Future Proofing Dalhousie’s Energy Platforms for the 21st Century

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Agenda:

• Sustainability Drivers
• Operational Drivers
• AC Project Implementation
• Halifax Plant
• Q&A
Where are we?
Dalhousie University Campuses

Founded in 1818

100+ buildings/houses on 79-acres in downtown Halifax.

50+ buildings AC campus

Includes 5.8 million gross square feet of building space.

A campus population of approximately 26,500 (19,000 students, 7500 faculty and staff).

Four Campuses: Studley, Carleton, Sexton – Downtown Halifax, AC – Truro Bible Hill

Two Heating Plants & District Heating Systems that connect 96% of the load
Dalhousie University - Studley, Carleton & Sexton – Halifax Campuses
Dalhousie University - Agricultural Campus
Sustainability Drivers

• Ethical and social ramifications

• Environmental implications – air pollution, climate change

• Economic – carbon policies, life-cycle savings, security, hedge against rising utility pricing

• Leadership role

• Reputation

• Student and employee recruitment

• Teaching, learning, and research role
Key Goals

- reduce life-cycle costs
- increase energy-water efficiency
- conserve energy and water
- reduce air quality contaminants and greenhouses gases
- improve energy security
Planning Context for Energy and Renewables
Climate Change

MITIGATION

- Reduce GHG emissions and carbon footprint
  - Energy and water efficiency
  - Conserve energy
  - Fuel switching and renewable energy
  - Bike/walk/bus to campus
  - Carbon sinks

ADAPTATION

- Planning for inevitable climate changes (warmer, wetter, wilder)
  - Energy Security
  - Flooding
  - Resilient skins
  - Emergency centre

Co-generation, District Energy, Hot Water, Renewable Fuel
In the fall of 2012, Dalhousie and the Agriculture College merged. A basic audit of electrical opportunities had been done for the College in 2010. To supplement this work, a report was completed in 2014 on renewable energy opportunities including pursuing biomass co-generation.
Background

• The current biomass boiler (28 years old) is at the end of its useful life.
• Small scale efficient biomass co-generation one of the 10 projects in the AC Renewable Energy Master Plan (2014). Other projects being explored solar, anaerobic digestion, wind partnership.
Background

• A COMFIT rate (17.5 cents a kW for electricity) was approved for this project in June 10, 2014 (Amended April 19, 2016 – to be 1 MW).

• A report on the life cycle of a number of heating systems for the campus was completed. (October 2014).

• A report on stakeholders’ perceptions of biomass fuel and plant operations was completed. (October 2014).
COMFIT

• Operational Date – No later than June 10, 2018 (4 yrs)

• Directive 2 & 4:
  – Priority on wood waste; descriptions of types and environmental conditions
  – Air quality requirements – 35 pm mg/m3 based on total thermal input – ESP needed
  – High efficiency
Project Goal

- Address facilities renewal costs of an existing end-of-life system
- Support university and community carbon reduction goals
- Promote and support existing and new sustainable biomass supply
- Connect research, teaching and operations
- Support local economic development
Fuel Supply

• Created Fuel Values Statement
• Engaged Stakeholders in open houses, RFI, and RFP
• RFP – included reference to type of supply wanted and allocation of up to 5000 tonnes for research type fuel
• Supply – Main amount waste wood residue (bark, shavings from local sawmill); Yard waste; willow and selective harvesting (research fuel)
• Silviculture – directed to selective thinning to increase biomass
What is special about Nova Scotia?
Agricultural Campus Heating Plant
Agricultural Campus – Heating Plant

Boiler #1 – 20,000 pph, HP steam boiler (furnace oil), 48 yrs old

Boiler #2 – 20,000 pph, HP steam boiler (furnace oil), 5 yrs old

Boiler # 3 – 12,000 pph, HP steam boiler (furnace oil), 36 yrs old

Boiler # 4 – 15,000 pph, HP steam boiler (Biomass), 28 yrs old
Agricultural Campus – Heating Plant

Peak Steam load – 27,500 pph

Annual Steam Production – 72,000,000 lbs

Annual biomass consumption – 8000 tons

June – Sept – 14hrs per day

Oct – May – 24/7 operation
AC Heating Plant – Operational Drivers for Renewal

Age – Biomass boiler is 28 years old

February 2014:  
- Biomass boiler experienced internal cracks
- Out of operation for over 2 months
- AHJ imposed operating restrictions
- Significant additional cost of burning furnace oil
AC Heating Plant – Operational Drivers for Renewal

Biomass Storage & handling
- Poor access to chip bin
- chopping and sawing frozen chips
- auger blockages
- Ash disposal is cumbersome
DAL AC- Biomass CHP: Initial Concept

- Feasibility Study Concept: 1.7 MWe, 600 psi, Extraction Steam Turbine
- Enlarge the Existing Fuel Bin
- Larger Steam Boiler, Increased Operating Pressure
- Install the Turbine in a New Adjacent Building
- Sound Technical Concept

Fatal Flaw(s):

- A large capital investment in Steam Based Infrastructure
- Complexity of Operating a High Pressure Steam Turbine
- Changes to Staffing Requirement
Five (5) Options were evaluated:

1) Replace Biomass Steam Boiler (Status Quo)

2) Biomass Superheated Steam Boiler w/ Extraction Steam Turbine

3) Biomass Thermal Oil Boiler w/ 700 kWe Organic Rankine Cycle CHP

4) Biomass Thermal Oil Boiler w/ 968 kWe Organic Rankine Cycle CHP

5) Biomass Superheated Steam Boiler w/ Back Pressure Steam Turbine
## DAL AC- Biomass CHP
### Screening Report- Quantitative

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<tr>
<th>No.</th>
<th>Description</th>
<th>Alt 1</th>
<th>Alt 2</th>
<th>Alt 3</th>
<th>Alt 4</th>
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[Images of DALHOUSSIE UNIVERSITY and FVIB ENERGY INC logos]
## DAL AC- Biomass CHP Screening Report - Qualitative

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<th>Criteria Descriptions</th>
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<th>Alt 3</th>
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DAL AC- Biomass CHP: Revised Concept

- Revised concept: 1.0 MWe Organic Rankine Cycle Generator
- Build a New Fuel Bin; Improve Delivery Logistics
- New Upsized Thermal Oil Boiler
- Install the ORC Turbine in New Adjacent Building
- Convert the Backup Boilers and Distribution Network to Hot Water
- No Change to Current Staffing Requirements
DAL AC- ORC Layout

- Condenser
- Regenerator
- Electric generator
- Pre-heater
- Evaporator
- Electric cubicles
- ORC turbine
- Feed Pump
DAL AC- Organic Rankine Cycle Generator

ELECTRIC POWER OUTPUT

BIOMASS POWERED BOILER (PRUNING OF BRANCHES, MARCS, HUSK, WOOD CHIPS, SAW DUST, BARK)

THERMAL LIQUID LOOP

DISTRICT HEATING

DRYING

REFRIGERATION

HEAT SINK

*Turboden ORC units can be also fed with saturated vapor or superheated water.*
DAL AC- Why an ORC Generator at DAL?

- High Turbine / Thermodynamic Cycle Efficiency
- Low Working Pressures; Unattended Operation
- Long Operational Life
- Large Turn Down
- Proven Technology
DAL AC - Biomass CHP LDC

Dalhousie Truro Plant Load Duration Curve - Full Conversion
Alternative 4 - Turboden 10 Electrical Production Mode

- ORC - Turboden 10
  - Thermal Input: 5,140 kW, 668 kW
  - Thermal Output: 4,087 kW, (@ 60-60°C)

- Fuel Oil Trim Heating
- Recoverable Heat Available from ORC System
- Biomass Thermal to Campus (13,800 MWh)

- Hot Water:
  - Peak: 7,000 kW, Energy: 15,000 MWh

- Steam:
  - Peak: 0 kW, Energy: 0 MWh

- Total:
  - Peak: 7,000 kW, Energy: 15,000 MWh

Future Available Heat

Fuel Oil Boilers 2 week shut down
DAL AC: Hot Water Conversion

- Hot Water Conversion was part of the Long Term Campus Energy Plan
- The Existing Campus Already used Hot Water for >95% of Campus Heating Requirement
- The Steam Distribution System was Nearing End of Useful Life
- Existing Oil Steam Boilers Could be Converted
- Twined Steam Lines Could Be Repurposed

DALHOUSIE UNIVERSITY

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