



SUBJECT	BIOENERGY RESEARCH AND DEMONSTRATION FACILITY – BOARD 4 PROJECT CLOSE-OUT REPORT
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MEETING DATE	APRIL 14, 2015
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Forwarded to the Board of Governors on the Recommendation of the President

APPROVED FOR SUBMISSION

Arvind Gupta, President and Vice-Chancellor

DECISION REQUESTED	For Information
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Report Date	March 11, 2015
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Presented By David H. Farrar, Provost and Vice-President Academic
 John Hepburn, Vice-President Research & International
 Lisa Castle, Vice-President Human Resources
 (Acting Vice-President Finance, Resources & Operations)
 David Woodson, Managing Director, Energy & Water Services
 Brent Sauder, Director, Strategic Initiatives, Vice-President Research & International Office
 John Metras, Managing Director, Infrastructure Development
 Michael White, Associate Vice-President, Campus + Community Planning
 Peter Smalles, Treasurer

EXECUTIVE SUMMARY

The Bioenergy Research and Demonstration Facility (BRDF) was one of six Canadian projects included on KPMG’s 2012 global list of the 100 most innovative and inspiring urban infrastructure developments. This biomass fuelled heat and power research project was one of the standouts in the “urban energy “category for its use of Cross Laminated Timber (CLT), collaborative partnerships, and purpose as the world’s first biomass fuelled heat and power generation system on a scale suitable for communities. The building has achieved LEED Gold certification and is winner of the Canadian Wood Council Wood Building & Design Award for Commercial Large Projects Category, the 2014 Vancouver Regional Construction Association (VRCA) Gold awards for General Contractor, the VRCA 2014 - Mechanical Contractor under \$15 million.

This successful project is a large contributor to UBC’s aggressive GHG emission reduction targets and was the first use of structural CLT made with BC sourced species in a BC plant. It is currently the largest industrial building constructed from CLT in Canada. The BRDF has been the source for over 20 Campus as a Living Lab research projects. This project delivered successfully on technology, a complex funding structure, community social licence issues and industry partner agreements thus contributing to UBC’s reputation and brand and demonstrating UBC’s commitment to its role as leader of change.

<p><i>If this item was previously presented to the Board, please provide a brief description of any major changes since that time.</i></p>	<p>The Board of Governors approved the BRDF Board 3 in June 2010. The project was completed within the approved budget of \$27.4 million. Building occupancy was 5 months after target and operations began in September 2012. Delays were caused by unforeseen site conditions, the staging of two major contractors on the same site, and some delay in the delivery, fabrication and installation of equipment.</p>
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INSTITUTIONAL STRATEGIC PRIORITIES SUPPORTED

- ✓ Learning
- ✓ Research
- ✓ Innovation
- ✓ Engagement
- International
- (Internal / External)
- ✓ Operational

DESCRIPTION & RATIONALE

The UBC Bioenergy Research & Demonstration Project (BRDF) is a world-leading initiative to demonstrate, at scale, a combined heat and power system fueled by biomass. The system provides clean energy to UBC’s Vancouver campus, facilitates research to set new global standards for performance and emissions, while lowering campus greenhouse gas emissions and fossil fuel consumption.

The project provided UBC with a unique opportunity to partner with Nexterra and General Electric (GE), two of the world’s leading developers of green technology, while generating clean energy for the campus and reducing its carbon footprint. FP Innovations was also a key participant, helping to incorporate the latest in engineered wood products and design in the energy system building.

The design and establishment of this operation provides UBC faculty and students with research and learning opportunities in the clean energy and sustainability sector and helps municipalities set new and better standards for future bioenergy operations.

System

The combined heat and power system brings together Nexterra’s pre-commercial gas conditioning system and biomass gasification system with a GE Energy high-efficiency gas engine generator. When operated in combined heat and power mode the system is designed to produce approximately 2.0 MW of electricity and 9,600 lbs/hr of steam. This represents enough power for the nearby 1,600-bed Marine Drive Student residences and 12% of the UBC base heating load, with the potential to eliminate approximately 4,900 metric tonnes of annual greenhouse gas emissions from UBC-controlled sources by reducing the amount of natural gas burned by the UBC steam plant. UBC operates and maintains the system and was obligated to run the system in co-generation mode for 2,600 hours in the first 12 months of operations in order to satisfy commercialization efforts as required by the potential funding agencies.

BENEFITS

Learning, Research, Financial, Sustainability & Reputational

The system provides heat and power to UBC’s Vancouver campus. It facilitates research to develop feedstock (fuel) and process innovations. Sets new global standards for performance and emissions. Lowers campus greenhouse gas emissions (GHGs) and fossil fuel consumption.

COSTS Capital Budget

Capital & Lifecycle Operating BRDF was completed at a cost of \$27.4 million, within the approved budget of \$27.4 million.

Operating Budget

Average Annual Operating Income/ Savings \$1,010,000

UBC's investment in the capital project was \$8.15million. The operating budget analysis for the Project considers costs savings and potential revenues generated. A comprehensive Net Present Value (NPV) calculation including revenues, expenses and costs avoided for the operation of the System was completed with price sensitivity around the power purchase rate, the cost of System fuel (wood bio-mass) and the cost of Natural Gas (off-set cost). The NPVs were calculated assuming a 15 year time horizon and a discount rate of 7 percent, \$50/green tonne for wood fuel, and natural gas at the rate of \$8.50MMBtu (the historical 3 year average).

In co-generation mode at full production, the breakeven price requires a power purchase rate of \$0.11/kWh. The recent MOU with the City of Vancouver for fuel supply was also factored which provides approximately \$165,000 in annual savings (or \$550,000 over the term of the agreement). At the end of the 15 year term, the project yields a positive NPV of \$1.8 million with a UBC contribution of \$8.15 million.

To date, the facility has performed as expected in the thermal mode. In the experimental co-generation mode the facility produced electricity from syngas for approximately 200 hours before experiencing a significant failure of one of the four heat exchangers that are part of Nexterra's tar removal process. The replacement of one heat exchanger has an approximate cost of \$1.4 million. As a result, further production of electricity from syngas has been put on hold until such time that funding can be secured.

In the meantime, to maximize the utilization of the remaining assets, UBC has partnered with FortisBC to run the engine on renewable natural gas (RNG). The plant is now running at a higher performance level than originally contemplated as it is achieving full cogeneration operation while at the same time maximizing the thermal output of the biomass system. UBC has the ability to switch back to syngas if, and when, the syngas system can be made operational.

The effect of these changes has impacted the operational budget assumptions. Annual operational costs (not including input fuel) are nearly \$300,000 per year less than originally anticipated due to less maintenance required for the cogeneration syngas operation and optimized plant efficiencies. Conversely, the fuel input costs are significantly higher due to the premium for renewable natural gas. The annual net revenues are less than projected by \$640,000 which will result in a longer payback period of the loan. The original 15-year term was projected to be completed in 2026. The loan is now projected to be paid back by 2028.

Key Assumption	Original Plan	Actual / Forecast
Price of Biomass	\$50/green tonne	\$73/bone dry tonne
Price of Natural Gas	\$8.5/GJ (\$11.1 including carbon tax/offsets)	\$8.5/GJ
BC Hydro - Load Displacement Agreement (LDA)	\$0.12/kWh	\$0.11/kWh
Other operational costs	\$1.4M	\$1.1M
Annual Fuel Input Cost	\$0.8M	\$2.6M
Revenue Generated/Expense Avoided	\$3.2M	\$3.9M
Loan Re-paid	2026	2028

FINANCIAL Funding

Funding Sources,
Impact on Liquidity

All project funding has been approved, and 97% has been received. Outstanding is the Sustainable Development Technology Canada (SDTC) commitment of \$1.5 million of which \$711,000 has been received with the balance anticipated in 2016.

	Revised Board 3 Approval	Board 4 (Actual)
Sustainable Development Technology Canada	1,500	1,500
NRCan (CFS-CLT Bldg.) Canadian Wood Council	800	800
NRCan Clean Energy Fund	8,000	8,000
BC Bioenergy Network	1,500	1,500
FP Innovations/Ministry of Forests (CLT Bldg.)	1,000	1,000
BC Innovative Clean Energy Fund	4,500	4,500
FP Innovations	350	350
Western Economic Diversification	1,400	1,400
Nexterra (In kind)	200	200
UBC Building Ops/Energy + Water Services	8,150	8,150
TOTAL	27,400	27,400

Financing

Financing is an internal loan of \$9.55 million from UBC Treasury with a projected interest rate of 5.75% amortized over 15 years. Annual debt service of approximately \$942,000 is sourced from energy savings associated with generating steam and electricity. The principal amount on the loan has been reduced to date through lump-sum payments from the operational budget due to lower than anticipated natural gas prices. In addition, the original loan amount has been further reduced through lump-sum payments as the various grants have been received. At the end of FY15, the remaining principal on the loan is \$7.4 million.

SCHEDULE Implementation Timeline	Milestone	Revised Board 3	Board 4
	Board of Governors (Board 1)	Sep-09	Sep-09
	Project Development Agreement	Dec-09	Dec-09
	Board of Governors (Board 2)	Feb-10	Feb-10
	Board of Governors (Board 3)	Apr-10	Apr-10
	Board of Governors (Board 3 – revised)	Jun-10	Jun-10
	Nexterra-UBC contract signed	Jun-10	Jun-10
	Construction start	Sep-10	Sep-10
	Substantial completion	Jan-12	Jun-12
	Board of Governors (Board 4)	Jan-13	Apr-15
CONSULTATION Relevant Units, Internal & External Constituencies	A post occupancy meeting with project occupants, operators and planners was held on February 26, 2015.		
	Successes:		
	Building Design		
	A great success from an architectural design view, the BRDF is visited by tour groups from around the world – over 400 tours for the architectural design and the Nexterra system has hosted over 200 tours.		
	The BRDF building, which houses the heat and power system, is LEED gold certified and is the first use of structural Cross Laminated Timber (CLT) made with BC sourced species from a BC plant. It is currently the largest industrial building constructed from CLT in Canada. The building design demonstrates the innovative use CLT as a building system and is a moment-frame structure with innovative connections. Solid CLT panels are used for walls, floors and roof, one of the first applications in Canada. The design of BRDF has contributed to the development of CLT technology and UBC has been involved in the production of the CLT manual and structural testing with FP Innovation.		
	Research		
	The BRDF is stimulating research at UBC and in Canada. Although many projects were planned federally, BRDF is unique in that it has been built with industry partners, UBC academic and operational support and is operating successfully. This has built trust and enhanced UBC’s reputation so federal funds are becoming available on other UBC projects. UBC successfully delivered on technology, a complex funding structure, community social licence issues and industry partner agreements and this has contributed to UBC’s reputation and brand and demonstrated UBC’s commitment to its role as leader of change.		
	The BRDF is the reference site for Nexterra’s foray into the development of 5 proposed projects in the United Kingdom.		
	UBC operations and academic research have supported a small alternate energy industry. The active commercial operation of the UBC system developed 11 spin-off research and development projects engaging 14 UBC faculty and a larger number of students. Example projects are:		
	<ul style="list-style-type: none"> • Metro Vancouver Fuel Study - Primary Investigator: Dr. Shahab Sokhansanj, Dr. Anthony Lau • Examination of Corrosion Mechanisms in Steel Vessels - Primary Investigator: Dr. Akram Alfantazi • Metallurgical Investigation of Materials Issues at the BRDF - Primary Investigator: Dr. Steve. Cockcroft 		

Greenhouse Gas Emissions

In 2010, UBC set an aggressive target to reduce GHGs an additional 33 per cent from 2007 levels by 2015. As of 2013, the BRDF represented 10% of that goal and this will continue to increase.

Electrical and Thermal Production

The BRDF reduced the peak demand on the existing steam plant (powerhouse boilers) which were at capacity in 2007. The 5.8 MW generated by BRDF reduces the thermal peak loads and eliminates that risk exposure. The BRDF production will also allow the existing steam plant to be shut down even though there are still some steam dependent buildings that cannot transition off steam prior to the completion of the Academic District Energy System.

The BRDF 2MW electrical production mitigates the electrical demand deferring major electrical infrastructure upgrades and so will defer capital investments – e.g. reduction of peak load will lengthen the time before a costly new electrical supply to UBC will be required.

Load Displacement Agreement (LDA)

The LDA with BC Hydro is the first one in the province wherein BC Hydro pays UBC a premium for generating power. The value to BC Hydro includes a:

- 1) Source of clean power,
- 2) Demonstration of distributed power, and
- 3) Means of deferring large infrastructure investment.

Lessons Learned:

Mitigation of Air Emissions, Noise, Fuel Supply

UBC successfully overcame initial perceptions regarding the placement of a biomass plant in an urban setting, near to student residences and child care. Issues included air emissions, noise, truck traffic. These issues were anticipated and through mitigation techniques were addressed to great success. The project team used an intensive public consultation process, monitored emissions continuously from a pre-project baseline, provided accurate and transparent results, and put in place traffic control measures. This attention to detail established a precedent for successful integrated mixed uses in planning.

Regulatory Environment

When working with entrepreneurial start up partners, it is important to ensure understanding and compliance with expectations regarding performance, design standards, provincial regulatory and UBC safety standards. Inclusion of the commissioning agent at an earlier stage will assist in the overall operation and delivery.

Intellectual Property (IP)

Clear expectations of use of intellectual property must be developed for the benefit of both industry and operators.

Corrosion of Gasifier

Nexterra has identified a problem of corrosion within the gasifier and the repairs may require down time while the problem is fixed. Discussions are currently underway.

UBCPT COMMENTS Complete for all reports that include a property component	Date of Review:		Signed off by:	
		N/A		

Previous Report Date	June 9, 2010												
Decision	Revised Board 3 Conditional Approval												
Action / Follow Up	<p>Approval:</p> <table border="0"> <tr> <td>Revised Capital Budget:</td> <td style="text-align: right;">\$27,400,000</td> </tr> <tr> <td>Average Annual Operating Income/Savings Schedule</td> <td style="text-align: right;">\$1,010,000</td> </tr> <tr> <td>Proceed to Construction</td> <td></td> </tr> <tr> <td>UBC Funding Release up to</td> <td style="text-align: right;">9,325,000</td> </tr> </table> <p>Information:</p> <table border="0"> <tr> <td>Expenses to Date: (May 31,2010)</td> <td style="text-align: right;">\$475,000</td> </tr> <tr> <td>UBC Funding Releases to Date*:</td> <td style="text-align: right;">\$225,000</td> </tr> </table> <p><i>*The \$225,000 released from UBC has been matched by a \$350,000 contribution from FP Innovations. This combined funding of \$575,000 is sufficient to cover total project expenses to date.</i></p> <p>Revised Financing Approval: Approve internal financing of up to \$9.55 million for UBC’s share of the Bioenergy Research and Demonstration Project. This is increased from previous approval for internal financing of up to \$5.5 million. The loan will be repaid over a maximum period of 15 years and debt service will be funded from energy savings associated with generating steam and electricity.</p>	Revised Capital Budget:	\$27,400,000	Average Annual Operating Income/Savings Schedule	\$1,010,000	Proceed to Construction		UBC Funding Release up to	9,325,000	Expenses to Date: (May 31,2010)	\$475,000	UBC Funding Releases to Date*:	\$225,000
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UBC Funding Release up to	9,325,000												
Expenses to Date: (May 31,2010)	\$475,000												
UBC Funding Releases to Date*:	\$225,000												

Previous Report Date	April 8, 2010												
Decision	Board 3 Conditional Approval												
Action / Follow Up	<p>Approval:</p> <table border="0"> <tr> <td>Revised Capital Budget:</td> <td style="text-align: right;">\$27,400,000</td> </tr> <tr> <td>Average Annual Operating Income/Savings Schedule</td> <td style="text-align: right;">\$845,000</td> </tr> <tr> <td>Proceed to Construction</td> <td></td> </tr> <tr> <td>UBC Funding Release</td> <td style="text-align: right;">5,275,000</td> </tr> </table> <p>Information:</p> <table border="0"> <tr> <td>Expenses to Date: (to March 31, 2010):</td> <td style="text-align: right;">\$425,000</td> </tr> <tr> <td>UBC Funding Releases to Date**:</td> <td style="text-align: right;">\$225,000</td> </tr> </table> <p>* Board 3 approval is conditional on the following:</p> <ul style="list-style-type: none"> • Confirmation that all external funding sources for the project are in place. • The purchase cost of the complete Nexterra System is within the project budget. • The tender for the building and site-work is within the project budget. 	Revised Capital Budget:	\$27,400,000	Average Annual Operating Income/Savings Schedule	\$845,000	Proceed to Construction		UBC Funding Release	5,275,000	Expenses to Date: (to March 31, 2010):	\$425,000	UBC Funding Releases to Date**:	\$225,000
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Conditional approval will require:

- Authorization for the signing officers of the University to execute the funding agreements necessary to receive the funding for the Bioenergy Research and Demonstration Project.
 - Authorization for the signing officers of the University to execute the Purchase and Collaboration Agreement with Nexterra.
- ** The \$225,000 released from UBC has been matched by a \$350,000 contribution from one of our industry partners, FP Innovations. This combined funding of \$575,000 is sufficient to cover total project expenses to date.

Previous Report Date	February 4, 2010																		
Decision	Board 1 Revised and Board 2 Conditional* Approval																		
Action / Follow Up	<p>Approval:</p> <table border="0"> <tr> <td>Capital Budget:</td> <td style="text-align: right;">\$26,000,000</td> </tr> <tr> <td>Average Annual Operating Income</td> <td style="text-align: right;">\$845,000</td> </tr> <tr> <td>Schedule</td> <td></td> </tr> <tr> <td>Final Location</td> <td></td> </tr> <tr> <td>Revised Program</td> <td></td> </tr> <tr> <td>Proceed to Working Drawings & Tender</td> <td></td> </tr> <tr> <td>UBC Funding Release</td> <td style="text-align: right;">\$25,000**</td> </tr> </table> <p>Information:</p> <table border="0"> <tr> <td>Expenses to Date: (Projected to Jan 31, 2010)***</td> <td style="text-align: right;">\$250,000</td> </tr> <tr> <td>UBC Funding Releases to Date:</td> <td style="text-align: right;">\$200,000</td> </tr> </table> <p>* Board 2 approval is conditional on confirmation that all external funding sources for the project are in place. ** Total funding required to complete the design and working drawings is \$900,000. It is understood in principle that UBC will release funds for this project up to a maximum 25% contribution or \$225,000. Initial UBC funding release was \$200,000. Current approval request is for \$25,000 UBC funding release. UBC is currently working with Nexterra to free up funds from other sources to cover the additional \$475,000 required to move to the next phase of the project design. *** The \$200,000 released from UBC has been matched by a \$200,000 contribution from one of our industry partners, FP Innovations. The total project expenses, estimated to January 31, 2010, represent about 63% of the total funding currently available for the project.</p>	Capital Budget:	\$26,000,000	Average Annual Operating Income	\$845,000	Schedule		Final Location		Revised Program		Proceed to Working Drawings & Tender		UBC Funding Release	\$25,000**	Expenses to Date: (Projected to Jan 31, 2010)***	\$250,000	UBC Funding Releases to Date:	\$200,000
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UBC Funding Release	\$25,000**																		
Expenses to Date: (Projected to Jan 31, 2010)***	\$250,000																		
UBC Funding Releases to Date:	\$200,000																		

Previous Report Date	September 24, 2009																
Decision	Board 1 Approval																
Action / Follow Up	<p>Approval:</p> <table border="0"> <tr> <td>Capital Budget:</td> <td style="text-align: right;">\$26,000,000</td> </tr> <tr> <td>Average Annual Operating Income</td> <td style="text-align: right;">\$845,000</td> </tr> <tr> <td>Schedule</td> <td></td> </tr> <tr> <td>Revised Program</td> <td></td> </tr> <tr> <td>Proceed to Working Drawings & Tender</td> <td></td> </tr> <tr> <td>Funding Release</td> <td style="text-align: right;">\$790,000</td> </tr> </table> <p>Information:</p> <table border="0"> <tr> <td>UBC Expenses to Date:</td> <td style="text-align: right;">\$10,000</td> </tr> <tr> <td>Funding Releases to Date:</td> <td style="text-align: right;">\$0</td> </tr> </table>	Capital Budget:	\$26,000,000	Average Annual Operating Income	\$845,000	Schedule		Revised Program		Proceed to Working Drawings & Tender		Funding Release	\$790,000	UBC Expenses to Date:	\$10,000	Funding Releases to Date:	\$0
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Interior of BRDF



Exterior of BRDF

