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

Darrell Boutilier, Director – Operations, Facilities Management
Rochelle Owen, Executive Director - Office of Sustainability
Michael Conte, Project Manager – FVB

DALHOUSIE UNIVERSITY

FVB ENERGY INC

Agenda:

- Sustainability Drivers
- Operational Drivers
- AC Project Implementation
- Halifax Plant
- Q&A

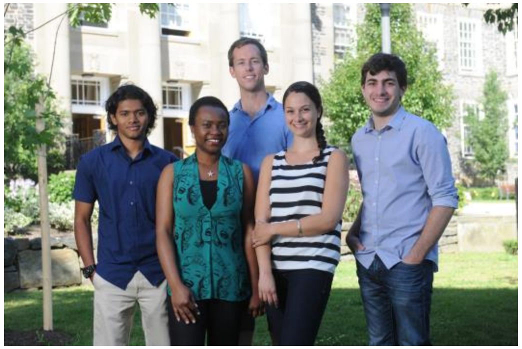
DALHOUSIE UNIVERSITY

FVB ENERGY INC

Where are we?


QUÉBEC
NEW BRUNSWICK
MAINE
PEI
16
Sydney
Louisbourg
4
105
Port
Hawkesbury
104
Canso
Trenton
New Glasgow
Port Bickerton
104
Truro
NOVA SCOTIA
Shear-
water
Kentville
Halifax
10
Lunenburg
8
Liverpool
Shelburne
Yarmouth

Dalhousie University Campuses



DALHOUSIE UNIVERSITY

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

DALHOUSIE UNIVERSITY

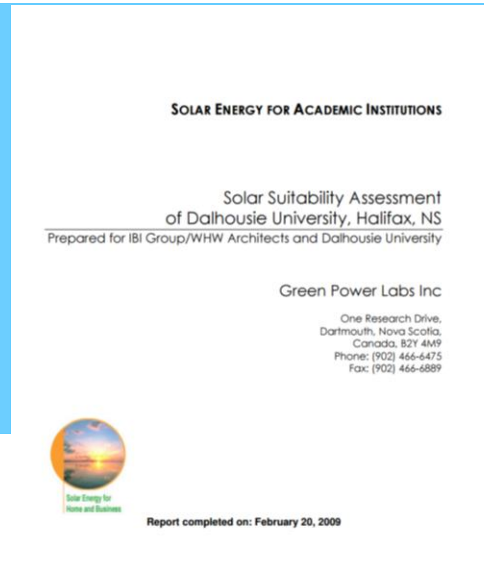
FVB ENERGY INC

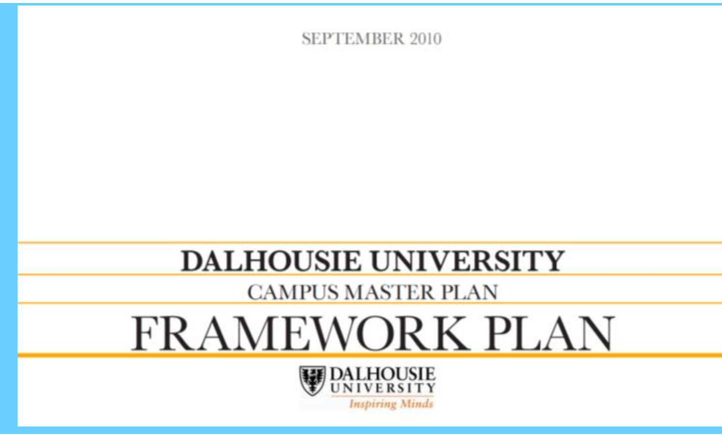
Key Goals

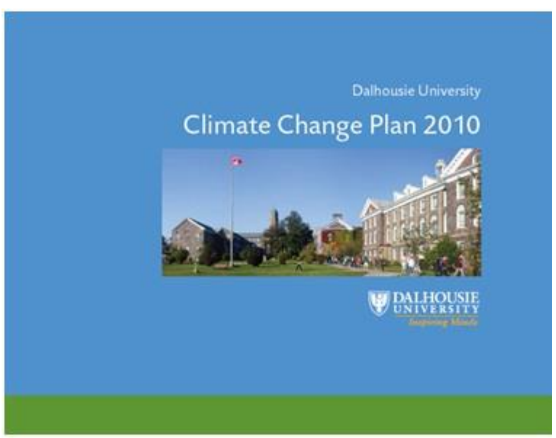
- reduce life-cycle costs
- increase energy-water efficiency
- conserve energy and water
- reduce air quality contaminants and greenhouses gases
- improve energy security

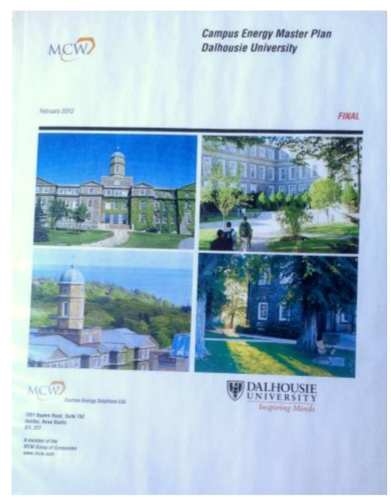
DALHOUSIE UNIVERSITY

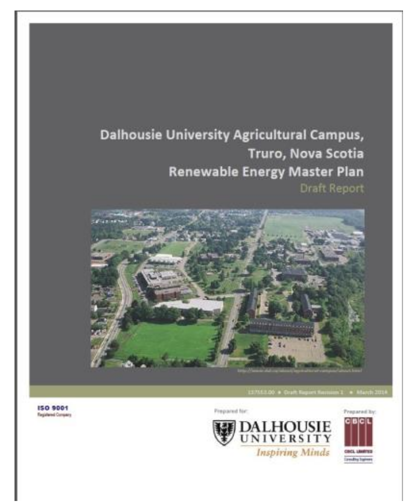
Planning Context for Energy and Renewables











Climate Change

MITIGATION

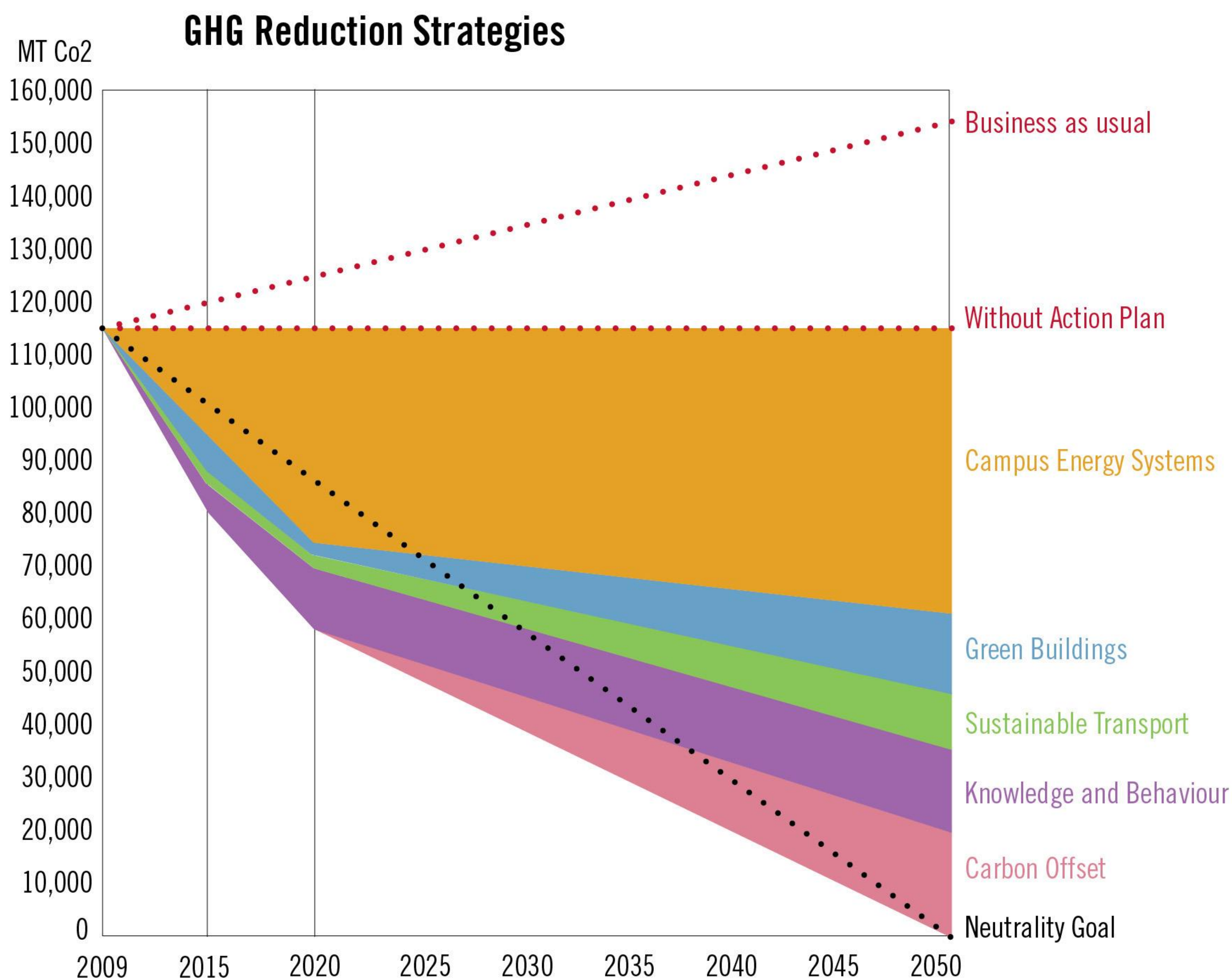
- Reduce GHG emissions and carbon footprint
  - Energy and water efficiency
  - Conserve energy
  - Fuel switching and renewable energy
  - Bike/walk/bus to campus
  - Carbon sinks

ADAPTATION

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

DALHOUSIE UNIVERSITY

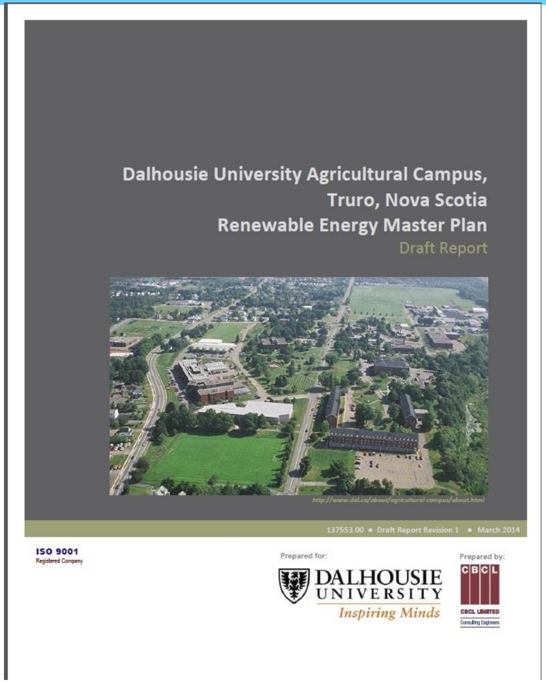
Co-generation, District Energy, Hot Water, Renewable Fuel



GHG Reduction Strategies
MT Co2
160,000
150,000
140,000
130,000
120,000
110,000
100,000
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
2009
2015
2020
2025
2030
2035
2040
2045
2050
Business as usual
Without Action Plan
Campus Energy Systems
Green Buildings
Sustainable Transport
Knowledge and Behaviour
Carbon Offset
Neutrality Goal

AC Campus

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.


Dalhousie University Agricultural Campus,
Truro, Nova Scotia
Renewable Energy Master Plan
Draft Report

137553.00 • Draft Report Revision 1 • March 2014

ISO 9001
Registered Company

Prepared for:
DALHOUSIE UNIVERSITY
Inspiring Minds

Prepared by:
CBCL
CBCL LIMITED
Consulting Engineers

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.

DALHOUSIE UNIVERSITY

FVB ENERGY INC

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).

DALHOUSIE UNIVERSITY

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

DALHOUSIE UNIVERSITY

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

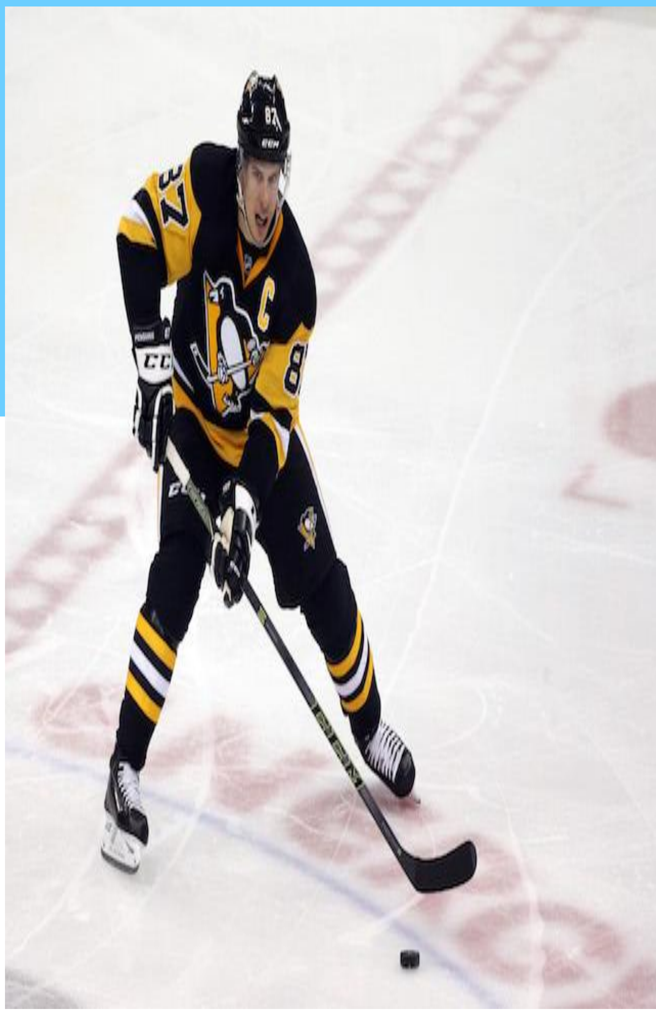
DALHOUSIE UNIVERSITY

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

DALHOUSIE UNIVERSITY

What is special about Nova Scotia?



Agricultural Campus Heating Plant

DALHOUSIE UNIVERSITY

FVB ENERGY INC

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

DALHOUSIE UNIVERSITY

FVB ENERGY INC

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

DALHOUSIE UNIVERSITY

FVB ENERGY INC

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

DALHOUSIE UNIVERSITY

FVB ENERGY INC

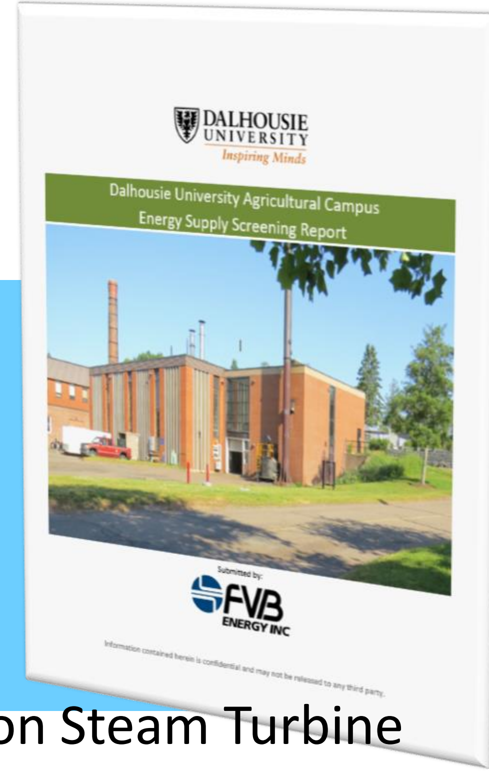
DAL AC- Biomass CHP: Initial Concept

- 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**

DALHOUSIE UNIVERSITY

FVB ENERGY INC

DAL AC- Biomass CHP Screening Report: Options



- 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

DALHOUSIE UNIVERSITY

FVB ENERGY INC

DAL AC- Biomass CHP
Screening Report- Quantitative

No.	Description	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5
1	Construction Capital	$6,100,000	$18,700,000	$15,900,000	$16,800,000	$12,500,000
2	Steam to HW Conversion Cost	$0	$0	$6,720,000	$6,720,000	$6,720,000
3	Steam Upgrades	$6,720,000	$6,720,000	$0	$0	$0
4	Sum: Total Capital [1+2+3]	$12,820,000	$25,420,000	$22,620,000	$23,520,000	$19,220,000
5	**Incremental Capital (Compared to Alt 1)**		**$12,600,000**	**$9,800,000**	**$10,700,000**	**$6,400,000**
6	Annual Operating Costs	-$1,853,000	-$3,501,000	-$1,908,000	-$2,252,000	-$2,120,000
7	Incremental Operating Cost (Compared to Alt 1)	NA	-$1,648,000	-$55,000	-$399,000	-$267,000
8	Power Generation Sales Revenue	$0	$2,100,000	$980,000	$1,360,000	$770,000
9	**Net Revenue (Compared to Alt 1) [7+8]**	**NA**	**$452,000**	**$925,000**	**$961,000**	**$503,000**
10	**Simple Payback (Compared to Alt 1) [5÷9]**	**-**	**27.8 yrs**	**10.6 yrs**	**11.2 yrs**	**12.7 yrs**
11	GHG Emission Reductions (Compared to Alt 1)	-	8,900 tCO_{2e}	4,900 tCO_{2e}	6,300 tCO_{2e}	3,800 tCO_{2e}
12	**Net Present Value**	-$60,086,343	-$66,515,519	-$50,174,381	-$51,802,956	-$56,660,690
13	**Net Present Value Compared to Alt 1**	-	-$6,429,177	$9,911,961	$8,283,386	$3,425,652

DALHOUSIE UNIVERSITY

FVB ENERGY INC

DAL AC- Biomass CHP Screening Report- Qualitative

Criteria Descriptions	Weight	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5
Efficiency: Cogeneration + Heat	3	15	9	15	12	12
Environmental Impact / Carbon Footprint Reduction	3	6	15	9	12	9
Reliability of Supply (Elect & Thermal)	3	3	9	12	15	9
Safety	3	9	6	15	15	6
Energy Security / Fuel Flexibility	2	2	10	6	6	8
Support Sustainable / Local Bioenergy	3	9	15	12	12	12
Lowest Capital Cost	2	10	6	6	6	8
Revenue Generation	3	0	15	9	12	9
Non Labour Annual Operating Cost	2	10	2	8	6	6
All In Net Annual Operating Cost	2	2	6	8	10	4
Simple Payback vs. Oil	1	5	4	3	3	3
Simple Payback vs. Biomass	3	0	6	12	12	12
Transition from Existing Plant / Minimize Downtime	2	10	6	8	8	6
Future Adaptability	3	3	0	15	15	9
Total		**84**	**109**	**138**	**144**	**113**
Ranking		**5**	**4**	**2**	**1**	**3**

DALHOUSIE UNIVERSITY

FVB ENERGY INC

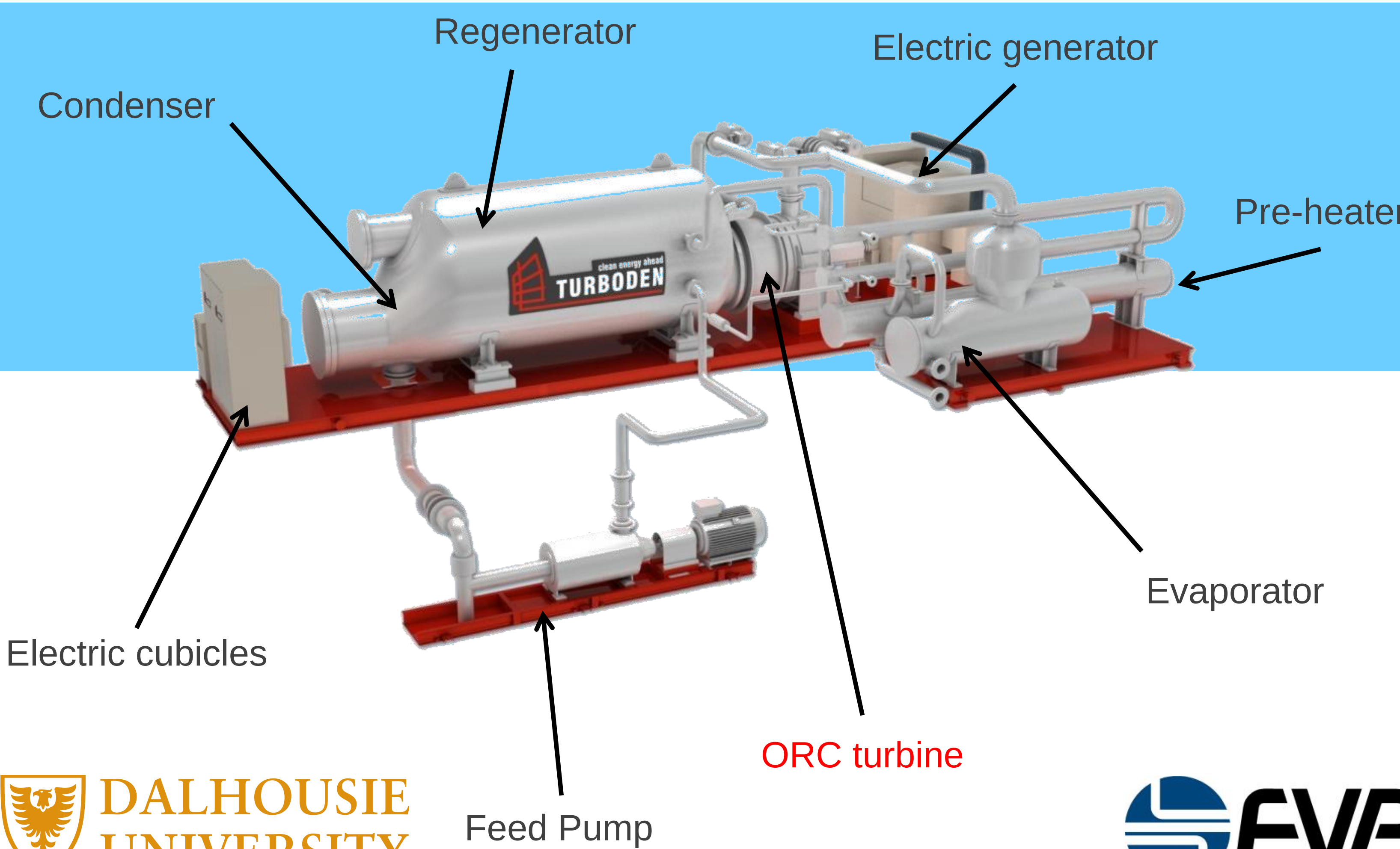
DAL AC- Biomass CHP: Revised Concept

- 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

DALHOUSIE UNIVERSITY

FVB ENERGY INC

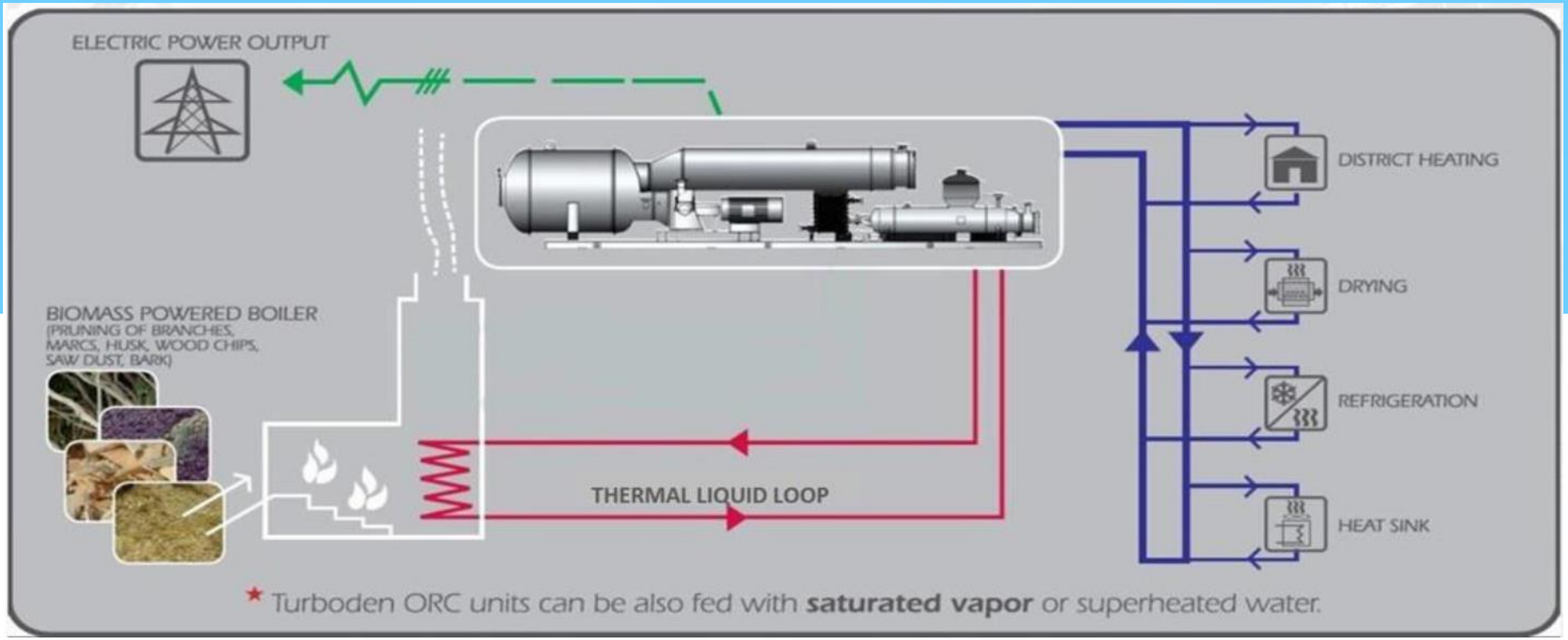
DAL AC- ORC Layout



DALHOUSIE UNIVERSITY

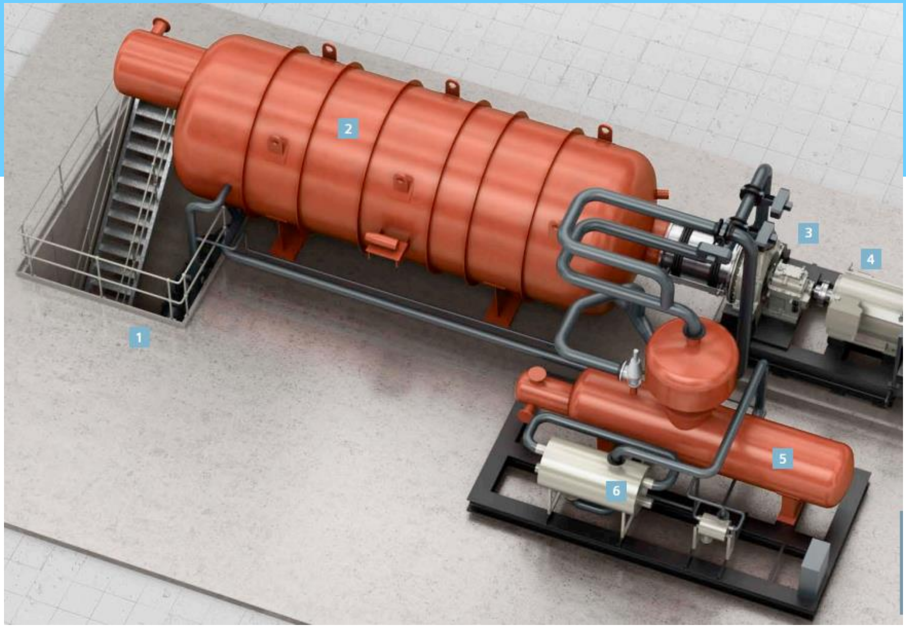
FVB ENERGY INC

DAL AC- Organic Rankine Cycle Generator



DAL AC- Why an ORC Generator at DAL?

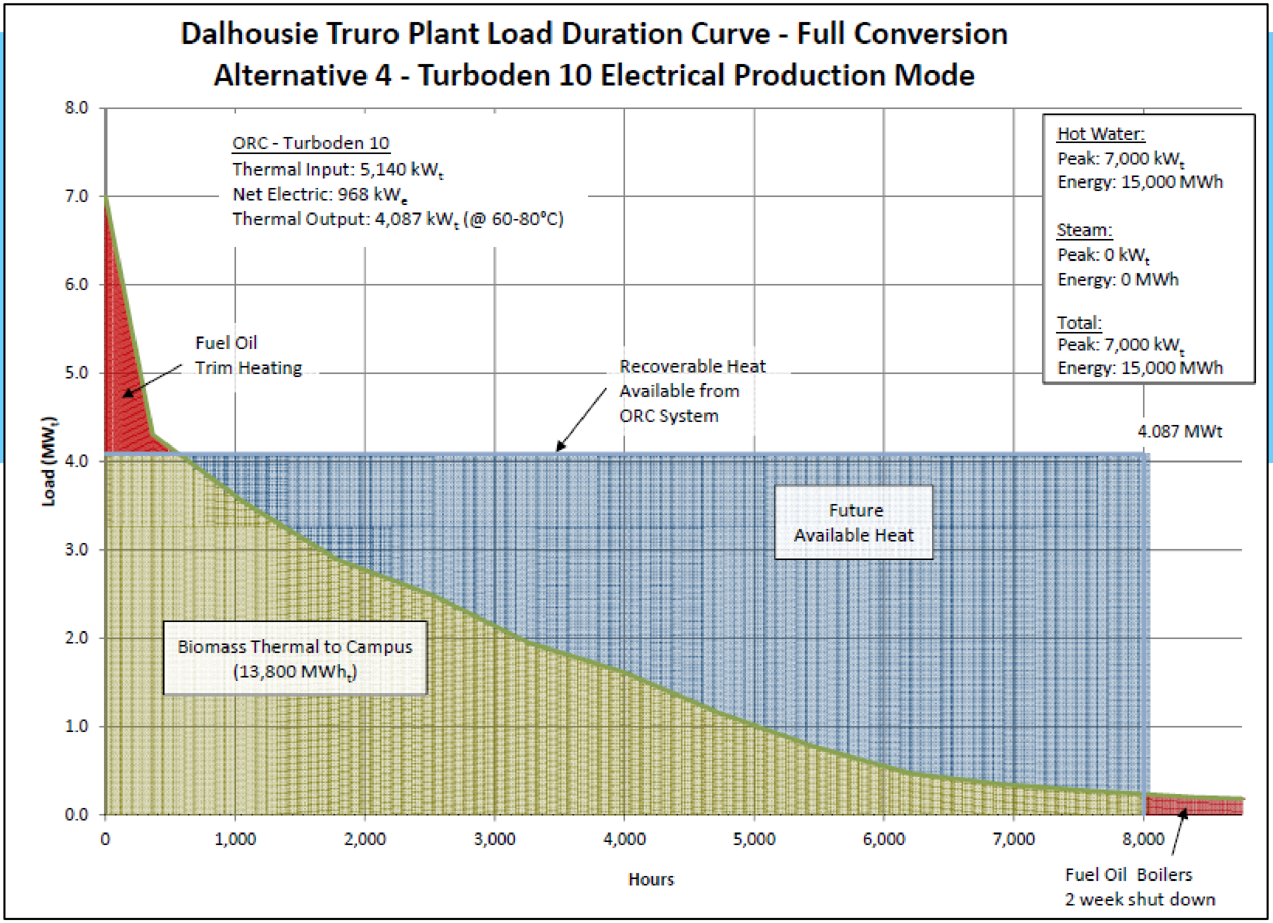
- High Turbine / Thermodynamic Cycle Efficiency
- Low Working Pressures; Unattended Operation
- Long Operational Life
- Large Turn Down
- Proven Technology



DALHOUSIE UNIVERSITY

FVB ENERGY INC

DAL AC- Biomass CHP LDC



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

FVB ENERGY INC