Application of Flexible Thermal Loads for Balancing Renewable Energy in Cold Climates

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Flexible Thermal Loads: Electric Thermal Storage (ETS) and Water Heater (EWH)

- Winter Peaking Power System
  - 9 provinces out of 10 in Canada
  - Two peaks per day
- Lower load factor of the T&D network < 50 %
- Residential water heaters and electric heating at peak time

**Graph:**
- Peak reduction with EWH and ETS
- Load Profile (GW)
- Time of day (Hours)
- Reduction in peak demand through smart EWHs, ETS, and fuel switching
Controlled Heating and Wind Integration - New Brunswick Case Study

- Quantified benefits that the provincial energy generation system could receive by adopting smart-grid connected ETS

CanmetENERGY Findings:

- Controlled heating can permit much higher penetrations of wind
- At 25% penetration of smart electrical loads (electric water heaters and electric heating) will save 1% of generation costs each.
- Result in 0.3 and 0.5 t reductions in CO2 per unit per yr (0.7%).

Electric thermal storage (ETS) unit winter operation, demonstrating that the smart grid is important for controlling these devices (rather than time-of-use).
Yukon Electric Smart Grid - Case Study

~15,569 homes (~15,000 electrically heated)
- Must run diesel generators to meet peak demand
- Wind integration with local flexible hydro resources opportunity

CanmetENERGY Findings to date:

• Wind and electric thermal storage (ETS) can reduce the need for additional generation capacity
• The new technologies enable utility savings through better asset utilization and optimized generation
• Reduction in GHG (-29 to -86%)

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GHG Reduction (t CO\textsubscript{2}e) 830 (-29%) 7100 (-77%) 13 500 (-85%) 14 800 (-86%)
Award winning community engagement -

Demonstration Project - Summerside, Prince Edward Island, Canada
Summerside Local Municipal Utility

- Summerside Electric - Municipally owned utility, operating since 1920
- 14,500 population, 7,000 customers
- 12 MW wind farm built in 2009 by City of Summerside with power purchase agreement ($0.08 / kWh)
- In 2010 produced on average 15% excess electricity (8,500,000 kWh)
- Exporting surplus to New Brunswick Grid provided very low market prices ~ $0.03-$0.05 / kWh therefore net losses for Summerside Electric (~ $300,000 annually)
- Encourage customers – Heat for less with local wind power (Residential heating oil more expensive)
Summerside “MyPowerNet” Vision

Customer savings:
• CO2 emissions ↓ 42 %
• ↓ heating and hot water costs by 35 %
• 99 % customer satisfaction

Utility savings:
• Reduce exports, increase off-peak sales
  • 2010 exports: 8 500 MWh
  • 2011 exports: 7 443 MWh
  • 2012 exports: 4 103 MWh
  • 2013 exports: 3 363 MWh

Summerside 2006 Strategic Plan:
• Become 100 % green city (wind farm)

MyPowerNet Vision:
• Passing wind farm benefits to residents
• Creating additional revenue for the utility
• Create economic development opportunities
Summerside Dashboard and Gateway

- Higher wind energy integration – community profits; Wind farm creates long-term stable prices (wind-powered electricity vs. market-driven oil prices)
- Gateway for building energy management at no cost for the Community – Web Portal
- Living Lab for R&D in Energy Sectors – new HUB for renewable energy innovations.
“Empower the people of Summerside”

• 5 year or less payback (ROI >20%)
• $0.69 / Litre of Oil versus $1.153 today – savings on heating costs of 40%
• Convenient and comfortable (no life style change)
• Wind Green energy option - environmentally friendly
• Increased disposable income
• Electricity Conservation and Information – consumer portal
First of a kind community engagement -

Alaska First Nation Remote Community, USA
Multi-Village System Design

- Estimated average homeowner consumes 766 gallons of heating fuel at a cost of over $6.24 per gallon.
- Heating can be more than 60% of a household budget.
- The decision was then made to implement a wind system sufficiently large enough to generate excess wind energy.
- Local resources and local employment.
- This would represent a significant cost savings to the average consumer while increasing revenues to the local utility.

Source: Denis Meiners, Intelligent Energy Systems
Community Dashboard

- The Puvurnaq Power Company serves the community of Kongiganak, a traditional Yup'ik Eskimo village of 439 permanent residents.
- The community includes a school, washeteria, community center, clinic, lighted 2500-foot runway, a bulk fuel storage facility, two small local stores, and 135 residences.
- The economy is based primarily on a fishing and subsistence lifestyle.
- Wind-diesel systems hold promise for lowering power costs and reducing diesel fuel use for this and many communities in rural Alaska.
- Local employment includes work at the school, limited commercial fishing and seasonal construction.

Source: Denis Meiners, Intelligent Energy Systems
Electric Thermal Storage

- Heat from wind estimated to be approximately 50% lower compared to oil heating
- Regulated according to seasonal weather conditions using an outdoor temperature sensor and an onboard microprocessor
- Brick core of the heater ETS unit
- ETS control features include:
  - Under frequency detection and disconnection relay
  - Submetering of heating elements
  - Individual element control for 100 watt resolution per device
  - Two way communications between each ETS device and the powerhouse

Happy to replace oil heating to wind/ETS
Summary - Alaska remote village project

- Village local government formed the Chaninik Wind Group in 2005 as a way to pool resources.
- Cost of oil heating and diesel electricity was increasing every year. Wind is a local resources and clean power source at 50% lower cost.
- Heating surveys indicate that average hourly living room heat for a residence in Kongiganak is 14,000 Btu/hr.
- Each thermal storage unit can both produce and store up enough energy depending on the charge schedule to output 20,000 Btu/ per hour per unit, 24 hours a day. (This is similar in size and energy output to a Toyo Stove typically used – therefore replace oil heating).
- For the wind-diesel application using dynamic schedules, charging ETS in periods of high wind.
Concluding remarks

- Customer-Level Energy Systems Integration solutions are being deployed.
- Flexible thermal loads/Storage offer an opportunity to integrate variable wind energy.
- Demonstration projects show the benefit for the local community and the customers.
- Government funding helped to make these initial projects economic.
- The cost of residential solutions and communication systems need to decrease for these options to be deployed on a larger scale.
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