Alaska High Variable Renewable Penetration Microgrids
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Adapted from:
Ben Kroposki, NREL

References:


Published Concept Paper in 2016:
Achieving a 100% Renewable Grid

As solar and wind costs decrease – these penetration levels are economical.
Alaska wind-diesel systems

- ~2 dozen wind-diesel systems
  - 18 kW - 3 MW average load
  - ~6 30-40% average wind penetration
- Three operational diesel-off systems:
  - St. Paul Poss Camp (1999)
    - 70 kW average load
    - 34% (55%) average penetration
    - Synchronous condenser
    - Thermal storage
  - Kongiganak and Kwigillingok (2017/20)
    - 117 / 150 kW average load
    - 29% (before BESS - now?) / 34% avg. pen.
    - Li-ion BESS with Inverter
    - Electric thermal stoves - distributed heat
Some history

• Metlakatla (1997, 2008)
  • 3.5 MW peak load at time of installation (sawmill)
  • 5 MW hydro, 3.3 MW diesel now standby only
  • 1 MW / 1.4 MWh Lead Acid battery
  • Frequency responsive regulating reserve

• Kotzebue (1997, 2105)
  • 2 MW average load / 3 MW peak load
  • 2.94 MW wind, 20% average penetration, 80-90% max instantaneous penetration
  • 1.25 MW / 950 kWh lithium ion BESS
  • Frequency responsive reserve - wind plant support

• Wales (2002 - Non-operational)
  • 70% penetration (design)
  • Ni-CAD BESS with rotary converter
  • Electric boiler
  • Lessons learned
Challenges and opportunities

• Variable and uncertain resource
  • Regulating reserve
  • Contingency reserve

• Converter-dominated power systems
  • Stability
    • Low to zero inertia
    • Frequency is no longer a fundamental indicator of power balance
    • Converter control algorithms play leading role
  • Fault identification and clearing, protection coordination
  • Motor loads
  • Black start
  • Transient and dynamic modeling

• Replacing lost heat to heat recovery loads
• Emissions regulations
• DC interties
ACEP PSI Lab

- Diesel generators
  - 320 kW Caterpillar C-15, Woodward easYgen
  - 125 kW Detroit Diesel, Woodward easYgen
- 100 kW PV simulator
- 100 kW wind turbine simulator
- Battery energy storage system
  - 600 kW / 270 kWh lead-acid battery
  - 313 kVA ABB PCS100 Inverter
- Load banks
  - Two 250 kW / 188 kVAR RL load banks
    - 5 kW / 3.75 kVAR steps
    - 55 kW resistive load bank
- Fault emulator
  - 3-phase, 480 V, up to 10 kA faults
  - Faults: 3-phase, single l-l, single l-g
- Future: line impedance simulation
Three-phase fault emulator
Initial fault tests:
Bolted 3-ph fault with BESS, 40 A type K fuse
Characterizing system dynamics:

**Load Step Response Example**
Effect of ramp rate on diesel fuel efficiency

Steady state fuel curves

190 kW
Tier 4

320 kW
Tier 3

457 kW
Tier 2
Thank you!

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