generation Technologies

- **Thermal** - Renewable Power Technologies (DG, bio fuels, bio mass)
  - Bio-fuel & digester off gas blending for recip gas engines
    - Traditionally availability of unit is less than equivalent machine running on pipeline quality natural gas
  - Gasification of biomass (snyn-gas) fueling a modified gas engine. (50kWe, ~150kWe modules)
    - Market expanding in Europe for this technology; high reliance on standardized fuel supply
    - OPEX higher than a traditional gas engine
  - Conversion of traditional boiler to carbon neutral biomass fuel(s)
    - Traditionally significant investment required on front and back ends of the boiler (furnace)
    - Spatially can be challenging with existing sites (facilities)
    - Boiler capacity (MCR) usually de-rated

Technology Analysis & Modeling

- Traditional modeling efforts offer paralleled comparison to matching electrical:thermal profile for system studied, but lack ability to integrate complexity of external variables such as:
  - Multiple generation technologies under varying forms of dispatch
  - “Look-ahead” forecasting for renewable generation assets
  - Peak-shave forecasting
  - Thermal & electrical energy storage opportunities
  - Building management systems
- A number of commercial & institutional software options exist in the marketplace to simplify these “complex” modeling efforts

Thank You.

For more information, please contact:

William John Joyce, PEng
Senior Project Manager
p. (905) 984-8383, ext. 260
e. wjoyce@gryphoneng.com