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Evaluation and Lessons Learned from a Campus as a Living Lab Program to Promote Sustainable Practices

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Abstract: Any group that creates challenging goals also requires a strategy to achieve them and a process to review and improve this strategy over time. The University of British Columbia (UBC) set ambitious campus sustainability goals, including a reduction in its greenhouse gas emissions to 33% below the 2007 level by 2015, and 100% by 2050 (UBC, 2006). The University pursued these goals through a number of specific projects (such as major district energy upgrade and a bioenergy facility) and, more generally, through a "Campus as a Living Lab" (CLL) initiative to marry industry, campus operations, and research to drive innovative solutions. The CLL program has achieved significant successes while also demonstrating many opportunities for improvements and lessons learned. The aim of this study was to examine the UBC CLL program, to identify and formalize its operations, to extract key transferable characteristics, and to propose replicable processes that other universities and municipalities can follow to expand their sustainable practices in similar ways. There was a learning curve with implementing a CLL program at UBC; thus, the goal of this study was to potentially shorten this learning curve for others. The research involved an ethnographic approach in which researchers participated in the CLL process, conducted qualitative analysis, and captured the processes through a series of business process models. The research findings are shared in two parts: (1) generalized lessons learned through key transferrable characteristics; (2) a series of generic organizational charts and business process models (BPMs) culminated with learned strategies through defined processes that illustrate what was required to create a CLL program at UBC. A generalized future improvement plan for UBC CLL programs is defined, generic BPMs about CLL projects are evaluated, and the level of engagement of multiple stakeholders through phases of project life cycle given in the conclusion for future use of other Living Lab organizations.

Keywords: Campus as a Living Lab (CLL); business process model (BPM); adoption of sustainable technologies; campus infrastructure

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1. Introduction

Universities play a vital role in addressing the global sustainability challenges and opportunities, because they are the intuitional platforms where research, educational activities, community engagement, and operations meet to produce a long-lasting impact on societal change [1,2]). Higher education institutions have been instrumental for transforming societies with regard to sustainable development. However, it takes substantial time for these institutions to explore sustainable development implementations and holistically integrate these to their systems [3,4].

By educating future leaders and community members about sustainability, International Sustainable Campus Network (ISCN) member universities such as the University of British Columbia (UBC) are dedicated to embedding sustainability in curricula, operations, research, and public–private partnership visions:

> In 2014, The University of British Columbia (UBC) approved a 20 Year Sustainability Strategy, which covered a wide spectrum of university activities including an enhanced focus on developing research within and outside the university involving strategic partnerships with industry and government, a renewed focus on university operations and infrastructure through the lens of the living lab to accompany UBC's goal of eliminating greenhouse gas emissions by 2050, and within teaching and learning, a renewed institutional commitment to embed sustainability learning across all undergraduate teaching programs by 2035 [5].

The Campus as a Living Lab (CLL) program, which is the focus of this research (This research's content is mostly drawn from the thesis of Paul Save, 2014 [6]), addresses collaboration between UBC's building operations, external companies, and researchers, in an effort to creatively and economically meet operational requirements while striving towards the goal of eliminating greenhouse gas (GHG) emissions.

The University of British Columbia's Campus as a Living Lab (UBC CLL) program involved significant effort by many groups and has been seen as a very useful initiative, however the full extent and working of the program were largely unknown to many of the participants. This research set out to examine the UBC CLL program as a major activity to promote technological innovation in sustainability, to identify and formalize its operations, to capture lessons learned and opportunities for improvement, and to propose a generic version of the CLL program to serve as a guide for other organizations interested in a similar initiative. There was a learning curve with implementing a CLL program at UBC; therefore, the goal of this study is to potentially shorten this learning curve for others.

The research involved an ethnographic approach in which researchers participated in the CLL process, conducted qualitative analysis of process outcomes—key transferrable characteristics—and captured the business processes through a series of business process models. UBC CLL program analysis has the potential to be a demonstrative example for all large organizations looking for managerial models for Living Labs. As identified in the literature review in the following background section, the need for a structured managerial model and standardized tools for decreasing the complexity of innovation activities and operational processes for living labs have been defined.

2. Background

The living laboratory (LL) concept is defined as "the co-creation process in integrating research and innovation in a systematic way, on a given territorial context" [7,8]. A wide variety of activities are carried out under the umbrella of living labs, and they feature many different methodologies and research perspectives [8,9].

Westerlund and Leminen also define living labs as "physical regions or virtual realities, or interaction spaces, in which stakeholders from public–private–people partnerships (4Ps) of companies, public agencies, universities, users, and other stakeholders, all collaborating for creation, prototyping, validating, and testing of new technologies, services, products, and systems in real-life contexts" [10,11]. Thus, living labs or urban labs are the collaborative entities of multiple stakeholders that are used by communities for innovation.

2.1. Literature Review on Living Lab Organizations and Institutions of Higher Education (IHE)

In the context of institutions of higher education (IHE), the campus acts as a living lab with its role and function as a teaching and learning institution of an educated society that allows more robust research output, improve the campus operation, and as a societal learning process arena. The campus sustainability has a great deal of potential and a role to play in translating sustainable development from a concept into more tangible results in a structured way [8].

UBC Campus as a Living Lab (CLL) program is one of the first CLL programs that tries to culminate multiple stakeholders considering most of the common indicators (CI)s [12] which the International Sustainable Campus Network (ISCN) defines. According to Kılkış's review study [12] on ISCN common indicator reporting, as of 2015, the ISCN consisted of 73

member university campuses [13]. In total, 36 member universities provided public reports in the ISCN-GULF Sustainable Campus Charter Directory [13]. The ISCN-Global University Leaders Forum (GULF) Charter obliges campuses to abide by three guiding principles. First, campuses must consider aspects of sustainability in the process of planning, constructing, renovating, and operating buildings. Second, sustainability goals must be integrated into campus-wide master planning. Third, campuses must align education and research with the aim of being a living laboratory for sustainability [14] in [12]. Campuses are given the flexibility to report on these principles according to their needs and interests [15] in [12]. Kılkış's review research aimed to compare the ISCN member campuses that provided publicly available ISCN reports by a systematic search for common indicators (CIs). The indicators that were used in the reporting practices were clustered into themes. Energy, water, waste, CO_2 emissions, transport, education, and research are the themes according to associated values for the relevant universities, which were compared on a quantitative basis. UBC has been stated as one of first three contributors with five reported CI themes after GU and Stanford [12]. UBC campus defined as active in an emerging role of being a living laboratory for more sustainable practices toward managing environmental quality.

While the term "living lab" was used as early as 1999 by Kidd [16], since then various studies emerged defining the "Living Lab" and "Campus as a Living Lab" concepts, generalizing the themes and reviewing Higher Education Institutions' role and efforts via literature review and surveys analysis [8,12,16–25]. However, management of multiple stakeholders and processes through CLL or the Urban Lab program has been thoroughly reviewed by only few studies [26–31]. Zen [26] is one of the main authors who discussed strengthening the campus sustainability initiatives by developing an integrative framework of "transformative and integrative approach of the university living learning labs". Leminen and Westerlund [27] proposed three ways to organize innovation activities in living labs—1. Standardized tools decreasing the complexity of innovation activities leading to predefined incremental innovation outcomes; 2. A predefined linear innovation process decreases the complexity of innovation activities; 3. Adopting an iterative, non-linear innovation process and customized tools for innovation activities increases the likelihood of a novel innovation outcome—by providing a set of implications to theory and practice, and suggesting directions for future research on living labs in their 2017 study titled "Categorization of Innovation tools in Living Labs". Sonetti et al. [28] proposed a new campus sustainability assessment (CSA) approach on campus typologies for meaningful comparisons and clustered problems related to current sustainability framework development, preparing charts according to case studies reviewed through this work. Voytenko et al. [29], on the other hand, define LL categories such as sustainable living labs (SLLs) and urban living labs (ULLs), where public–private–people partnerships (PPPPs) within LLs create beneficial preconditions to connect sustainable innovations with the market and society, and thus potentially advance sustainable urban transitions. The authors define the challenges occur due to collaborative alignment work with key stakeholders having divergent interests. Velazquez et al.'s 2006 study [30] presents a proposed comprehensive managerial model for a sustainable university, integrating the multiple roles of its campuses including partnerships for sustainability through empirical data collected from 80 Higher Education Institutions around the world.

Through evaluated literature, the need for a structured managerial model and standardized tools for decreasing the complexity of innovation activities and operational processes has been defined. Additionally, it is stated that multiple stakeholders' divergent interests must be addressed by collaborative alignment strategies. Therefore, there is a need for a roadmap for collaborative integration of multi-stakeholder projects defined by various studies. With this study, an evaluation and lessons learned from the UBC Campus as a Living Lab program outcomes are shared as a roadmap, and business process models (BPM) derived from public–private partnership projects at the University of British Columbia will also be generalized for future use of living lab organizations.

2.2. History of Sustainability and the CLL Program at UBC

An important early spark of sustainability at UBC began with the signing the Talloires Declaration in 1990 [32]. This declaration arose from the convening of "twenty-two university presidents and chancellors in Talloires, France, to voice their concerns about the state of the world and create a document that spelled out key actions institutions of higher education must take to create a sustainable future" [33]. In 1997, "UBC became the first university in Canada to adopt a sustainable development policy" [34]. This policy directed UBC to create Canada's first sustainability office in 1998.

Sustainability activities accelerated in 2006, when UBC developed a four-year sustainability strategy and, one year later, became "one of six founding signatories to the University and College Presidents' Climate Statement of Action for Canada" [33]. Sustainability then became part of UBC's core mandate, with several sustainability-related goals incorporated into the University's overall strategic plan, including the goal to "make UBC a living laboratory in environmental and social sustainability by integrating research, learning, operations with industrial and community partners" [33].

UBC began the process of developing plans and initiatives to pursue this goal, beginning with the development of a "Sustainability Academic Strategy" in 2009. This strategy led to the creation of an organizational focus for sustainability at UBC, the University Sustainability Initiative (USI), with the objective to integrate campus-wide academic and operational sustainability efforts. The USI started with two major initiatives: the "Campus as a Living Laboratory" (CLL) program to achieve influence through the campus's own operations in collaboration with academic functions and outside with industry, and the "Agent of Change" initiative to drive change through the campus's procurement and supply chain mechanisms [34]. The USI also developed recommended goals to reduce the university's greenhouse gas emissions to 33% below 2007 levels by 2015, 66% by 2020, and 100% by 2050; these goals were then included in UBC's climate action plan [35].

The USI had its first formal meeting in March 2010, and it was able to pass a budget for the program by the following April to support the initiatives [36]. This budget also supported the CLL in starting to reduce GHG emissions. The first projects to be completed were the Centre for Interactive Research on Sustainability (CIRS) Building, designed as a testbed for building science research [37]; the bio-energy research and diversification centre in 2012 [38]; and the Academic District Energy System, a retrofit to convert the campus heating infrastructure from steam to hot water [39,40]. The result of this conversion was expected to reduce GHG emissions by 22 percent while saving "CAD 5.5 million in annual savings including the cost investment for not reinvesting an aging steam system" [41].

2.3. UBC Campus as a Living Lab Organization

The Campus as a Living Lab (CLL) organization has experienced a steep learning curve. The UBC CLL has been a loosely defined initiative from its beginning. The CLL program grew to involve dozens of individuals (academics, board representative member, student advisory members, various managerial staff) participating in several different committees under the University Sustainability Initiative (USI) in 2014 (see Figure 1).

The major activity of the CLL was centred on projects that usually corresponded to major building or infrastructure developments on campus, with some off-campus operational projects that are relatively smaller. The CLL program works to identify opportunities for CLL projects, to review project proposals (internal and external) to select which should proceed, and to participate in the development through to completion of the CLL projects. Some of the main organizational groups involved are a high-level steering committee, a working committee (the focus of the majority of CLL effort), and CLL project groups for each project that moves forward. Figure 2 shows the organizational chart (as of 2014).

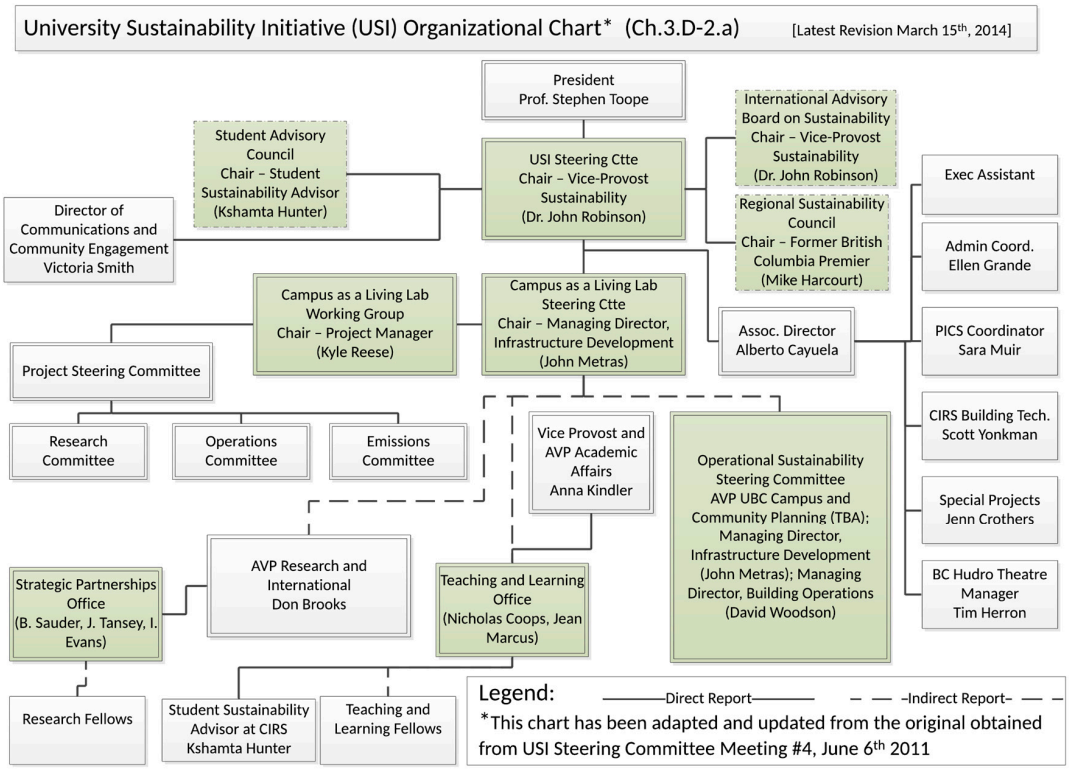

Figure 1. University Sustainability Initiative (USI) generic organizational chart. PICS (Pacific Institute for Climate Solutions), BC (British Columbia), AVP (Assistant Vice Provost), UBC (University of British Columbia), CIRS (Centre for Interactive Research on Sustainability).

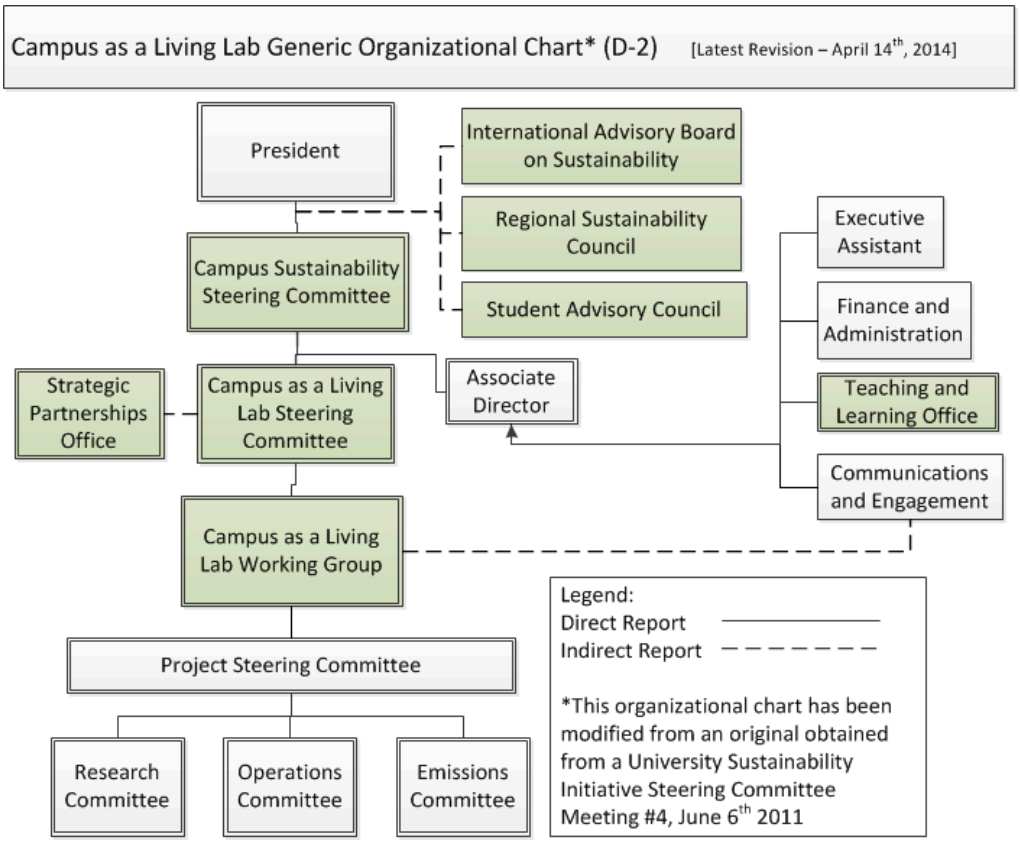

Figure 2. Campus as a Living Lab (CLL) generic organizational chart.

Consisting of a group of individuals from various areas and levels of authority that review CLL projects (Figure 1), the intent of the CLL Working Group was to provide a review process which ensured that a majority of stakeholder representatives have a chance to provide input before a project is proposed to the board of governors (BoG) for approval. This does not only provide an opportunity to refine the scope of a project, but it also creates greater alignment between the intent of the project and the needs of the institution and broader community. However, the aim of incorporating multiple stakeholders also incurred higher management and overhead costs. Therefore, reorganization was needed to remove duplicated effort in other parallel research and organizations related within UBC (see Section 6 discussion).

3. Objective and Research Questions

The main objective of this ethnographic study was to document and model the CLL related processes; the stated questions below directed the methods of analysis. Lessons learned and ideas for improvement through answered research questions can provide a valuable reference for others interested in pursuing their own CLL strategies.

Main Research Questions

Research questions before starting the ethnographic study were:

- How do CLL Working Group members and Steering Committee members interact during meetings to mediate the problems on the integration process of multiple stakeholders' needs?
- How do these meetings lead to a better process definition for future actions?
- Is it possible to document the development of the project processes through different charts for enabling a replicable method for universities and cities?

4. Methodology

It has been a challenge, even for people who have been directly involved in the CLL program, to clearly define its processes and practices in a way that would allow the program to be replicated elsewhere. Therefore, two different studies—both built on a broader ethnographic study—were conducted to formalize the CLL process, capture lessons learned, and generalize an idealized process roadmap, process model overview, level of engagement chart of multiple stakeholders that others could replicate. This paper first graphically summarizes the chronologic history of organizational structures within the UBC's sustainability scope built on the qualitative analysis of collected data. Then, business process models (BPMs) created for easing the evaluation of case projects are summarized and some key diagrams are created to define the overall UBC CLL processes. Lessons learned, captured from both the qualitative analysis and the BPM generation process, are presented and used to propose a generic version of the CLL process that others could replicate.

The methodology involved extensive data collection through document collection, interviews, analysis of numerous meeting minutes, and direct observation of 36 CLL meetings over 16 months. Analysis involved qualitative analysis of the dataset, the development of business process models of the actual work processes followed on three large projects, the distillation of lessons learned from the interviews and feedback sessions, and the development of a set or proposed generic CLL processes and tools to service as a guide for other organizations.

4.1. Ethnographic Study Coding

During the ethnographic study, 98 weekly CLL Working Group and 20 monthly Steering Committee meeting minutes and associated documentation were reviewed. Based on the meeting minutes and the researchers' field notes, the items discussed in the meetings were coded to classify the topics and business processes. The contents of these meetings were encoded against a classification system derived to identify the correlation between

committee discussions and CLL processes. This facilitated an understanding of the evolution of the CLL, and provided a foundation for developing a method of writing notes on project updates, project assessment, project funding, and recruitment options of researchers for designated projects as well as creating new project opportunities for researchers and students. Furthermore, the researchers conducted numerous interviews to uncover the history leading up to the current CLL implementation. The findings from three more interviews with key people conducted after a restructuring in 2017 are also included in this paper.

In order to develop a coding scheme, two international standards that define a range of business processes were adopted to provide a framework with which the meeting contents could be coded. These standards were version 6.0.0 of the Cross Industry Process Classification Framework from the American Productivity and Quality Centre [42], and the fourth edition of the Project Management Body of Knowledge from the Project Management Institute [43]. This framework was further refined by excluding processes that were found to be irrelevant to the CLL discussions and adding some processes that were not adequately defined in the APQC/PMI standards.

Each item discussed in the observed meetings was then coded against this final framework. An example is shown in Figure 3, which shows a sample of the business processes defined in the coding framework in the matrix rows, and three columns representing three CLL meetings. The number of instances of a particular type of business process discussed in each meeting is then represented as a number in the matrix cells, with the total number of instances summed in the right-hand column. The results of this analysis enabled the researchers to identify a series of business processes that were demonstrably important for the CLL program.

	N162-14	N162-15	N162-16	TOTALS
Develop Vision, Strategy and Assessment Tools (1.0)				**148**
Develop, evaluate, establish, and re-evaluate vision and mission				**5**
Develop, evaluate, establish, and re-evaluate high level goals				**13**
Develop, evaluate, establish, and re-evaluate objectives				**14**
Develop, evaluate, establish and re-evaluate organizational structure, reporting, and governance				**21**
Develop, evaluate, establish and re-evaluate methods and tools for assessing projects				**41**
Learn from others and develop ideas for improvement				**54**
Develop and Manage Business Capabilities (2.0)				**61**
Develop, evaluate, establish, and re-evaluate human resource management, planning, policies, and strategies				**7**
Manage departments financial resources				**1**
Develop, evaluate, establish, publish, and re-evaluate process management				**10**
Develop, evaluate, establish, and re-evaluate knowledge management practices				**8**
Develop, evaluate, establish and re-evaluate metrics for post-implementation of projects				**4**
Plan meetings				**31**
Develop Opportunities (3.0)				**257**
Develop, and evaluate opportunities			1	**63**
Evaluate risk, determine and implement risk mitigation strategies	1	1		**32**
Evaluate opportunity allignment with vision, mission, goals, and objectives				**28**
Identify requirements, objectives and resources for opportunities	1	1	1	**54**
Develop, and evaluate, and present business case(s)				**18**
Develop requests for information/proposals; negotiate, establish, and manage contracts				**26**
Develop, evaluate, and obtain funding				**36**
Assess the Environment (4.0)				**161**
Assess internal needs, capabilities, and opportunities				**89**
Evaluate the internal economic, environmental, and social landscape				**26**
Assess external needs, capabilities, and opportunities				**29**
Evaluate the external economic, environmental, and social landscape				**17**

Figure 3. Example of plotting data points across the Campus as a Living Lab process framework. The first column illustrates a portion of the coding system developed for this study. Columns 2, 3, and 4, represent three sample meetings, illustrating the mapping of individual discussion items with specific coding items. The total count of all coded items for each code is shown in the fifth column.

4.2. Business Process Modelling Methodology

The CLL processes identified through the qualitative analysis—both as-followed for the three major projects that it undertook as it was being formed, and as-intended for future projects—were formally modelled and mapped (see Section 6.1) using a combination of spider charts to assess the individual characteristics of candidate CLL projects, and business process modelling visualization techniques for charting the CLL processes. The legend for business process models (BPMs) created is explained in Figure 4. All the case project BPMs can be encoded via this legend.

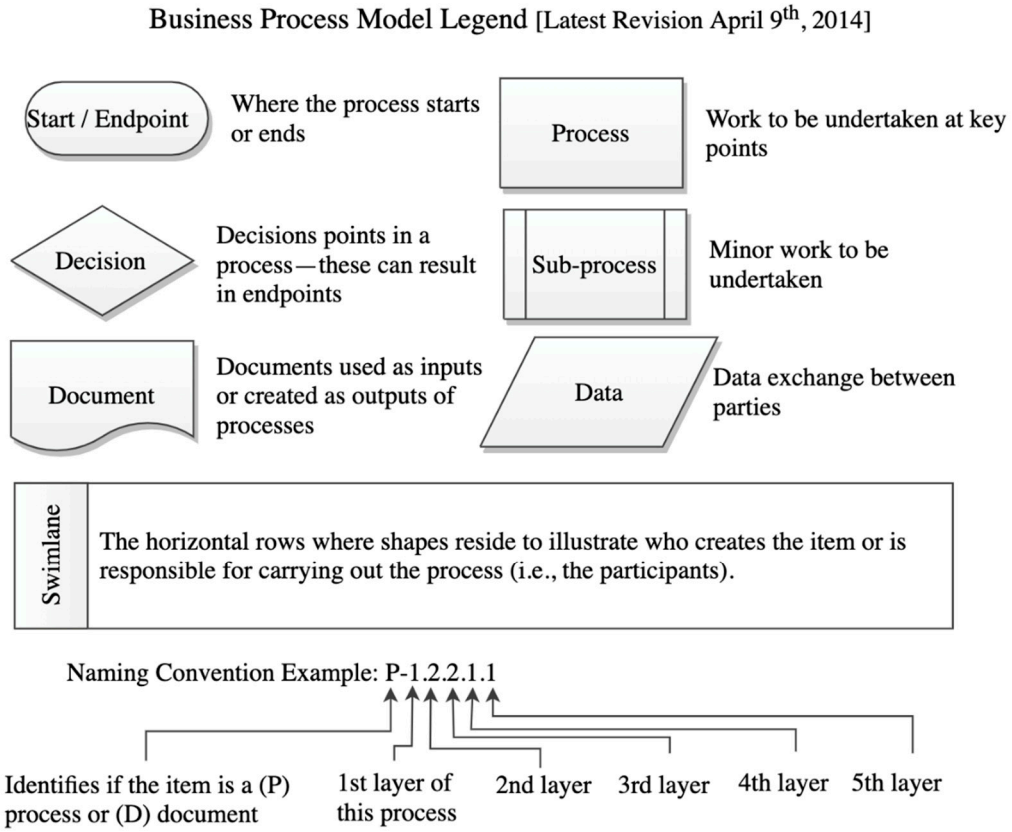

Figure 4. Business process model (BPM) legend, updated in 2014.

The final step in the research methodology was to analyse the "as-is" CLL program, based on both the researchers' personal assessments built on ethnographic coding and on interviews with CLL participants, as well as the case-based BPMs. In order to produce generalized BPMs for future CLL processes at UBC and a better roadmap for CLL committees and programs that could be implemented elsewhere, generic BPM diagrams and organizational structure schemes were created as an outcome.

5. Analysis of the CLL Process

Analysis of the overall CLL process with defined methods is presented both quantitatively and qualitatively via generated business process models (BPMs).

5.1. Quantitative Analysis of the Overall CLL Process

Figure 5 shows the percentage of data points that were listed in each coding category of ethnographic study on UBC CLL (as illustrated in Figure 3). This provides a summary of the quantity of attention given for each major category of business process. Further analysis decomposed this summary into finer detail within each process category, and also assessed how the relative focus changed over time as the CLL program was initiated and became increasingly established.

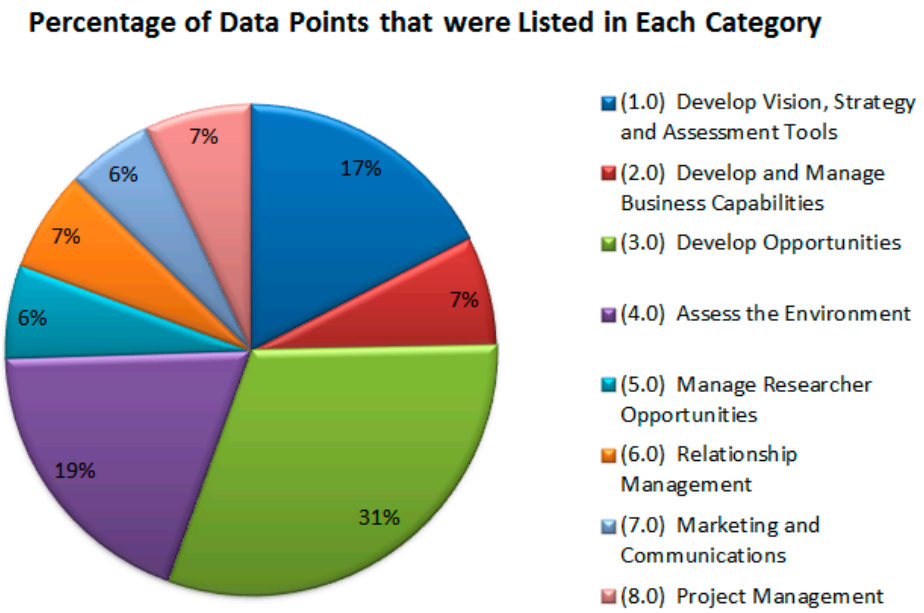

Figure 5. Percentage of data points that were listed in each coding category of ethnographic study on UBC CLL.

A review of how priorities shift over time was completed to understand how the CLL Working Group changed their workload or scope (Figure 6). All categories were first graphed together to identify any interesting relationships. Patterns for three categories in particular emerged. For the first 260 data points, it appeared that the categories "(3.0) Develop Opportunities" and "(1.0) Develop Vision, Strategy, and Assessment Tools" were in constant flux. This fluctuation indicates movement between conducting the work itself and trying to improve strategies for the work being conducted. From data points 261 onwards, "(4.0) Assess the Environment", and "(3.0) Develop Opportunities" were in flux. This was due to the current urgency to develop a comprehensive energy plan for the UBC campus for high carbon footprint reduction targets to be met in time.

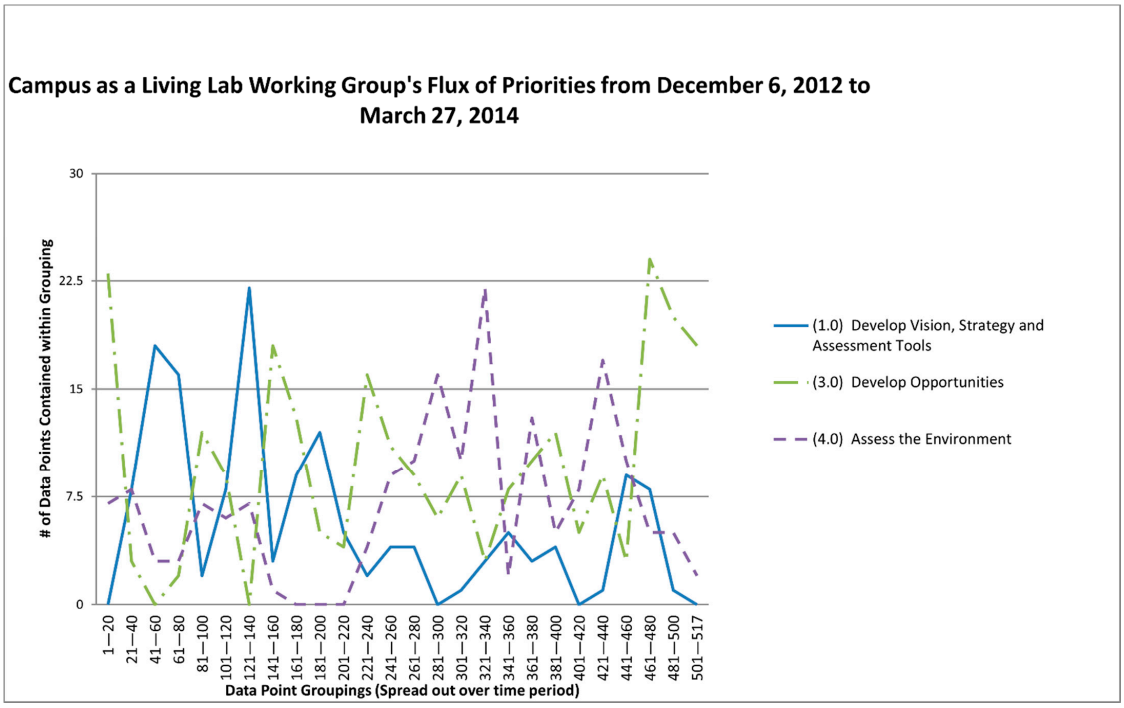

Figure 6. Campus as a Living Lab Working Group's flux of priorities from 6 December 2012, to 27 March 2014.

5.2. Business Process Models of UBC CLL Driven from Qualitative Analysis of Project Meeting Outcome

The business process models (BPMs) are depicted according to timeline, and involved multiple stakeholders, and legend-defining illustrations containing the item responsible for carrying out the process at the time by the involved stakeholder group (Figure 4).

5.2.1. Project-Specific Business Process Models of Representative UBC CLL Projects

Three main UBC CLL representative projects illustrate the pathway of developing the project proposal and acceptance process for the UBC CLL.

In deciding how to potentially improve on future projects, this ethnographic study also followed these three case studies: CIRS, the Academic District Energy System, and the Bioenergy Research and Demonstration Facility. These case studies are examples that gave reference cases to a building, an analysis of campus wide infrastructure options and a facility project, respectively. They represent key initiatives to address UBC's long-term sustainability goals.

These CLL projects were studied in detail, and the CLL-related business processes that were followed identified and mapped. These projects are summarized as follows:

(1) The Centre for Interactive Research on Sustainability (CIRS, Figure 7): CIRS is a CAD 36.9 million project to create a building that is, itself, a "living laboratory" to test the ability to meet aggressive, net positive goals (The building owner representative's overall goals for CIRS are to be a net-positive energy producer and a net-zero carbon building. It is designed with the intention of being a "living lab" (Robinson et al., 2013) with ongoing performance monitoring and activities to further improve performance. The building is equipped with an energy monitoring system (EMS) and a building management system (BMS). Data collection from over 3000 monitoring points (occupancy sensors, CO_2, VOC, temperature of rooms, energy meters, many details of HVAC operations such as pump and fan temperature and flow details, window status sensors, solar PVs and transmitters, water reclamation and irrigation system details) has been available since the building was fully occupied and operating in 2012. The building is also equipped with a tertiary water treatment system [44].

(2) The Academic District Energy System (Figure 8) emerged from a larger initiative (building operations) to review alternative energy sources at UBC. In addition to an initial feasibility study, a local "Energy X Contest" was also created for people at UBC to pitch their ideas for additional options for UBC to pursue. Key drivers for the project included aging infrastructure, skyrocketing natural gas prices, newly implemented carbon taxes, and public sector offset requirements that caused the campus to look for ways to reduce the carbon footprint. The result was an CAD 88 million project to convert the campus district heating system from steam to hot water. The project entailed the conversion of 131 buildings from steam to hot water, 14 kilometres of hot water distribution piping, and a new 60 MW hot water thermal energy centre. This resulted in "CAD 5.5 million in annual savings" and a reduction in GHG emissions by 22 percent [37].

(3) The Bioenergy Research and Demonstration Facility (Figure 9) is a CAD 27 million investment in using a renewable resource for fuel and reducing the demand for imported power on campus. In its full operating mode, the facility was designed to produce heat in the form of steam at the rate of 20,000 pounds per hour. This reduces UBC's base requirement on natural gas heating and reduces UBC's GHG emissions by 9000 tonnes per year [45].

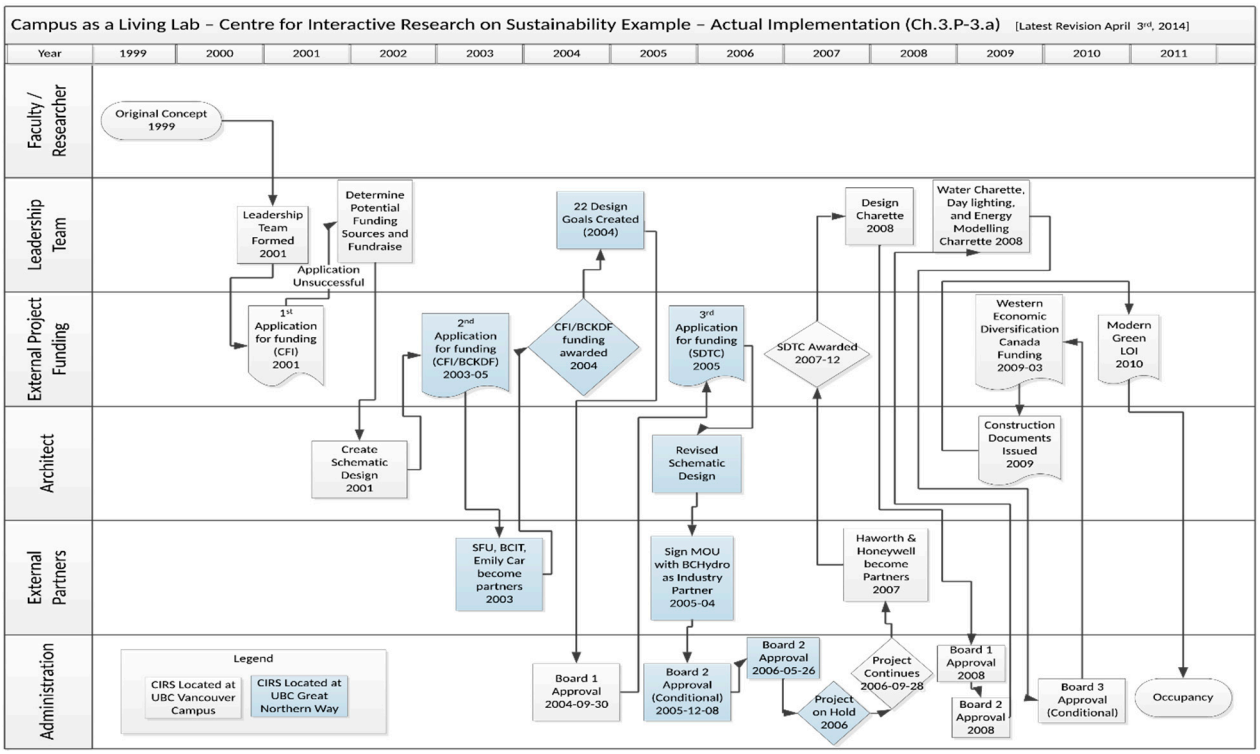

Figure 7. Centre for Interactive Research on Sustainability building BPM actual implementation. CFI (Canadian Foundation for Innovation), BCKDF (British Columbia Knowledge Development Fund), SDTC (Sustainable Development Technology Canada), LOI (Letter of Intent), SFU (Simon Fraser University), BCIT (British Columbia Institute for Technology), MOU (Memorandum of Understanding).

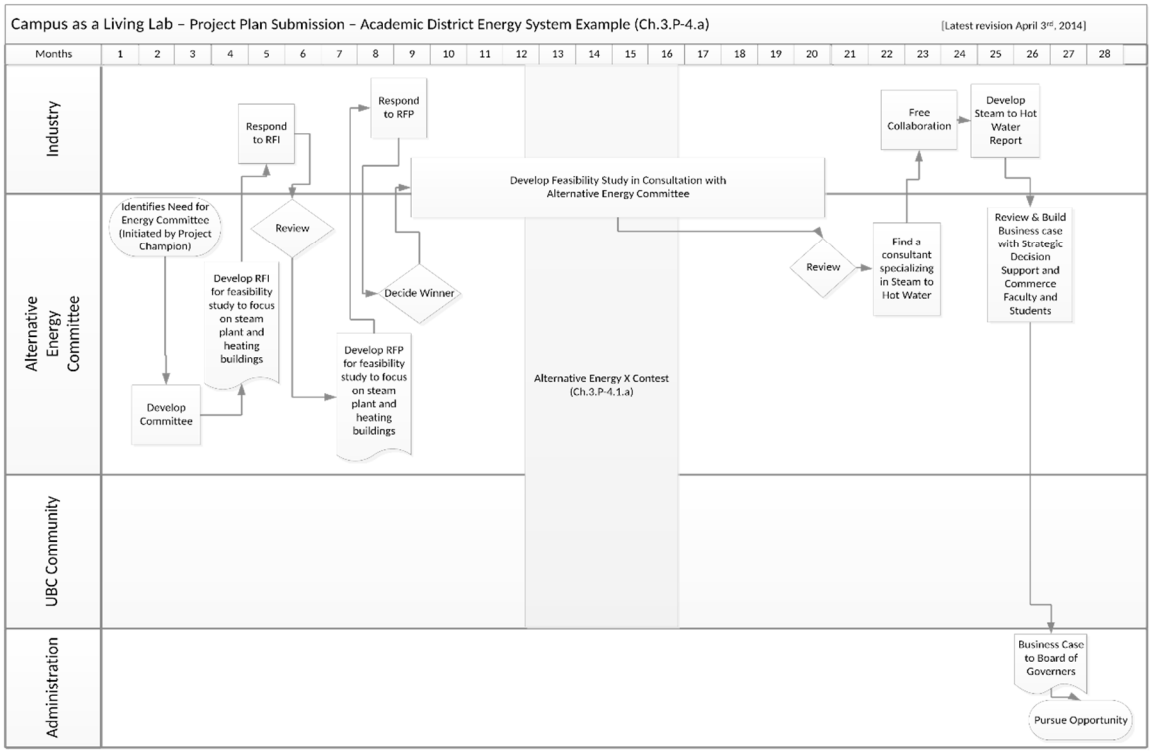

Figure 8. Academic District Energy System BPM actual implementation. RFI (Request for Information), RFP (Request for Proposal).

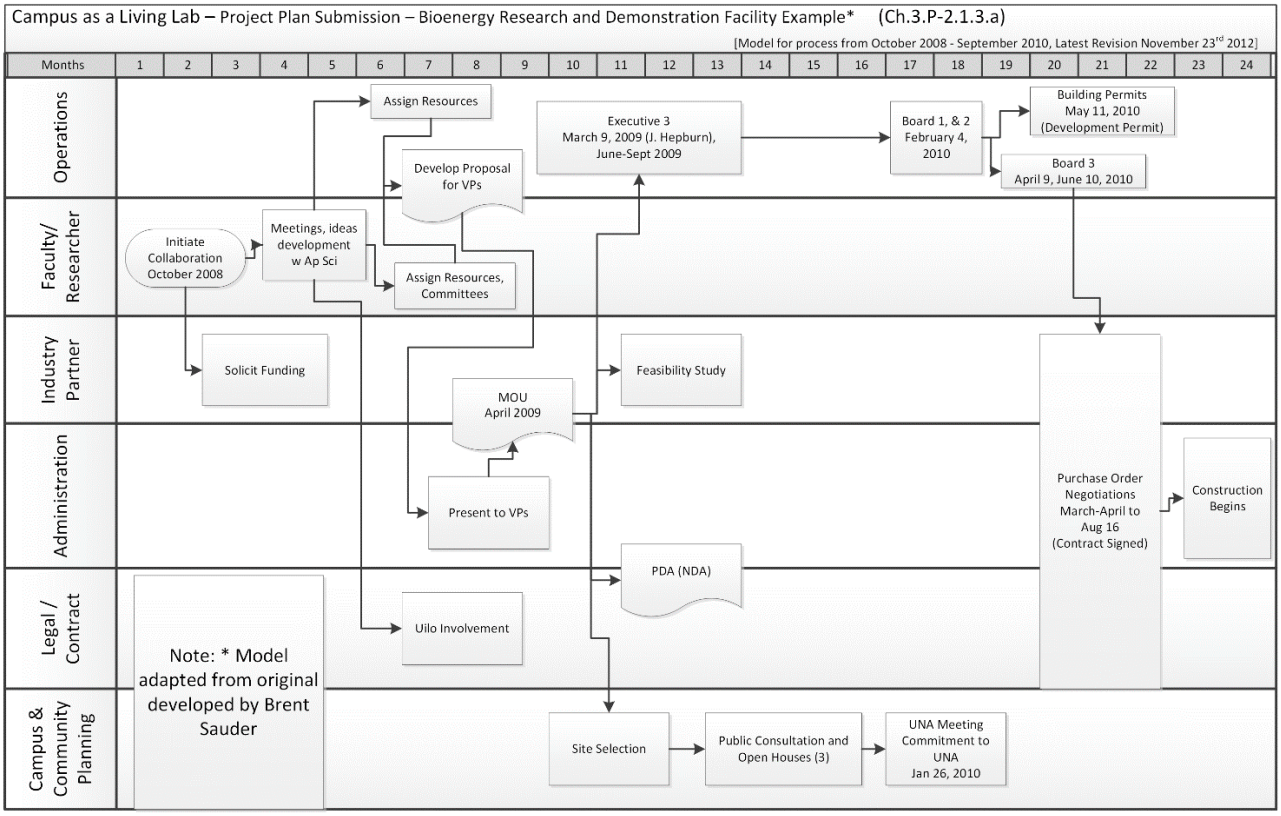

Figure 9. Bioenergy Research and Demonstration Facility BPM actual implementation. PDA (Pre Disclosure Agreement), NDA (Non Disclosure Agreement), UNA (University Neighborhoods Association).

From the produced case study BPMs, the evolution of each process for different project types on campus can be followed by timeline, stakeholder involvement, and items required.

5.2.2. General Business Process Models Given as Steps of Project Requests at UBC CLL

One of the main goals of the CLL program is to use the UBC campuses as a testbed for the potential commercialization of products that can help with campus sustainability. UBC can act as a launching pad for technologies to move out of the lab and into main-stream use. Industry collaborators are interested in fast, effective, and value-orientated solutions to develop their products; therefore, the CLL can be seen as a path-of-least-resistance testing environment. The value proposition of the CLL to industry is that it can provide additional researcher capacity for development, assistance (with potentially government funding to match industry investment), monitoring, and verification of results in a lab environment.

After UBC issued a request for information to develop strategic partnerships with industry in 2011, an increasing number of companies approached UBC wishing to collaborate. UBC had been following an ad-hoc process to pursue projects, but it was found that a more formal structure was needed if it was to scale its CLL program efforts successfully. Due to an influx of unsolicited requests, the CLL needed to adapt to a more proactive, rather than reactive, model of governance. In order to achieve this, assessment tools for varying levels of analysis were developed to evaluate project fit with UBC.

The CLL program projects evolved into two main categories: unsolicited and solicited proposals (Figure 10). While UBC has a formal process for all CLL requests for proposals, for strategic sustainability reasons and in accordance with its innovative CLL approach, UBC entertains unsolicited proposals with a refined process. These are subject to a screening procedure that is as rigorous as the formal request for proposal process.

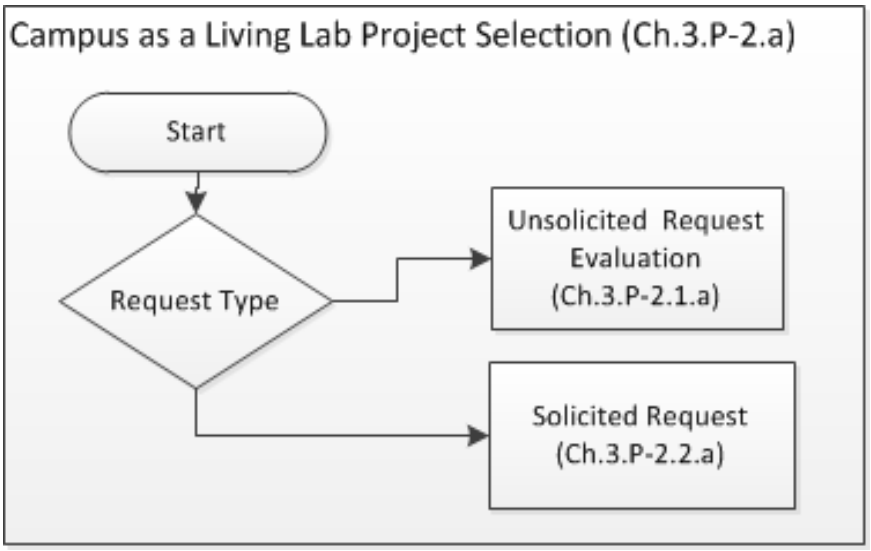

Figure 10. Request type structure at UBC CLL.

The Strategic Partnership Office, CLL Working Group, CLL Steering Committee, and Institutional Project Approval Group are groups involved in the Solicited Request approvals, and the approval process can take up to three years.

Fast evaluation needs of unsolicited proposals increased the threshold value of proposals to CAD 5 million in 2016 [46], which was stated before as over CAD 2.5 million in 2011 (Figure 11).

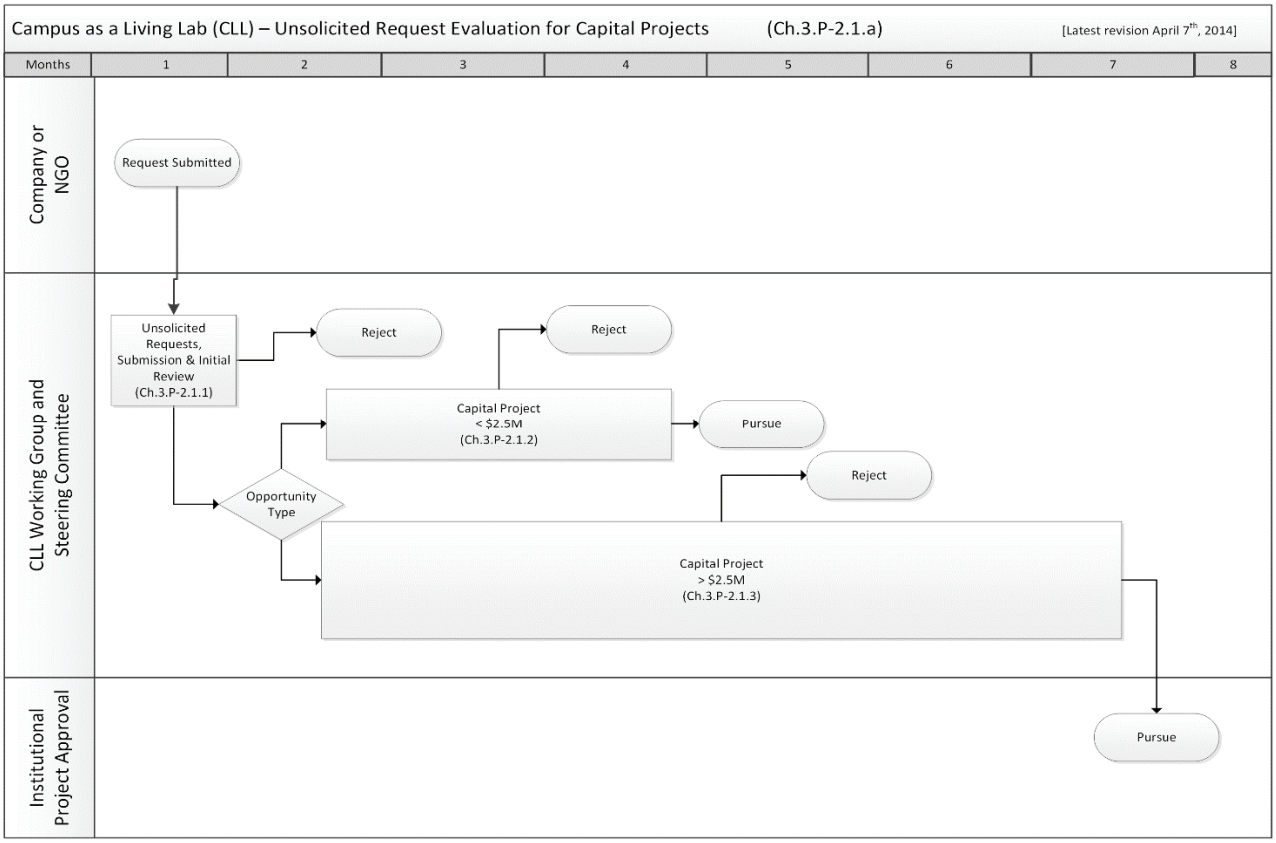

Figure 11. Campus as a Living Lab—overall view for unsolicited requests for capital projects in CAD.

Capital projects that were over CAD 2.5 million needed to be evaluated with a rigorous process, which could take up to eight months. Projects not requiring this approval were able to proceed much quicker than those that required it. In either case, the length of time required to complete a project can be longer than participating company may anticipate [40].

The first stage (*step 1*) of an unsolicited request requires completing an online form and submitting a two-page proposal. This first step is crucial in ensuring that UBC's objectives align from the beginning of the project, and that it has been tailored to ensure that the information addresses specific questions.

As a second step (*step 2*), the proposal is reviewed by the Strategic Partnerships Office, who provides feedback to the CLL Working Group for review. This is an important step because these reviews are carefully done by a diverse team of administrative individuals who contribute various areas of campus expertise and who examine the four cornerstones of CLL projects:

(1) The integration of UBC's core academic mandate (research and teaching) with the University's operations;
(2) Partnerships between the University and private sector, public sector, or NGO organizations;
(3) Sound financial use of UBC's resources and infrastructure;
(4) The potential to transfer the knowledge UBC gains into practical, positive action applicable to the greater community [47].

Then, the proposal is transferred to the CLL steering committee members in (*step 3*). The CLL Steering Committee consists of a group of individuals from various areas and levels of authority that provide another thorough review of the project (Figure 2).

If the working group considers the project to have potential, then in (*step 4*), the Strategic Partnerships Office will pursue the company for additional information to further review with the CLL Working Group. If the CLL Working Group agrees that there is a fit, then a champion for the project is identified, preferably an academic (*step 5*) (appointing a champion for a project can prove challenging when everyone already is balancing a full-time workload; an award policy was believed to increase attraction). Once a project champion has been appointed, then a presentation is made to the CLL Steering Committee by the project champion lead for final vetting before an informal steering committee is created to develop a memorandum of understanding. Then, with the memorandum of understanding is in place, formal committees are struck to govern the project in (*step 6*).

If UBC funding is required, then a detailed business case would also be created for institutional project approval in (*step 7*). For UBC, this body is the board of governors. The number of review points and the number of groups reviewing projects before presenting proposals to the board of governors ensures that a majority of stakeholder representatives have had a chance to provide input before a project is initiated for funding. Refining the scope of the project can help to ensure that UBC receives just what they need at the time they need it. Integrating researchers on projects is a key component of the CLL program itself; it is important to develop as many avenues as possible to find the right people to work on a project (such as charrettes, steering committee meetings, etc.). Finding the right people can involve breaking down silos and fostering greater interdisciplinary collaboration. This can also be seen as a benefit of the CLL (i.e., Figure 12).

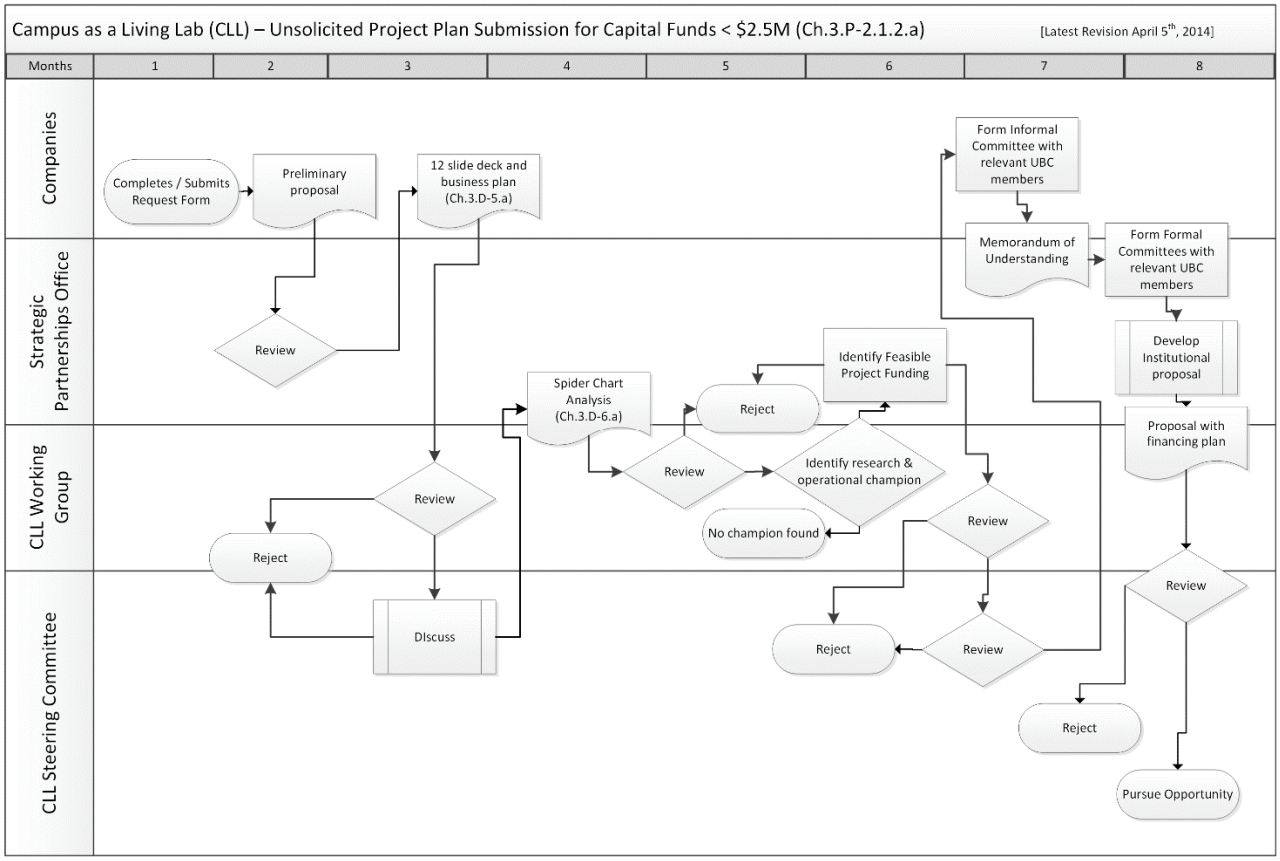

Figure 12. Unsolicited project plan submission for capital projects <CAD 2.5 million.

6. Main Results of Case Study

The main results obtained through the analysis of the UBC CLL process case study are categorized as evolution of BPM evaluation documentation for unsolicited requests, evolution of BPMs of case projects after recognized failures and lessons learned, overview of proposed generic living lab processes, and key transferable characteristics from ethnographic study and BPM exercises.

6.1. Business Process Modelling for Evaluation of Funding Opportunities

UBC funding requirements are evaluated as a business case from UBC's board of governors' perspective. A BPM for this process was initially created by the Director of Strategic Partnerships Office. Revisions from the original model included condensing the submission and initial review phases into one process and the addition of a project time component to illustrate typical durations.

6.1.1. Evolution of BPM Evaluation Documentation for Unsolicited Requests

The BPM presented in Figure 12 is the process for unsolicited requests derived by this study. It provides an overview of how the CLL's business processes for unsolicited proposal requests have developed since September 2010 for unsolicited project plan submissions greater than CAD 2.5 million.

Key documents were developed to support this process: a 12-slide "proposal summary" deck (Table 1) and a business plan were added in January 2012, and a spider chart analysis was included in June 2013 (Figure 13).

Table 1. Slide deck overview for companies presenting opportunities to UBC (Evans 2012).

Slide # & Item	Contents
(1) Introduction Slide	Project name, Company name, Company location, Company lead
(2) Presentation Outline	Slide headings of 3 to 12 on this list
(3) Executive Summary	How UBC helps achieve the company's corporate goals
(4) Opportunity Positioning	The key problem they are solving and why it is unlike any other product
(5) Solution Overview	Outlines the value proposition and core technology
(6) Solution Example	Describes how problems will be overcome
(7) Program Plan	Provides key resources, tasks, and milestones
(8) Program Partnerships	Partnerships that will develop within BC and beyond
(9) Product Cost Assumptions	A detailed cost breakdown
(10) Innovation Opportunities	Researcher involvement opportunities, risks, and barriers to commercialization
(12) Operations and Maintenance Support Plan	How support will be provided to UBC
(13) Value-added Opportunities	Other potential synergistic opportunities for UBC

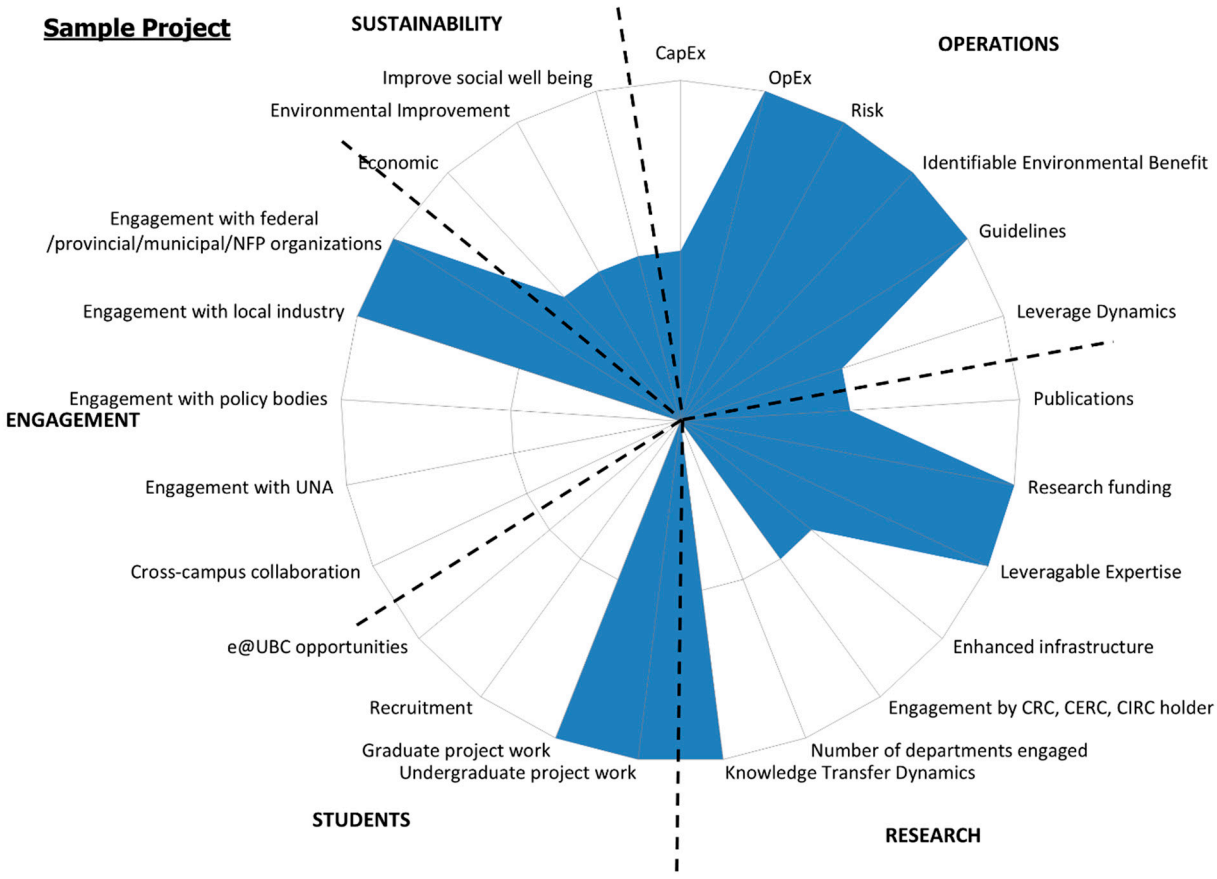

Figure 13. Spider chart analysis for UBC CLL project selection, illustrating relative evaluation scores for a proposal for a variety of criteria. e@UBC opportunities (entrepreneurship at UBC opportunities).

6.1.2. Evolution of BPMs of Case Projects after Failures Recognized and Lessons Learned

The identification and mapping of the business processes used for the three representative projects shown in Section 5.2.1 were used primarily to inform general overall CLL BPM development. All three of these projects were completed and regarded as successful

projects, although they all led to the identification of opportunities for lessons learned and business process improvements. Some examples include the following:

- CIRS project process evaluation demonstrated how it is helpful to have design charrettes informing the project early to aid with technology decisions. Additionally, it was realized that linking funding with specific building components can reduce the potential for specific items (and project objectives) to be lost through value engineering, and having one decision-maker can streamline a project.
- The Academic District Energy System project process evaluation showed how long of a process it can be to evaluate campus energy options and how both third-party consulting and the campus community can collaborate. As an outcome of this project, the Bioenergy Research and Demonstration Facility emerged, the evaluation process for which formed the initial basis of all future CLL project evaluation processes (Figure 14).
- The timing, scale, and participants of the Bioenergy Research and Demonstration Facility project caused this project to become a primary vehicle for the initial development of the CLL processes and the collections of early lessons learned. Immediately following the implementation of the Bioenergy Research and Demonstration Facility, eight themes for improvement emerged (stakeholder engagement, funding, managing expectations, legal, risk assessments, champions and project managers, due diligence, information sharing, and communications), and from these, 12 recommendations emerged:
    (1) "Expand public consultations process to include other elements of community engagement" (resources on engagement here: http://tamarackcommunity.ca/, accessed on 6 March 2014). Proactive consultation is required early and often.
    (2) Provide sufficient funding and/or resources for pre-feasibility and feasibility resources, project management, and due diligence and evaluation.
    (3) Identify secure project funding earlier in the project life cycle to prevent a "moving target" when approaching the UBC board of governors.
    (4) Inform all stakeholders of process steps, key decisions, milestones, and all UBC expectations at the outset.
    (5) Identify and share expectations and needs of all stakeholder groups at the project outset.
    (6) Host project kick-off with all players.
    (7) Share the broad vision, knowledge, context, and objectives of the project, creating a consistent message and understanding of the project for all stakeholders.
    (8) Identify and adequately resource project managers and key champions within the organizations.
    (9) Assess all potential projects using technical and sustainable criteria, as well as against alternative possibilities to ensure adequate due diligence. Ask the right questions.
    (10) Coordinate communications with all stakeholders; ensure announcements are timely and have been approved by all.
    (11) Develop risk assessment and evaluation document to guide/frame various interactive or negotiated steps in the development of the project.
    (12) Need a process road map that lays out the action steps required [45].

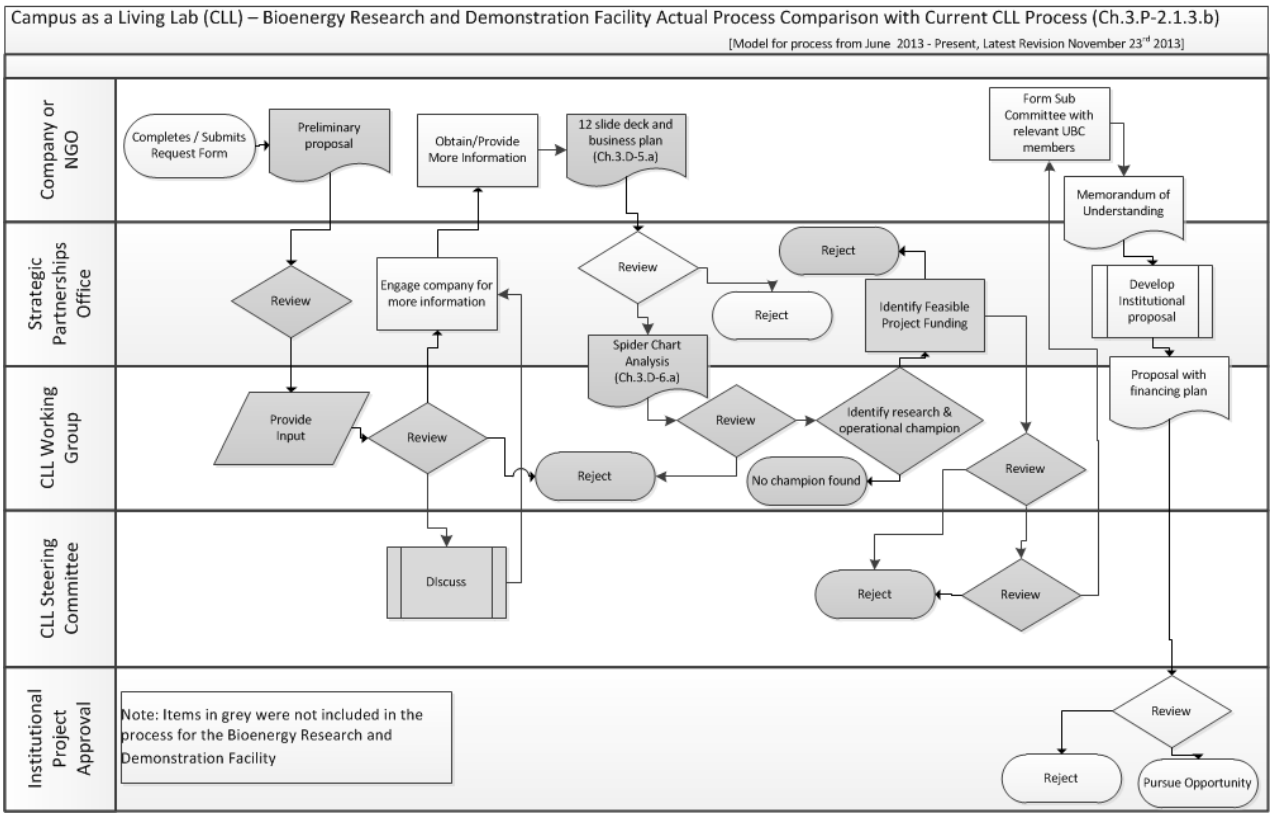

Figure 14. Bioenergy Research and Demonstration Facility actual process comparison with current CLL process; 5 recommendations emerged from the UBC CLL process.

These recommendations were implemented, along with a significant increase in the number of reviews and stakeholder checks throughout the process (including the preliminary review of the company and proposed technology via a slide deck summary and spider chart analysis, as described previously). Figure 9 represents the BPM followed for the Bioenergy Research and Demonstration Facility project; Figure 14 represents the same process mapped on top of the revised BPM for unsolicited requests >CAD 2.5 million, where the steps shown in grey represent tasks, reviews, and checks not included in the original project. It can be seen that significantly more steps have been added, and leads to final BPM requirements for such projects.

6.2. Proposed Generic Living Lab Processes

The goal of the UBC CLL is to improve sustainability by driving innovation that benefits its own operations and facilities, its core mission (research), and the industry partners' interests. The pursuit of this goal involves a particular focus on the demonstration phase of the technology readiness scale. This introduces a level of technological risk that is well beyond that of "tested" technological solutions, and this risk is significant because of the financial scale of campus infrastructure and facilities projects. Therefore, the business processes to manage and assess these projects are vital to achieve the CLL objectives while avoiding undue risks and project failures. It took a significant amount of time, as well as trial and error, to derive the tools necessary for the evaluation of high technology and high budgeted projects for technology readiness and strategy alignment.

Overview of Proposed Generic Living Lab Processes

A number of important attributes emerged from the case studies and analysis conducted under this research, including increasing support, aligning goals, improving pro-

cesses, developing multi-stakeholder involvement, and developing strategic decision-making tools.

In summary, UBC attempts to de-risk projects by leveraging UBC infrastructure investments with matching funds from industry and the government, by reducing potential liability on carbon taxes, and by using projects to contribute to research and teaching. Therefore, the funding for any incremental costs arising from CLL projects is sought from sources external to the University [46]. Technology accessibility and development is increasing, which could lead to more widespread adoption if the inhibiting barriers were reduced by removing organizational barriers and addressing the future improvement steps given in Figure 15.

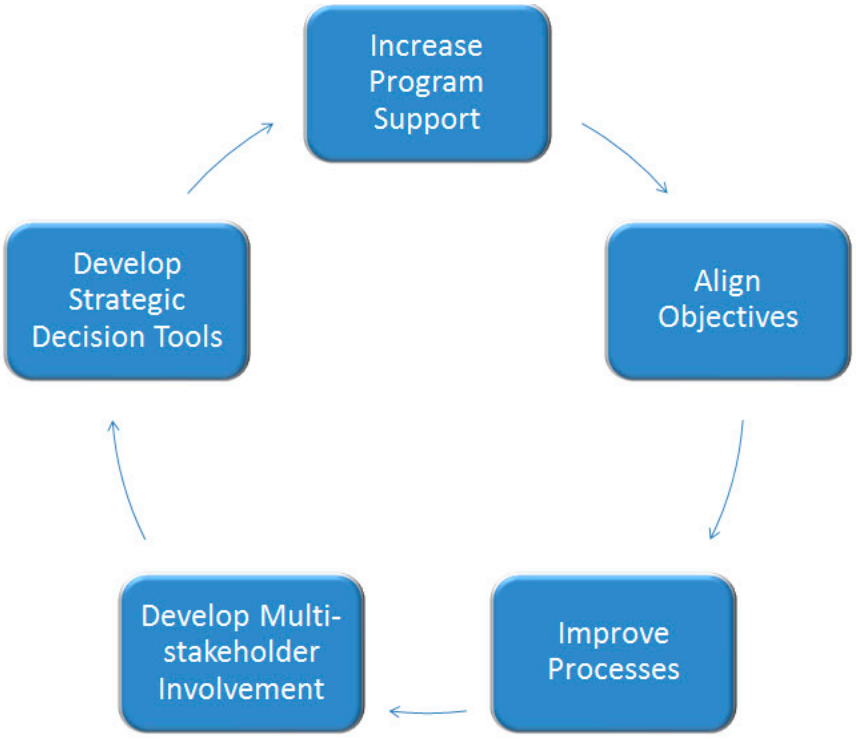

Figure 15. Generalized future improvement plan for UBC CLL.

6.3. Key Transferable Characteristics from the Ethnographic Analysis

The quantitative analysis (Section 5.1) showed that the majority of the CLL Working Group's time is absorbed by tasks related to the development of opportunities, assessing the environment, and developing a vision, strategy, and assessment tools. It is a delicate balance to juggle these items while trying to remain on-course. To assist with strategizing, recommendations include a dedicated budget for the CLL Working Group and time allocated for a strategic retreat.

The qualitative analysis provided a number of sub-themes, challenges, and partial solutions for further exploration. These are all meant to be a starting point for a rigorous analysis and business case development. The summary of key transferable elements and characteristics obtained by ethnographic study is provided as follows:

Develop strategic documents:

- Continual optimization of strategic documents
- Terms of reference
- Project selection principals
- Metrics for success
- Processes to follow
- Continual optimization of CLL processes
- Integration of new technical guidelines for campus

Administration:

- Implement a governance model to capture all groups who may potentially work on CLL projects
- Ensure adequate human resources are available
- Develop a database of researchers ready to work on projects, and projects ready for researchers
- Ensure the committee has technologically savvy members
- Create a strategic marketing and communications plan
- Establish a CLL identity
- Have a marketing and communications budget
- Identify research potential research champions early
- Create relationships with other groups within the campus who are interested in CLL projects

Knowledge transfer:

- Share general challenges
- Share successes and failures
- Cultivate relationships with other institutions to share information about new technologies

Being strategic:

- Review proposals side-by-side to reduce stretching of resources and select the most viable options
- Have an inter-disciplinary business case review team on hand
- Develop a list of technology items ready to be integrated
- Develop a presentation schedule for committee learning
- Forecast potentially major campus issues and work on a plan early

Integration with campus:

- Link construction and operating cost into building budget
- Incentivise deans to improve operational efficiency of buildings
- Monitor energy usage of buildings, and ensure monitoring equipment is installed

6.4. Key Transferable Characteristics from the Business Process Modelling Analysis of UBC CLL

A summary of the key transferable elements and characteristics identified from the BPM analysis of UBC CLL program is as follows:

(1) An organizational structure for the University Sustainability Initiative (USI);
(2) A diverse multi-stakeholder committee membership structure;
(3) A process of categorizing projects based on size (high-level view);
(4) A process of project evaluation (due diligence) and approval (mid-level view);
(5) Tools for project evaluation: slide deck and spider chart;
(6) A process for selection of a research champion;
(7) A process for selecting strategic partners;
(8) Design goals and charrettes for high performance buildings;
(9) An approach of linking funding to sustainable technologies so that they are not value-engineered out the equation;
(10) Contests to solicit ideas for alternative energy;
(11) The linking of feasibility studies to contests for the wider community to contribute ideas.

The UBC CLL documents and business processes were generalized, adapted based on the key transferrable characteristics, and assembled into a proposal—Model Overview—of generalized CLL processes that might be implemented by other institutions interested in pursuing a CLL initiative. The items that make up this proposal are either documents (represented by a "D") or processes (represented by a "P"), as outlined in Figure 16.

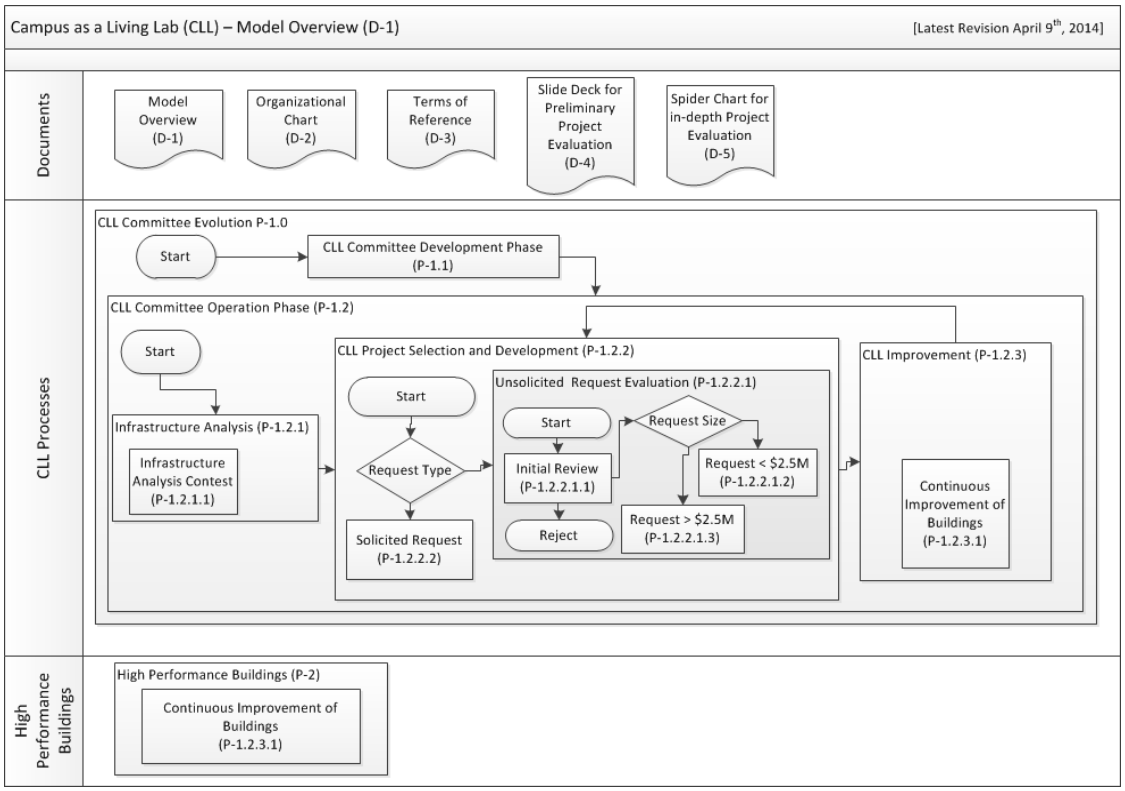

Figure 16. Campus as a Living Lab—model overview.

7. Discussion on Current Status of CLL

Overhead costs and changes in the teams and groups of USI required simplification in the managerial staff and also caused restructuring in the existing administrative structure. As of October 2016, the CLL steering committee merged within the USI organization, and the working groups decided to become part of the bigger organization. The current organizational chart for the USI is undergoing restructuring. Figure 17 shows some of the updates based on limited information available through interviews conducted in spring 2017. Interviewees indicated that further organizational structure will be defined for the ongoing CLL activities, but these have yet to be developed.

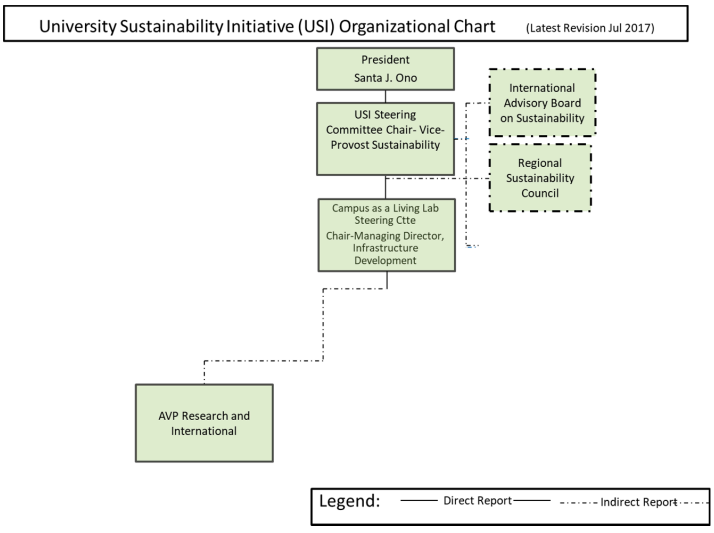

Figure 17. University Sustainability Initiative (USI) generic organizational chart update.

The new organization aims to merge the roles of the administrative director and the CLL working group management chair positions, and the new chair will provide leadership as the Sustainability Provost [46].

> The USI has a steering committee that provides strategic guidance and oversight to UBC's campus-wide sustainability initiatives, including academic, research, operational, and policy decisions. The USI Steering Committee also works closely with a Student Sustainability Council and a Regional Sustainability Council. The Student Sustainability Council provide input on priorities in research and partnerships, teaching and learning, operations and policy recommendations, and meets twice a year with the Steering Committee [46] (See Figure 1).

After the reorganization started in October 2016 by downsizing the central management in USI and CLL, the student sustainability council meetings are on hold, the faculty sustainability fellow meetings started in July 2017, and the regional sustainability council meetings are operating through informal channels for now [46].The Steering Committee met two times in the last fiscal year. According to the interviewee Giffin, the Research Operations and Emission Committees under the project Steering Committee (Figures 1 and 2) did not meet for an extended time and were disbanded [48].

The CLL business processes that have been followed, which were initially substantial but somewhat ad-hoc in reaction to the demands of several large early CLL projects, have started to be increasingly formalized and clarified and were consequently not found to be applicable in many cases [46]. The main committees still function as illustrated in Figure 18 through the project's life cycle [46].

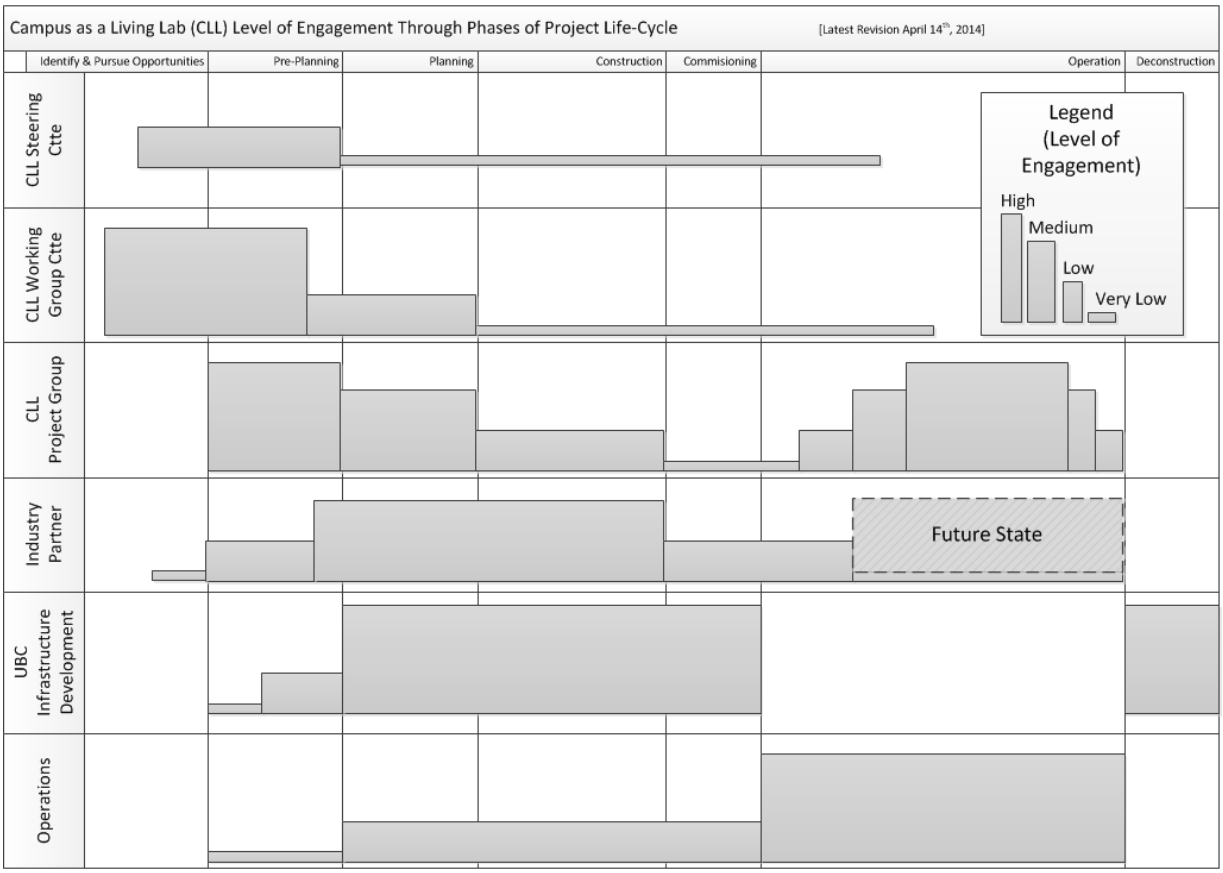

Figure 18. Campus as a Living Lab level of engagement through phases of project life cycle.

A future step of the CLL program is to include a bioenergy facility using the infrastructure of the previous facility built in 2013 [48], which reflects the infrastructure readiness for an upcoming project through CLL.

8. Conclusions

Sustainability is a growing interest in the world, and UBC is developing a strategy of tackling some of the tough challenges related to improving efficiencies with energy production, transmission, and consumption through technology adoption with the Campus as a Living Lab (CLL) program. UBC is at a scale that is large enough to prove that a technology could work for other campuses or municipalities, which can be a model for similar organizations or municipalities to follow for living lab programs and reduce their ecological footprint. Therefore, the UBC CLL program analysis has the potential to be a demonstrative example for all large organizations looking for managerial models for living labs and to showcase leadership in sustainability.

As identified in the literature review, the need for a structured managerial model and standardized tools for decreasing the complexity of innovation activities and operational processes for living labs have been defined. Additionally, according to the theoretical framework, multi-stakeholders' divergent interests must be addressed by collaborative alignment strategies [26–30]. In this perspective, a roadmap illustration set for collaborative integration of multi-stakeholder projects was defined with this study. Additionally, lessons learned and related key transferrable characteristics for other institutions to benefit are shared in Sections 6.3 and 6.4.

Through this extensive ethnographic research, answers to the main research questions are given by referring to multiple tools generated for structured managerial model of UBC CLL. Addressing the main research questions, results can be summarized as:

- How do CLL Working Group members and Steering Committee members interact during meetings to mediate the problems on the integration process of multiple stakeholders' needs?

Quantitative analysis of the coded meetings is given in Section 5.1, where the meeting coding plot is explained by Figure 3. Interactions between the CLL working group members and steering committee members are depicted in Figures 5 and 6. Assessing the environment and developing opportunities to test new sustainable technology are the key issues discussed in the flux. To address multiple stakeholders' needs without losing the attention to key issues, further documentation such as the slide deck (Table 1), business plan (no format set), and spider charts (Figure 13) are required for project proposal requirements.

- How do these meetings lead to a better process definition for future actions?

These meetings enabled the trial-and-error of multiple tools derived for UBC CLL projects. Three case studies: *CIRS, the Academic District Energy System, and the Bioenergy Research and Demonstration Facility* shared through generated building process models (BPMs) specific to UBC CLL give reference cases to *a building, an analysis of campus wide infrastructure option, and a facility project*, respectively. They represent key projects to address UBC's long-term sustainability goals and cases to test the BPM method. For example, the Bioenergy Research and Demonstration Facility project acted as the main trial and error demonstration of BPMs generated for CLL projects. Necessary improvements in the process have been depicted to update the BPM in Figure 14. Looking at the added steps and documents required between the older (Figure 9) and updated version (Figure 14) of this project's BPM, a step forward for better process definition and tools added can be identified with dark grey additions in Figure 14.

- Is it possible to document the development of the project processes through different charts for enabling a replicable method for universities and cities?

According to our ethnographic study findings, it is possible to document the development of the project processes through replicable charts and graphs. Although different organizations may have different structures and needs, the generic business process model

legend (Figure 4) has the potential to be implemented as a replicable model. BPMs shared through this study demonstrate the potentials of use in various project evaluation steps. The generic model overview (Figure 16) illustrates the potential use of generated documents, CLL process model schemes of unsolicited request, and high-performance buildings' continuous improvement at managerial level, which can be adapted to multifarious phases of CLL needs in other organizations. BPMs aim to provide clear and detailed representations of the sequence of tasks associated with the CLL activities of identifying new project opportunities, evaluating project proposals, obtaining the institutional commitments for selected CLL projects, and the oversight of these projects' stakeholders' roles as they move through their life cycle phases (Figure 18). BPMs have the potential to identify the task sequencing, the parties involved in each task, and some of the key documents or artefacts associated with these tasks. Additionally, the spider chart (Figure 13) illustrates the relative evaluation scores for a proposal, which could be replicated in alignment with the set criteria of the adopting organization.

While the extensive review process created through the UBC CLL aimed to be helpful in easing the process of evaluating high budgeted high-technology project proposals for the board of governors, the administrative structure of CLL needed to be re-evaluated with changing actors. According to the final interviews conducted [46,48], business process modelling used in some initial projects has not been used since then, and the proposed BPM sets were not being pursued at the date of interviews.

The main contribution of CLL to UBC is defined as its culture-building activity to enhance collaboration in opportunities, where the campus can be used as a testbed with all of its resources, infrastructure and facilities [46]. It is believed that the ethnographic study and overall methodology with BPM analysis is a base to build on for UBC or any other organization interested in embedding sustainability at campus/municipality scale. Generalized future improvement plans for UBC CLL programs (Figure 15) are a roadmap driven for CLLs in the future by the authors. Well-depicted processes reflect the problems transparently, where the improvement steps become easy to identify. Another main suggestion is the need for industry partners to be more involved in the operation process of projects partnered through CLL (Figure 18). It was realized that the involvement of partners diminished in the operation phase, which started to change because the failures happening through trial-and-error steps needed fixing.

Goals of fostering sustainability innovation and continuous development/optimization of processes applies to UBC and other organizations (other universities, cities, municipalities, living labs). Therefore, this research generalizes the UBC CLL business processes, tools, and lessons learned to develop a set of proposed generic living lab processes for all interested organizations. The main limitations of this study are the time limitation of the ethnographic study and availability of information transferred through the formal meetings. It is believed that discussions occurring regarding BPMs are ongoing through informal meetings cannot be tracked.

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Informed Consent Statement: This research included an ethnographic study where meetings of public record were attended to aid with collecting information about the organizational practices, not about individuals or their opinions. No research involving human subject was involved.

Data Availability Statement: Data is contained within the article.

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