THE ABC'S OF SUSTAINABILITY: IMPLEMENTING THE SUSTAINABLE RESOURCE STRATEGY AT THE UNIVERSITY OF BRITISH COLUMBIA

by

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Abstract

The Sustainable Resource Strategy allows the University of British Columbia a unique opportunity to take a leadership role in community resource planning. The Strategy addresses four broad water and energy resource questions for the UBC campus. It outlines where the University is now with energy and water consumption. It shows where the campus will be with water and energy use and supply if current trends continue. It poses the question of where the University wants to be in terms of energy and water supply and demand and sets long-terms targets. Finally, the Sustainable Resource Strategy outlines a path to follow in order to meet these goals, by outlining a flexible resource portfolio of resource options. High priority options include demand management for transportation, renewable energy sources for buildings and infrastructure, and alternative water supply sources. This document was prepared with input from two stakeholder workshops. A series of interviews were also conducted for the final chapter that focused on the challenges and strategies for implementation of the completed Sustainable Resource Strategy. The Strategy has a number of benefits for the University including improved health and safety, improved air quality, local economic development, links with research and development, and meets many of the goals of the UBCTrek 2000 vision document.

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Preface

During the summer of 1999, the UBC Campus Sustainability Office received a grant from BC Hydro for the preparation of an energy and water plan for the campus, that would consider sustainability in planning. The Sustainable Resource Strategy would include sustainable and renewable alternatives. In May of 1999, I was hired for four months to research, collate input, and write the Sustainable Resource Strategy. The work was supervised by Freda Pagani at the Campus Sustainability Office, and was supported by Allan Grant at BC Hydro and Eliot Allen of Criterion Planners/Engineers in Portland, Oregon. Two workshops were held in June to solicit input from UBC and external stakeholders for the preparation of the plan. The first draft of the Sustainable Resource Strategy was ready for distribution by November of 1999.

This expanded version of the Sustainable Resource Strategy includes a final chapter that focuses on challenges to implementation and highlights opportunities to facilitate its implementation. This chapter was added after a series of five interviews with key players in resource planning at UBC that were conducted in May, 2000. Many of the lessons are applicable to other campus sustainability initiatives.

Maggie Julian
March 2000

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Thanks to BC Hydro for funding my summer position with the UBC Campus Sustainability Office.

This project would not have been possible without the people who participated in the workshops in June of 1999, and those who were interviewed in May of 2000.

And finally a thank you to the supportive community at the School of Community and Regional Planning, and my family and friends.

Chapter 1: Introduction to the UBC Sustainable Resource Strategy

This chapter introduces the goals, objectives, methods, and limitations of the Sustainable Resource Strategy.

1.1 Goals and Objectives

The Sustainable Resource Strategy has benefits for the University of British Columbia community, the region and the global initiative to address climate change and resource depletion. Energy and water use affect air quality, health and safety, aesthetics, land use and local economic development. Sustainable resource planning moves away from a non-renewable, finite, polluting resource base, to a robust, diverse, renewable, low-impact resource portfolio.

The Sustainable Resource Strategy is an 'action plan' to implement the resource component of UBC's Sustainable Development Policy. This policy, adopted in 1997, has committed UBC to providing leadership on sustainable development by demonstrating the means to a sustainable community on campus.The Sustainable Resource Strategy identifies existing goals and develops visionary but achievable energy and water related objectives for UBC campus. It also outlines strategies for achieving these objectives while supporting broader community and regional goals. The Sustainable Resource Strategy addresses four broad water and energy resource questions at UBC:

1. Where are we now?
2. Where are we going?
3. Where do we want to be?
4. How do we get there?

The first chapter introduces the goals, methods, and limitations of the Sustainable Resource Strategy. The second chapter outlines the concept of sustainable development and what this means in both a community and campus context. The third chapter provides a detailed geographic and population context for resource planning at the University of British Columbia, including how the Sustainable Resource Strategy is congruent with other UBC planning initiatives. Chapter four identifies existing water and energy usage on campus, and projects potential future needs. Chapter five outlines the recommended resource portfolio for energy and water. Chapter six illustrates existing sustainability targets, and sets new targets for energy and water. Chapter seven outlines how the Sustainable Resource Strategy can be implemented. Chapter eight focuses on monitoring and evaluation. The final chapter highlights the challenges of implementing the Sustainable Resource Strategy and provides strategies to overcome these challenges, based on a series of interviews with key players in resource planning at UBC.

The Sustainable Resource Strategy provides a catalyst for the development of UBC as a leading renewable energy research and development institution. The Strategy highlights opportunities for research and demonstration projects, and possible links to teaching and student projects. The Sustainable Resource Strategy also serves to inform the Comprehensive Community Plan, which is currently under development. Planning at a community level encourages public participation, involvement and interest in the future of the community. A community based planning initiative helps to build a sense of community pride in moving towards self-sufficiency.

Reduction in greenhouse gas emissions will limit the number of common air contaminants and improve air quality. Beyond reducing dependence on the finite supply of fossil fuels and addressing the serious implications of global climate change, community resource planning also has local benefits. Planning for the socially, ecologically and economically responsible use of water and energy increases a community's self-reliance and local control of these resources. A healthy economy and economic viability is a component of sustainability. Community resource planning offers savings in both capital and operating costs to the University. Energy efficiency and related technology support local employment opportunities.

Table 1: Characteristics of a Sustainable Community

Sustainable Characteristics
• Compact form
• Integrated multimodal transportation system
• Mix of uses at appropriate densities
• Concentrated activity centres
• Use of local renewables, wastes, and alternative supplies
• Use of high-efficiency infrastructure
• Use of local-origin and reused, recycled, and recyclable materials

Source: Criterion Planners/Engineers, 1999

A Sustainable Resource Strategy can also help to accomplish several University goals in developing a sustainable campus community (see Table 1). The Sustainable Resource Strategy supports a more complete community, with affordable housing, more ways to travel and less traffic, and cleaner air. The Strategy supports a number of the UBC Trek 2000 goals including people, learning, research, and community.

Economically there is a strong argument for a Sustainable Resource Strategy. More on-site energy production will result in lower utility costs. Initial investments in renewable technology and efficiency measures will offer savings in the long term. Gas prices have been rising steadily for the last two years (BC Gas, 1999). Planning for renewable resource use is a response to increasing fuel prices. By increasing self-reliance, potential vulnerability to disruption of energy supply and fluctuations in non-renewable energy prices is reduced.

1.2 Methods

This document is an expanded version of the Sustainable Resource Strategy, and is being submitted as a project for my Master of Science in Planning. The Sustainable Resource Strategy was conceived and developed through UBC's Campus Sustainability Office in 1999. The Strategy development process was planned during the spring of 1999, before I came on board with the project. My role with the Sustainability Office was to provide background research, assist in implementing the process as it was designed, and finally to collate the research and input from the workshops into the Strategy document. I expanded the introduction and added a chapter on implementation for submission of this document as a professional project to the School of Community and Regional Planning.

Planning for preparation of the Strategy began in March of 1999. The Community Energy Planning model, developed for municipalities in British Columbia, was the template for the development of the Strategy (B.C. Energy Aware Committee. 1997). BC Hydro provided funding for a facilitator for two workshops to solicit input for the development of the Strategy and for a summer student to work on the development of the Strategy from mid-May until early September 1999.

Over 50 invitations were issued for the first workshop and 26 people from the UBC community participated in the half-day session on June 14, 1999. The first workshop focused on providing information about the Sustainable Resource Strategy development and gaining direction as to which sustainable water and energy supply options should be included in the resource portfolio. Water and energy working groups were formed and they each met once in the two-week period between the two workshops.

The second workshop had an expanded invitation list that included stakeholders from outside the UBC community including utility and alternative energy service providers, First Nations, tenants associations, non-governmental organizations, and government representatives. This all-day workshop, held June 28, 1999, provided further information to internal and external stakeholders on the development of the Sustainable Resource Strategy, developed a portfolio of resource options, and revised the list of resource evaluation criteria.

The revised list of resource evaluation criteria was used to make a qualitative analysis of the resource options, given the information that was available about the quality and quantity of resources at UBC. The results of this analysis are shown in tables in Appendix C. The results of this analysis were used to rank the resource options as high, medium or low priority (see 5.5).

Table 2: UBC and External Stakeholders

Stakeholders
• Utility and alternative energy service suppliers
• Campus Planning and Development
• Residents and tenants associations
• Non-governmental organizations
• Government representatives
• UBC faculty and staff
• Adjoining neighbourhoods
• UBC Students
• UBC Utilities
• UBC Plant Operations
• UBC Properties

A series of energy and water profiles of the resource options being considered for inclusion in the Strategy was prepared, and are included in this document as appendices. The information sources for these profiles is current literature and world wide web information on renewable energy and sustainable water options. UBC-specific information was gathered from campus planning and development and other UBC research units.

The Sustainable Resource Strategy was completed by October 1999. The Steering Committee made up of key UBC stakeholders provided input during the development of the Strategy. A final chapter , focusing on moving the Sustainable Resource Strategy forward in its implementation, was added in June of 2000. The information for this chapter was gathered through five key informant interviews with the Sustainability Director at UBC, the head of UBC Utilities, a representative from UBC Properties, the Vice-President of UBC Land and Building Services, and a community energy planner from BC Hydro who had participated in the development of the Sustainable Resource Strategy. Constraints and challenges to implementation of the Sustainable Resource Strategy were identified, and strategies to help to overcome these challenges were identified through the interviews.

1.3 Limitations of Study

The final draft of the Sustainable Resource Strategy is complete but there are limitations to the depth and comprehensiveness of this research. The most significant limitation to the strategy development was the availability of time. There was a very short lead time from the planning stages to the execution of the stakeholder workshops. As well, the Strategy itself needed to be completed over a period of two months, whereas in other community energy planning initiatives, the process has taken up to a year.

Many of the participants had limited time and energy to commit to the process, which may have detracted from the quality of the final product, and from their 'buy-in' to this resource planning initiative. Further fine tuning of the Strategy could have taken place after the formal planning process was completed at the end of August 1999, but limited funds were available to support this. Finally, renewable energy and sustainable water management is a new and developing field. There were instances where only limited information was available about resource options. As well, in some cases there is very limited knowledge about the condition and quality of energy and water resources at UBC, such as groundwater, which restricts decision-making about what resource development opportunities could take place until better information is available.

Chapter 2: Sustainability

This chapter introduces sustainable development in a community and university context and explores what it has come to mean at the University of British Columbia campus.

2.1 Sustainable Development

In 1987, the World Commission on Environment and Development, chaired by Gro Harlem Brundtland, released its report, *Our Common Future.* At the core of the Brundtland report lies the concept of sustainable development. The oft-cited definition of sustainable development comes from this report "Humanity has the ability to make development sustainable- to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987). However, the discussion around sustainability and operationalization of its meaning has encompassed a wide spectrum of theory and practice. Making the campus more sustainable means, among other initiatives, using less water and energy to meet existing and future needs. It also means shifting to renewable, local, non-polluting sources of energy and incorporating water management strategies that are non-polluting and that replenish the watershed.

2.2 Communities and Sustainability

The concept of sustainable development has been linked to community initiatives since the Brundtland report first brought the concept into the mainstream and the slogan "think globally, act locally" was popularized. The sustainable community movement both builds upon and contributes to the ideas of bioregionalism, community economic development, the green movement, green cities, social ecology, healthy communities, and appropriate technology (Roseland, 1997). Sustainable communities represent a goal for community development, but there is no accepted definition of what "sustainable communities" are, instead each community must determine that. Much of the literature recognizes the roles that communities must play in defining sustainability for themselves. For example, one American community defined a sustainable community as seeking:

> a better quality of life for all its residents while maintaining nature's ability to function over time by minimizing waste, preventing pollution, promoting efficiency and developing local resources to revitilize the local economy. Decision-making in a sustainable community stems from a rich civic life and shared information among community members. A sustainable community resembles a living system in which human, natural and economic elements are interdependant and draw strength from each other (Minnesota SEDEPTF 1995 in Roseland, 1998).

2.3 Campuses and Sustainability

Universities and colleges have been active in incorporating environmental management and practices since the early 1990s. Much of the research, critical thinking, innovation and training that is needed to address the problems and challenges of sustainability is central to the University community. Universities have a central role in educating the general community to improve environmental awareness and are large purchasers and consumers of goods and services.

Canada's National Round Table on the Environment and the Economy published a "Green Guide: A User's Guide to Sustainable Development for Canadian Colleges" in 1992. Steps to make educational institutions more sustainable tend to fall into three broad categories: greening operations and facilities, greening the content of programs and courses; and greening off-campus activities and interaction with the off-campus community (Chernushenko, 1995). UBC is the first institution of its kind in Canada to create an office devoted to campus sustainability. While several universities have made efforts towards increasing energy efficiency, the Sustainable

Resource Strategy is unique in Canada in that it addresses both energy supply as well as demand, and incorporates sustainable water planning in its resource planning.

2.4 Sustainable Development at UBC

The Sustainable Resource Strategy coordinates in a single document many existing University initiatives and incorporates new ideas that promote a socially, ecologically and economically sustainable future. The Sustainable Resource Strategy encourages the wise, efficient and creative planning, development and management of the resource requirements of the present and future community.

As a signatory to the Halifax Declaration and the Talloires Declaration by the University Presidents for a Sustainable Future, the University of British Columbia adopted a Sustainable Development Policy in May of 1997. UBC has committed to providing leadership by demonstrating the means to a sustainable community on campus. The UBC Sustainability Office was created in May of 1998, to coordinate sustainability initiatives at the University. UBC defines sustainability as the balance between ecological, economic and societal goals. An energy management plan was developed in late 1998 and is already being implemented, beginning with lighting upgrades in eight buildings. The recently completed C.K. Choi building demonstrates innovative green building design.

The most basic requirement for a sustainable and environmentally friendly campus is to demonstrate wise use of resources. As an educational institution, the University of British Columbia has a unique opportunity to take a leadership role in community resource planning for the new millennium. The largest single resource used on the campus is energy, followed by water. It follows that sustainable strategies for use of these resources are key not only for energy and water management for the existing infrastructure but also for future development. The campus has an opportunity to research and put into practice innovative planning, design and management of its human, economic and ecological capital as it moves into the next century.

Chapter 3: The University of British Columbia

This chapter sets the context of the University of British Columbia including the population, geography and developments plans for the University.

3.1 The University in the Community Resource Planning Context

British Columbia has taken a lead role in Community Energy Planning in Canada with recent initiatives by the Energy Aware Committee, a group of utility, provincial and community agencies committed to promoting energy planning in British Columbia. UBC's Sustainable Resource Strategy is a unique opportunity to adapt the Community Energy Planning model to the University setting, a planning initiative that is a first in Canada. In many ways UBC is similar to other Greater Vancouver Regional District municipalities.

As Electoral District A, UBC has an Official Community Plan and its development decisions influence energy and water use through zoning, transportation, land-use policy and design (Figure 3 shows the UBC campus lands and the comprehensive community plan areas). However, it is unique in that its population fluctuates more than in other municipalities due to the student population moving on and off campus. As well, its educational focus unites the structure and functions of the campus area. UBC has a rich history as a research institution and therefore is in a unique position to create a Sustainable Resource Strategy that addresses the present and future needs of the community and opens up new opportunities to capitalize on research synergies.

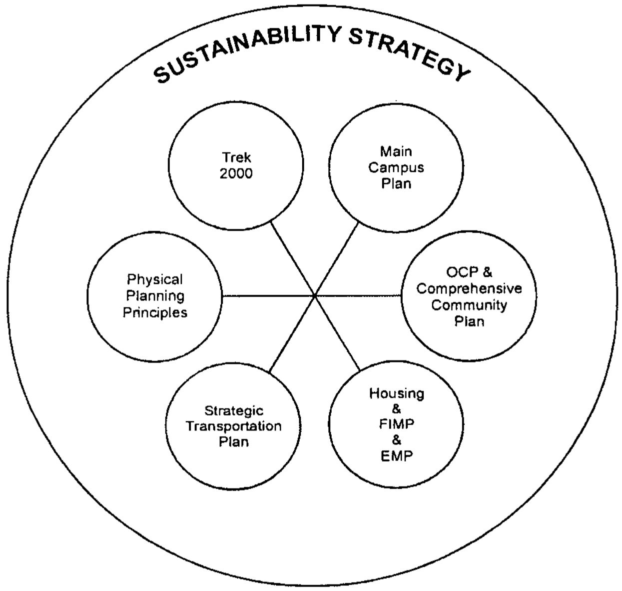


Figure 1: *Integrating Plans Using the Sustainable Resource Strategy*

Source: Criterion Planners/Engineers, 1999

3.2 Related Planning Initiatives

There are a number of planning processes underway or completed at UBC that contain elements directly related to sustainable energy and water planning. Figure 1 illustrates how *existing* measures in the University's Physical Planning Principles, Main Campus Plan, Official Community Plan (OCP), Comprehensive Community Plan (CCP), Facility and Infrastructure Management Plan (FIMP), Energy Management Plan (EMP) and the Strategic Transportation Plan can be directly integrated with sustainable energy and water management at UBC through data, planning horizons, forecasts, issues, goals, monitoring and evaluation.

Table 3 highlights specific opportunities from the Physical Planning Principles, the Main Campus Plan, the Strategic Transportation Plan, and the Official Community Plan where energy and water efficiency gains are already being incorporated into campus planning. The first column in Table 3 outlines the relevant component from the planning document, and the second column illustrates its applicability to energy or water efficiency gains.

Table 3: Applicable Efficiency Gains from Existing UBC Planning Initiatives

PLAN	EFFICIENCY GAINS
PLANNING PRINCIPLES	
Principle 1 The University Lands: As One. All spaces will be designed to their potential, each contributing to the experience of the University.	• Maximum efficiency in incremental growth.
Principle 2 The Community: Vibrant and Ever-Changing. UBC will be a place where many uses and activities happen in parallel; UBC will be viewed as a centre of growth in the Greater Vancouver region; more people will want to live and work on the University grounds.	• Better peak diversity (resource use is more evenly spread over 24-hour period) for energy and water systems. • Transportation benefits of concentrated activity centres. • A "systems approach" to development is more efficient.
Principle 3	• Mixed use provides opportunities to integrate

The Experience: A Place to Remember. New urban neighbourhoods will be mixed use; getting to and moving around the University city will be by several forms of transportation; People will be able to walk easily to places of activities.	sustainable energy and water projects. • Sustainable transportation strategies are encouraged through increased transit use, walking and cycling.
Principle 4 The Environment: Incredible Riches. As growth takes place at UBC, it is our responsibility to ensure that our actions contribute to sustaining the environment, locally and globally.	• "UBC will provide leadership by demonstrating the means to a sustainable community." This includes design, construction and operations and the sustainable management of resources including energy and water.
MAIN CAMPUS PLAN	
Strategy 5: Campus Cohesion and Limits to Sprawl All future mainstream academic development will occur within the Main Campus to establish a more cohesive campus and reduce sprawl.	• Increased density in land use will result in more sustainable energy and water use for buildings, transportation and infrastructure.
Strategy 6: The Spirit of the Place The buildings and landscapes are largely a product of the site's topography, vegetation and built form. The planning and design of new buildings will seek to clarify and support these distinctions.	• Land use and building siting will be micro-climate based, which will maximize energy and water use efficiencies.
Strategy 18: Pedestrians The entire main campus will become an environment with pedestrian priority.	• Sustainable transportation options will increase the emphasis on pedestrian infrastructure, which will encourage more pedestrian traffic.
Strategy 20: Bicycles The increased use of bicycles, both for access to and for moving around the campus, will be encouraged and accommodated in future development.	• Sustainable transportation is encouraged through the provision of bicycle lanes, storage shelters, lockers and shower facilities.
Strategy 23: Public Transit The University will seek to enhance public transit to the campus and to provide an upgraded on-campus system.	• Increased use and efficiency of public transit will decrease dependency on automobiles and decrease both energy use and air emissions. Campus transit is also included in this strategy.

Table 3: Applicable Efficiency Gains from Existing UBC Planning Initiatives (cont.)

Strategy 40: Project Design Checklist A project design checklist is outlined that includes the following criteria that are applicable to sustainability goals: 1 Site Use and Organization	• Land use efficiency should be maximized. • New buildings should be planned to assist the rationalization of the infrastructure.
2 Responding to Context	• 2.3 Buildings should be organized on the site to make new functions and circulation routes compatible with those of neighbouring buildings and open spaces. • 2.5 The Forest: Buildings should be independent pavilions set within the forest and forest gardens; open spaces should be treated as glades within the forest. • The Western Slopes: Buildings should be small and/or articulated, and stepped to reflect the area's topography. • The Town Centre: Buildings should strongly relate to and define the street which is itself the primary open space. • Focal Points- Buildings around primary focal points (Rose Garden, Library Garden, Science Quad, South Forecourt, Town Centre, West Square) should contain, define and animate the space.
3 Building Envelope	• 3.1 Buildings should generally be restricted to about four storeys to preserve the scale and image of a well-landscaped campus, and to capitalize on the economies and convenience of a walk-up format.
4 Building/Open Space Relationships	• 4.1 Buildings and associated open spaces should establish a mutually supportive relationship in which indoor and outdoor spaces animate and are connected to each other.
5 Response to Climate	• 5.1 Important public spaces, both indoor and outdoor, should benefit from the sun.
6 Circulation	• 6.1 Interior pedestrian routes should link with exterior pedestrian routes to provide logical connections through buildings. However, the continuity of exterior pedestrian routes should not be compromised when buildings are closed. • 6.2 Interior connections between functionally related buildings should be on-grade, and integrated with the outdoor pedestrian system. Bridges between buildings should be avoided except in the "Hill Town". • 6.3 Interior circulation routes should be easily understood. They should not be hierarchical, with the most important routes corresponding to the most public parts of the building. • 6.4 Buildings and associated open spaces should be universally accessible.
13 Exterior Materials	• 13.4 Building materials should suit the light and climatic conditions found on the campus.
14 Landscape Quality	• 14.2 Landscape design should receive the same level of attention and budget stability accorded to buildings and infrastructure.
16 Technical Performance	• 16.1 Building projects should be subject to life cycle costing to determine the best fit between capital costs, operating costs and ongoing maintenance costs. • 16.2 Buildings should be designed to reduce maintenance costs. • 16.3 Buildings should be designed to reduce energy consumption. • 16.4 Buildings should not be permitted to emit unacceptably noxious or otherwise unpleasant fumes or gases.

Table 3: Applicable Efficiency Gains from Existing UBC Planning Initiatives (cont.)

STRATEGIC TRANSPORTATION PLAN	
The goal of the plan is to reduce single occupancy vehicle trips by 20% by 2002 by increased transit ridership, cycling, car and vanpooling, and walking.	• The Strategic Transportation Plan encourages alternatives to automobiles, thus reducing overall fuel use and encouraging sustainable transportation strategies.
OFFICIAL COMMUNITY PLAN	
Regional Context Statement 2.0 Consistent with Greater Vancouver Regional District's Liveable Region Strategic Plan.	• Embedded efficiencies through building complete communities, achieving a compact metropolitan area, and increasing transportation choice.
Vision 3.1 The community is a place to live, work and play where learning is infused in daily life, the academic tradition is reflected in all aspects of the community; and the questioning inherent in learning permeates everyday activities.	• Peak diversity benefits for all systems: transportation, buildings, infrastructure.
Building Complete Communities 4.1.16 Sets objectives for a diverse range of housing types and tenures. 4.1.16 Directs that redevelopment, in-fill, and new housing areas will be developed at medium density. 4.1.16 Provides for housing that is primarily street-oriented and community design that is human-scaled, compact, and pedestrian-friendly. 4.1.17 Directs that new residential development will be focused around a South Campus village commercial centre. 4.1.10 Mandates the development of a pedestrian-oriented commercial centre near the transit centre at East Mall and University Boulevard. 4.1.18 Provides for a community centre and school in conjunction with a South Campus village centre 4.1.18, 4.1.19 Provides for social and community services to serve a growing population.	• Mixed use provides opportunities to integrate sustainable energy and water projects. • Increased density in land use will result in more sustainable energy and water use for buildings, transportation and infrastructure. • Sustainable transportation strategies are encouraged through increased transit use, walking and cycling. • A "systems approach" to development is more efficient.
Increasing Transportation Choice 4.2 Supports locally the regional emphasis on the development of a transit-oriented and automobile-restrained transportation system. 4.2.1 Encourages new local and regional transit services in conjunction with growth in activity and population. 4.1.16 Encourages the location of higher-density uses in proximity to the intended transit system. 4.2 Promotes alternative non-automobile travel modes (walking and cycling) both generally and through the development of greenways. 4.2.2 Encourages increased transportation demand management measures to restrain single occupant automobile use.	Sustainable transportation strategies are encouraged through increased transit use, walking and cycling Transportation benefits of concentrated activity centres

3.3 Population Scope

Defining the population of the 'UBC community' is a challenge, because a large percentage of the population only uses the campus during the day and the academic year. The current UBC population estimates are shown in Table 4. It is also difficult to anticipate growth in student and faculty numbers because growth is closely linked to budget constraints. If the student population alone grew at 2 percent a year (the present growth rate), the population would be 51,843 people by 2020.

Table 4: UBC Population (1998-99)

	Population	On-campus Residents
Students	30,000	8,700
Staff (full-time)	6,000	
Faculty	2,000	
Non-academic residents (Hampton Place–1,900 cap.)	1,470	1,470
Total	**39,470**	**10,170**

Source: UBC Properties, 1999

3.4 Geographic Scope

While the population of UBC , including the entire student body, is estimated to be almost 40,000 people the campus covers 402 hectares of land. It is located on a peninsula on the western side of Vancouver (see Figure 4). The area of all UBC buildings, including faculty and student housing, is 1.23 million square metres. The total is 1.32 million square metres if Hampton Place is included, a residential market development also located on the university campus.

This document focuses on campus lands only, while still recognizing that there are important regional linkages for water and energy. While the geographic scope for this sustainable resource planning is limited at this time, it is hoped that opportunities will be available in the near future for UBC to become involved in sustainable energy and water management at a regional level. Figure 2 illustrates the energy and water linkages between the campus, the surrounding community, and the region in terms of supply and demand, impacts, and shared infrastructure.

3.5 Campus Development

The Official Community Plan has laid out the following schedule for development on the campus. The tentative schedule is illustrated in Table 5. In addition to the 1.32 million square metres already developed on campus (see 3.4) roughly 837,000 square metres will be developed under current plans (UBC Properties, 1999). Figure 3 illustrates the UBC campus lands, and the highlighted areas are slated for further development and densification through the Comprehensive Community Planning process. An estimated 9,150 additional housing units will be built by 2020. The additional housing units will double the on-campus population (3.3 lists the current population numbers).

Table 5: Tentative Schedule for Housing and Development on Campus

Time Period	Housing Units	Commercial Retail/Office
2000-2004	2,000	8,500 m^2
2005-2009	2,000	6,500 m^2
2010-2014	2,000	
2015-2019	2,000	1,600 m^2
2020-2024	1,150	
Total	**9,150**	**16,600 m^2**

Source: Official Community Plan, 1997

GEOGRAPHIC SCOPE

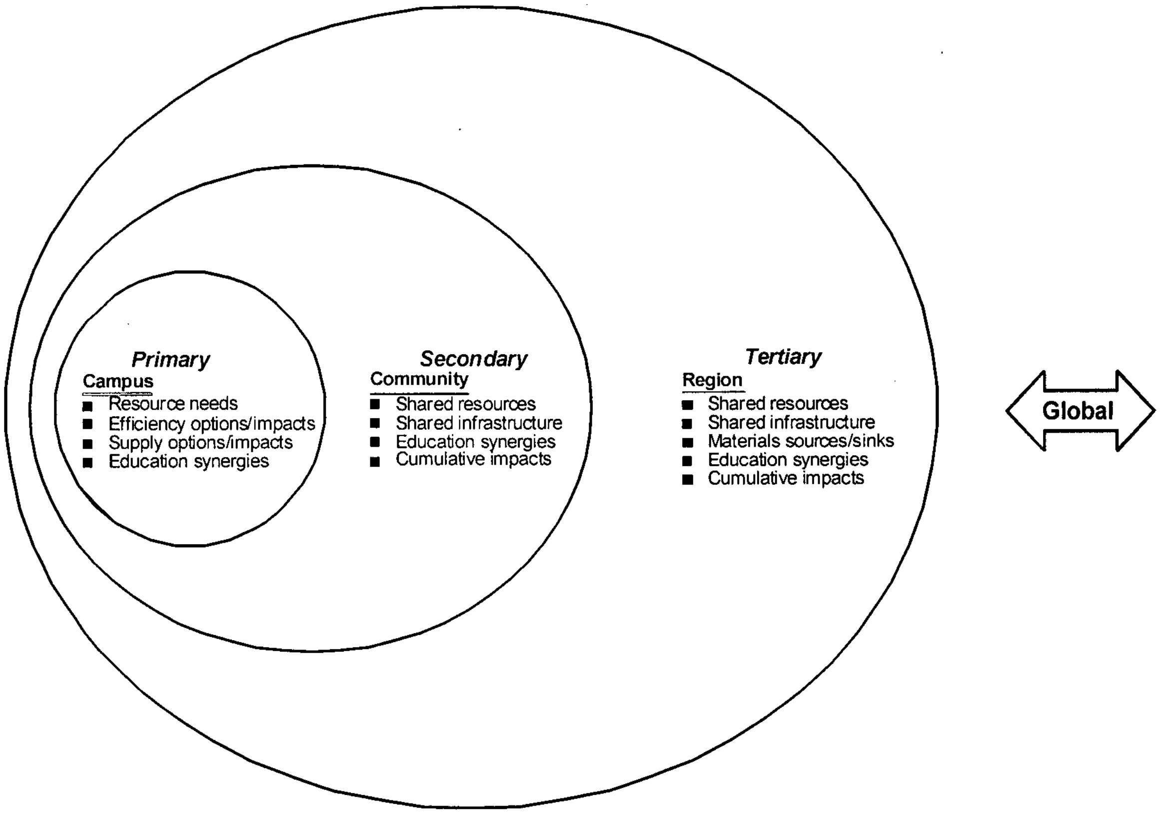


***Figure 2**: Geographic Scope*

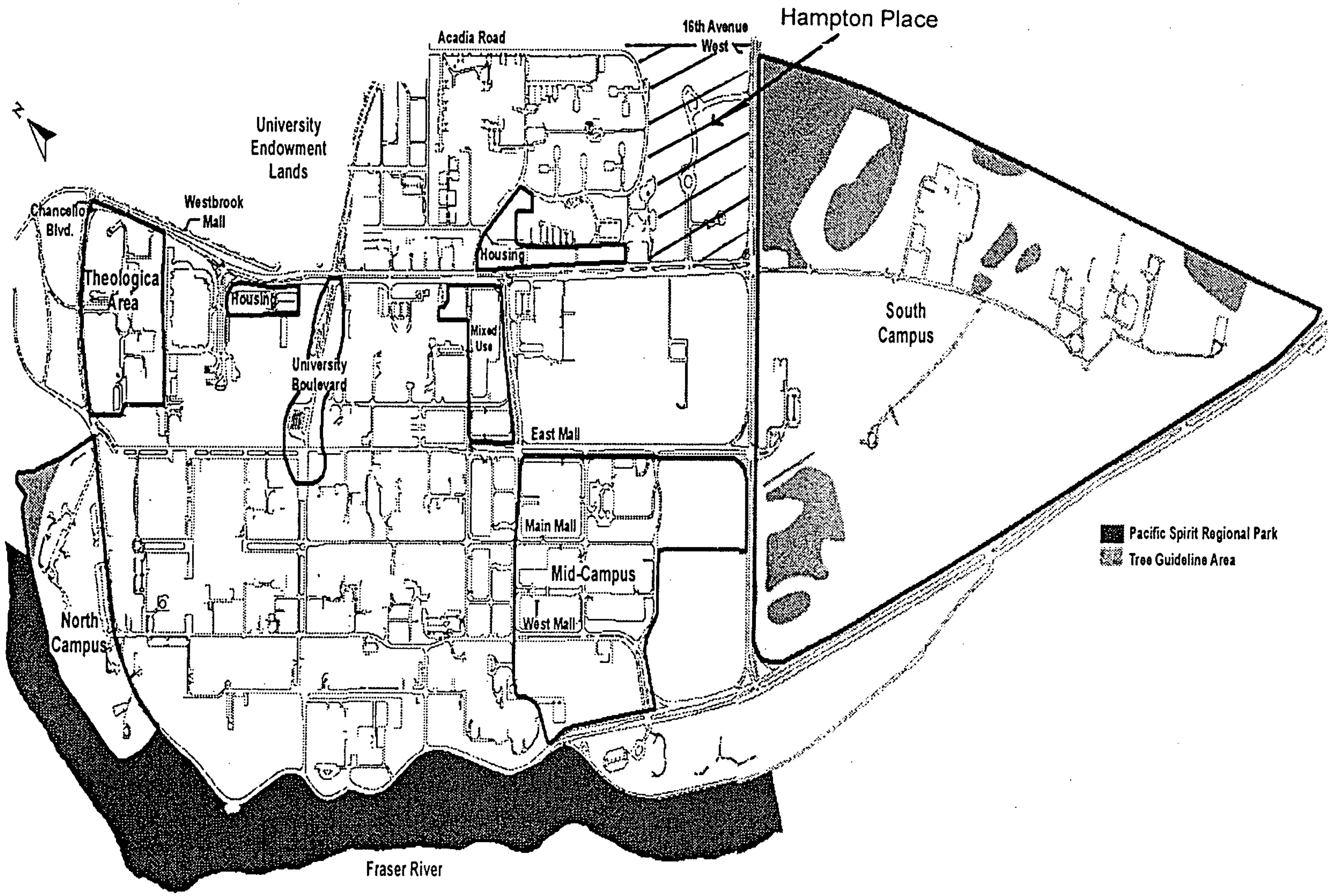


Figure 3: UBC Campus Lands showing Comprehensive Community Plan Areas

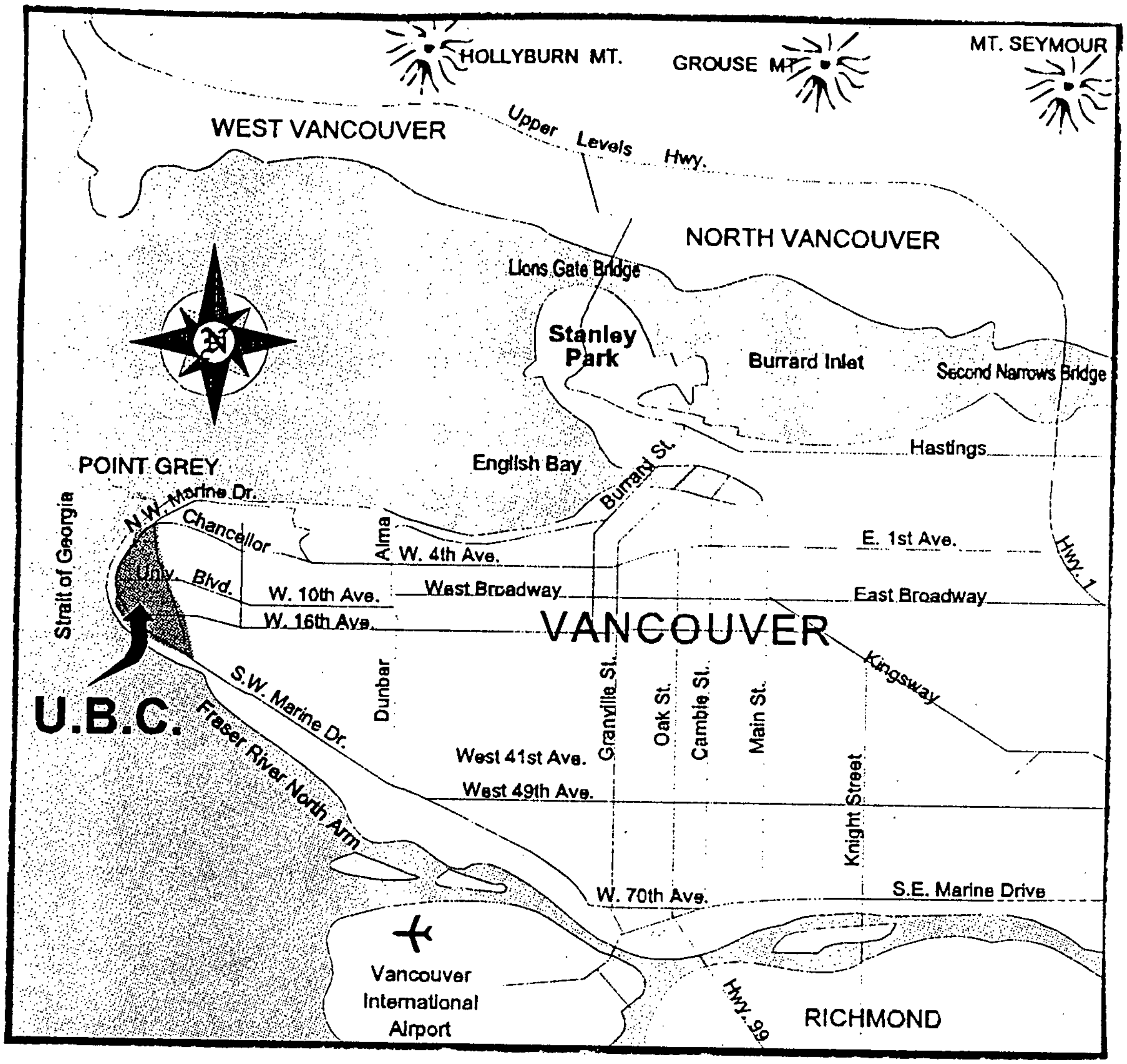


Figure 4: UBC and Surrounding Area

Chapter 4: Existing and Future needs

This chapter answers the question 'Where are we now?' as it outlines the existing water and energy usage at UBC, and 'Where are we going?' as it projects what the future needs will be.

4.1 Existing Energy Uses and Sources

Energy needs at UBC are currently met by steam generated by natural gas combustion, hydro-electricity from the BC Hydro network, and natural gas. Natural gas for steam generation is purchased at an interruptible rate with a 30% reduction in price. Oil is used for a few days a year in cold weather. A micro-cogeneration facility is also being incorporated into a new development in 1999-2000. Table 6 summarizes the energy use at UBC by facility type and transportation.

Table 6: Energy Use at UBC (GJ)

	Electricity (GJ)	Steam [gas + oil] (GJ)	Gas (GJ)	Total (GJ)	Percent of Total
Ancillary facilities	160,640	107,682	54,052	323,162	11%
Tenant facilities	88,047	60,644	42,402	207,798	7%
Core academic buildings	385,168	761,942	69,899	1,223,245	43%
TRIUMF	154,737		16,211	170,948	6%
Hampton Place	40,251		138,184	178,435	6%
Transportation [cars only]				579,167	20%
Steam Plant losses		180,958		180,958	6%
TOTAL	**828,843**	**1,111,226**	**320,748**	**2,863,713**	**100%**
Utility cost* (millions)	$7.5	$3.5	$0.7	$11.7	

* Base cost of energy purchased by UBC Utilities (i.e. not including Hampton Place). Water used on campus costs an additional $1.2 million and sewer levies total $850,000. Source: Data from UBC Utilities, 1999

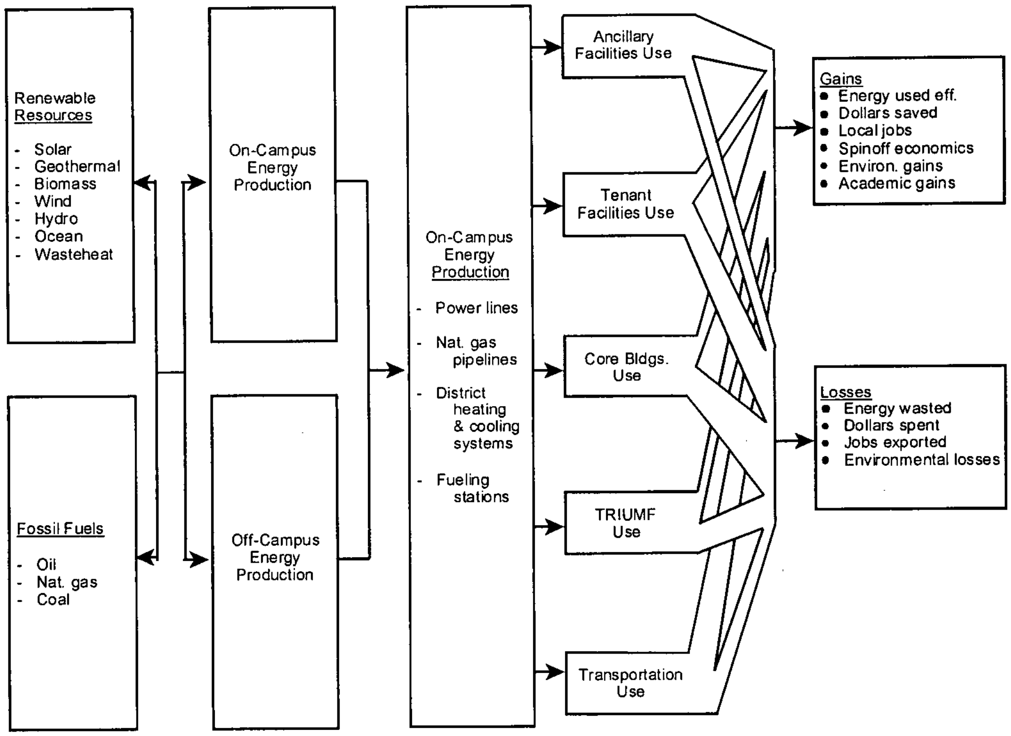


***Figure 4**: University Energy Flow* Source: Criterion Planners/Engineers, 1999

Figure 4 illustrates the supply, distribution and end-use of energy on the UBC campus. One of the aims of the Sustainable Resource Strategy is to shift energy supply from non-renewable to renewable energy sources, as well as to improve efficiency and reduce losses.

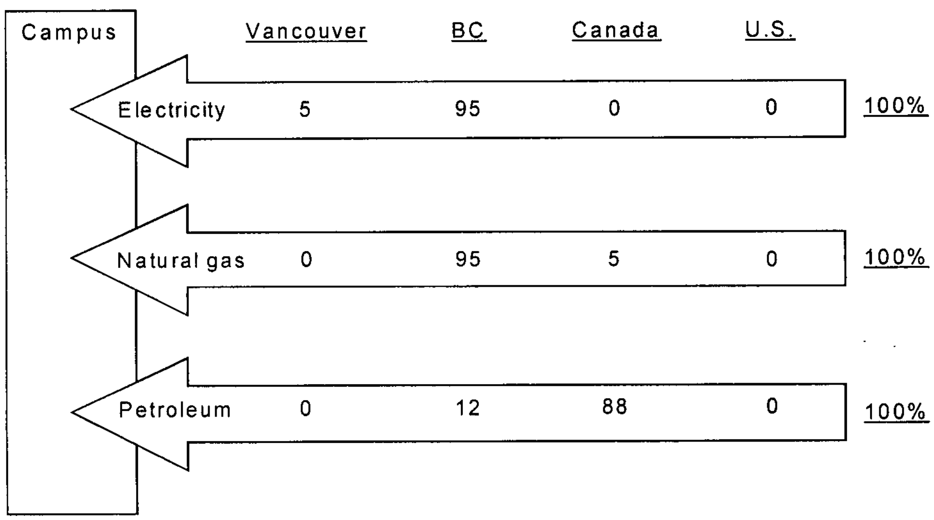


***Figure 5:** Existing Energy Supply Origins* Source: Criterion Planners, 1999

Figure 5 shows that the much of the energy used on the UBC campus is acquired from regional sources within British Columbia. Only petroleum products, used primarily for transportation energy, originate outside the region.

4.1.1 Electricity

Electricity is purchased from BC Hydro and is supplied from two high voltage 69 kV overhead lines. The northern line feeds the Main Campus via substation UNY, close to Thunderbird Winter Sports Centre. The southern line feeds the South Campus via a branch line to substation UNS close to TRIUMF. Both substations reduce the 69 kV voltage to 12 kV or lower.

The annual operating and maintenance budget for electricity for 1998-99 is approximately $400,000, while the total budget, including electricity purchase, is $7,567,000 (UBC Utilities, 1999). Table 7 shows the electricity use at UBC for different users. The largest users (per area) are the athletic facilities, commercial uses, and research facilities, closely followed by the hospital and core academic buildings.

Table 7: Electricity Use at UBC (1998-99)

End-Use Facility	Electricity Use (GJ)	Building Area Served by Electricity (m^2)	Energy Index (GJ/m^2)
Housing (Totem Park, Thunderbird A and B, faculty housing, Place Vanier, Gage Tower and Apartments, Fairview Crescent, Acadia, Green College, Thunderbird, St. Johns, Ritsumeikan)	109,346	278,125	0.40
Hampton Place	40,251	84,439	0.48
Core academic buildings	385,168	624,871	0.60
Theological College and residences	7,607	19,966	0.40
Hospital	39,178	68,469	0.60
TRIUMF	154,737	5,795	26.7
Research facilities (Agriculture Canada, Discovery Park, Forintek, B.C. Research, NRC, Gerald McGavin)	40,088	54,161	0.70
Athletic Facilities	28,965	37,134	0.78
• Winter Sports Centre	14,457		
• Other (Aquatic Centre, War Memorial Gym, Winter Sports Centre, Rugby Pavilion, Student Recreation Centre, tennis courts)	14,508		
Commercial (Thunderdeck, Bank of Montreal, The Delly, The Barn, Trekkers, bookstore)	6,453	7,848	0.80
Continuing Studies	109	3,822	0.02
Parking	16,722	131,278	0.10
Other	219	2,899	0.08
Total	**828,843**	**1,318,807**	**6.29**

Source: Data from UBC Utilities, 1999

4.1.2 Steam

A steam plant and distribution system functions to create steam from natural gas to heat many buildings on campus. The original section of the powerhouse was built in 1924, containing two operating boilers. There are now five operating boilers on campus. The boilers can also use heating oil, allowing for natural gas to be purchased at an interruptible rate that is 30% less expensive.

The steam is distributed through the system via 14 km of insulated steel (150 mm) underground pipe. Twenty percent of the pipes are secured in drained trenches or tunnels, and eighty percent are directly buried. A network of 12 km of 75-mm underground piping returns 75% of the delivered steam back to the powerhouse as condensate (UBC Utilities, 1999).

The steam budget for 1998-99 for the total cost of gas used to produce steam is $3,506,000. Table 8 shows the steam used at UBC by different users. The athletic facilities are the biggest users of steam on a per area basis, followed by the core academic buildings and research facilities.

Table 8: Steam Use at UBC (1998-99)

End-Use Facility	Steam Use (GJ)	Building Area Served by Steam (m^2)	Energy Index (GJ/m^2)
Housing (Totem Park, Place Vanier, Gage Tower and Apartments, Fairview Crescent, Acadia, Green College, Ritsumeikan)	75,992	120,729	0.6
Core academic buildings	761,942	569,887	1.3
Theological College and residences	9,779	19,966	0.5
Hospital	36,804	68,469	0.5
Research facilities (Agriculture Canada, Gerald McGavin)	11,486	9,154	1.3
Athletic facilities (Aquatic Centre, War Memorial Gym, Student Recreation Centre, Empire Pool)	34,498	19,136	1.8
Commercial (Trekkers, bookstore, Travel Cuts)	2,121	7,848	0.3
Continuing Studies	1,270	3,822	0.3
Steam plant losses	180,958		
Total	**1,111,226**	**819,369**	**1.4**

Source: Data from UBC Utilities, 1999

4.1.3 Gas

In 1998-99, 159,072 GJ of firm gas was piped in for commercial, residential and academic customers. Natural gas is distributed over 24.7 km of piping on campus. The gas budget was $718,500 in 1998-99 although this does not include the gas used by Hampton Place. TRIUMF is clearly the largest gas user on a per area basis.

Table 9: Direct Natural Gas Use at UBC (1998-99)

End-Use Facility	Gas Use (GJ)	Building Area Served by Natural Gas (m^2)	Energy Index (GJ/m^2)
Housing (Totem Park, Thunderbird A and B, Faculty housing, Place Vanier, Green College, St. Johns, Acadia)	42,839	146,590	0.30
Hampton Place	139,184	84,439	1.65
Core academic buildings	69,899	436,662	0.15
Theological Colleges and residences	2,701	17,419	0.15
TRIUMF	16,211	4,503	3.60
Research facilities (Colliers, Discovery Park, Forintek, B.C. Research, NRC, Gerald McGavin)	38,073	54,161	0.70
Athletic facilities	10,936	14,756	0.74
• Winter Sports Centre	9,184		
• Other (Tennis Centre)	1,752		
Commercial (Trekkers)	671	909	0.70
Other	1,234	2,900	
Total	**321,748**	**762,339**	**0.42**

Source: Data from UBC Utilities, 1999

4.2 Transportation

Table 10 illustrates the peak periods for commuting to and from UBC. Table 11 shows the modal split in transportation to and from campus. Single occupancy vehicle trips make up 44% of the commuter trips to and from UBC.

Table 10: Temporal Distribution of Trips To and From UBC

Person Trips	Eastbound	Westbound	Total	Percentage
24-hour estimate	55,011	55,667	110,678	100%
AM Peak Hour: 8–9 AM	1,932	9,960	11,892	10.7%
AM Peak Period: 7–10 AM	4,783	21,539	26,322	23.8%
PM Peak Hour: 4–5 PM	7,174	2,558	9,732	8.8%
PM Peak Period: 3–6 PM	18,713	7,900	26,613	24.0%
Midday 2 hours: 11:30–1:30	6,670	5,730	12,400	11.2%
Daytime (estimated): 7 AM–6 PM	44,507	46,925	91,432	82.6%

Source: TREK UBC, 1999

Table 11: Modal Split for Trips To and From UBC

Person Trips	Eastbound	Westbound	Total	Percentage
Single Occupancy Vehicle (SOV)	24,720	24,418	49,138	44%
High Occupancy Vehicle (HOV) 2 person	14,583	16,002	30,585	27.7%
HOV, 3 person	2,869	3,156	6,025	5.4%
HOV, 4+ person	1,339	1,218	2,557	2.3%
Transit	8,823	8,697	17,520	15.9%
Bicycle	1,554	1,336	2,890	2.7%
Pedestrian	669	543	1,212	1.2%
Commercial truck	454	297	751	0.8%
Total	**55,011**	**55,667**	**110,678**	**100%**

Source: TREK UBC, 1999

4.2.1 Fuel Use

The predominant fuel used for transportation to and from campus is gasoline. The UBC Fleet is operating on gasoline. Only two vanpool vehicles are fuelled by natural gas. Translink has 50 natural gas buses in the Greater Vancouver area, all operating in Coquitlam. The GVRD also has several buses that are hydrogen fuelled, but at the present time they do not run to the UBC campus (TREK UBC, 1999).

Table 12: Estimated Fuel Use and Fuel Emissions To and From UBC

Vehicle Type	Fuel Use* (litres/day)	CO_2 Produced** (kg CO_2/day)	Yearly CO_2 Emissions (tonnes)
SOV trips	47,668	98,504	26,596
HOV, 2 person trips	14,835	29,722	8,024
HOV, 3 person trips	1,948	4,036	1,089
HOV, 4+ person trips	551	1,104	298
Total	**65,002**	**133,366**	**36,007**

* Fuel use at 1.21 litres/km

Source: TREK UBC, 1999

** CO_2 production at 0.1851 kg CO_2/km

4.3 Existing Water Uses and Sources

Table 13 shows the water use in cubic metres per year by facility type. The core academic buildings account for approximately three-quarters of all the water used on campus.

Table 13: Water Use at UBC by Facility Type (1998-99)

Facility Type	Water Use (m^3/year)	Percentage (%)
Ancillary facilities	815,920	14%
Tenant facilities	700,320	12%
Core academic buildings	4,345,360	74%
Total	**5,861,600**	**100%**

Source: Data from UBC Utilities, 1999

Figure 6 illustrates the supply distribution and end-use of water on the UBC campus. One of the objectives of the Sustainable Resource Strategy is to reduce the amount of water drawn from Greater Vancouver Water District sources. The main ways of achieving this objective are to reduce the total amount of water used on campus and also to shift the supply to on-campus sources of water.

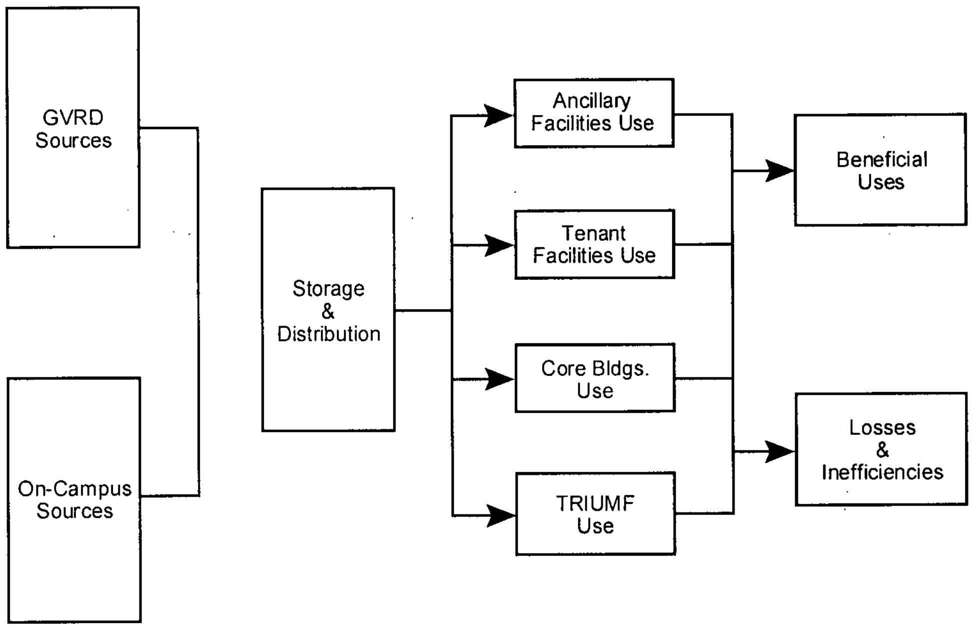


Figure 5: *University Water Flow* Source: Criterion Planners, 1999

Table 14 shows the water use on campus for various end-use facilities. TRIUMF is clearly a large water user on a per square metre basis. The athletic facilities are also intensive water users, mainly due to the irrigation requirements of the sports fields, as well as the large volumes of water required by the swimming pools and skating rinks.

Table 14: Water Use at UBC (1998-99)

End-Use Facility	Water Use (m^3)	Building Area Served by Water (m^2)	Water Use Index (m^3/m^2)
Housing (Totem Park, faculty housing, Place Vanier, Gage Tower and Apartments, Green College, Thunderbird, St. Johns, Ritsumeikan)	481,437	278,125	1.7
Hampton Place	177,982	84,439	2.1
Core academic buildings	4,345,848	624,871	7.0
Theological Colleges and Residences	53,790	19,966	2.7
Hospital	172,352	68,469	2.5
TRIUMF	142,689	5,795	24.6
Research Facilities (Colliers, Discovery Park, Forintek, B.C Research, NRC, Gerald McGavin)	150,501	54,161	2.8
Total Athletic Facilities	297,952	37,134	8.0
• Aquatic Centre	107,070		
• Winter Sports Centre	80,752		
• Other (Thunderbird, War Memorial Gym, Rugby Pavilion, Wolfson Fields, Student Recreation Centre, McGavin Sports)	110,130		
Commercial (bookstore,Trekkers)	24,081	7,848	3.1
Continuing Studies	3,790	3,822	1.0
Other	11,185	2,900	3.9
Total	**5,861,606**	**1,187,530**	**4.9**

Source: Data from UBC Utilities, 1999

4.4 Existing Sewage and Storm Runoff Volumes

The sanitary flow from UBC is estimated at 4 million cubic metres per year. The stormwater flow is estimated to be 4 million cubic metres per year (UBC Utilities, 1999).

4.5 UBC Baselines

It is important to establish a baseline of energy and water demand and supply, from which change can be measured. 1998-99 is being used as the baseline year. Tables 15–17 show the energy, water and wastewater baseline values for UBC.

Table 15: Campus Energy Use Baselines (1999)

Indicator	Baseline Value
Campus energy use (GJ/year)	2,863,713
Per capita energy use (GJ/person/year)	73
Renewable/non-renewable supply mix (%)	0/100
Building area* (m^2)	1,318,807
Energy use (GJ/m^2)	2.17

* (Gross building area on campus, including tenants and Hampton Place Source: Campus Planning and Development, 1999). Source: Data from UBC Utilities, 1999.

Table 16: Campus Water Use Baselines (1999)

Indicator	Baseline Value
Campus water use (m^3/year)	5,861,600
Per capita water use (m^3/person/year)	149
GVRD/onsite supply mix (%)	100/0
Building area* (m^2)	1,318,807
Water use (m^3/m^2)	4.4

* Gross building area on campus, including tenants and Hampton Place. Source: Data from UBC Utilities, 1999

Table 17: Campus Wastewater Baselines (1999)

Indicator	Baseline Value
Sanitary sewer (m^3/year)	5,000,000
Per capita sanitary sewer (m^3/person/year)	125
Storm Sewer (m^3)	4,000,000
Storm water runoff (m^3/m^2/year)	3.0

Source: Data from UBC Utilities, 1999

4.6 Future Needs

4.6.1 Future Energy Needs

Detailed energy forecasting has been completed for the planned development of campus. A preliminary calculation using the planned development total of 837,000 m^2 shows that an additional 400,000 GJ of electricity and 1,380,000 GJ of natural gas will be needed. This is based on the current average consumption for Hampton Place residential uses: 0.48 GJ of electricity per m^2, 1.65 GJ of natural gas per m^2.

It is important to note the link between urban form and energy and water use. If compact mixed-use development takes place at UBC, the efficiency of energy and water use will increase. As well, less infrastructure is required with increasing density of development and there are more opportunities for on-site energy development such as district heating and water conservation.

4.6.2 Future Water Needs

The Official Community Plan and the Comprehensive Community Plan call for approximately 837,000 m^2 of development. Based on this growth, and if water use per square metre remains the same as current Hampton Place residential use (2.1 m^3/m^2), 1.76 million additional cubic metres of water will be needed.

4.6.3 Projected Sewage Volumes

The projected increase in sewage loading will be an addition of 2.25 million cubic metres. This is based on the expected increase in population on the UBC campus and the current average sewer generation of 125 cubic metres per person per year.

Chapter 5: Resource Portfolio

This chapter answers the question 'Where do we want to be?' as it outlines the resource options and the preferred resource portfolio for UBC.

5.1 The Flexible Portfolio

A qualitative analysis of resource options was undertaken to create a resource portfolio for campus water and energy. The portfolio is not intended to be rigid and inflexible. Within the building, infrastructure and transportation categories, a number of viable options have been evaluated. Using criteria (outlined below) they have been given high (most desirable), medium and low priority (least desirable) for planning for both new development and retrofitting of existing facilities. The high priority areas satisfy the most criteria and should become the top energy and water options for UBC. Medium priority satisfy a fewer number of the criteria while low priority options generally maintain the status quo and do little to meet the sustainable energy and water targets. Rather than creating a narrow path towards sustainable development, a number of pathways are available, also encouraging diverse research and development opportunities.

5.2 Resource Evaluation Criteria

An initial list of criteria to evaluate the resource options was presented to the workshop participants in the second workshop. These were modified during the workshop with feedback from participants into the final criteria list (Table 18) which was felt by participants to be a comprehensive list.

Most of the criteria are self-explanatory, refering to the quantity of energy supplied, the magnitude of local benefits, how cost-effective it will be over its lifetime, the maturity, practicality, durability and reliability of the technology, the lead time to get the technology going, the risk involved, how equitably the benefits or burdens will be spread over time (not all at once), if the technology can link to academic research, and its environmental acceptability. The final criterion is intended for the portfolio as an entity to ensure that through the individual selection process, the selected portfolio itself will be diverse and flexible.

Table 18: Criteria for Resource Evaluation

Criterion
• Relative quantity or abundance of source
• Magnitude of local benefits
• Life cycle cost effectiveness
• Academic research and development potential
• Technological maturity and practicality
• Durability and reliability
• Short lead time to get technology working
• Risk avoidance
• Equitable benefits and burdens
• Environmental acceptability
• Diversity and flexibility of resource portfolio

5.3 Energy Resource Categories

5.3.1 Efficiency Improvements

Efficiency improvements include demand-side management for new buildings and existing facilities. Other supply-side improvements include space conditioning and ventilation, more efficient lighting, appliances and equipment, water heating and motor improvements. Land-use coordination can also be managed to increase efficiency. This includes locational efficiency, and high-density and mixed-use site design.

5.3.2 Potential Renewable Sources

On-site sources of energy include solar, wind, biomass, geothermal and ocean thermal energy. Energy cogeneration and fuel cell technology can also be used onsite.

5.3.3 Non-renewable Sources

Non-renewable fuels such as oil, natural gas, propane, fuel oil, coal and nuclear technology are available off-site. Electricity purchases can be made from out of region, in the region or in the community.

5.3.4 Transportation Energy Resources

Transportation resources also offer opportunities for efficiency improvements. Land-use coordination can be improved for locational efficiency, use mix and density, site design and parking supply. Conventional, non-renewable fuels such as gasoline and diesel are available offsite, as are most alternative fuels.

5.4 Water Resource Categories

5.4.1 Efficiency Improvements

Water resource efficiency improvements fall under demand-side management. Efficient fixtures, metering, xeriscaping (the use of native species that require less water in landscaping) and the installation of cooling towers would all decrease demand for water on campus. A distribution system leakage survey can identify additional efficiency improvements.

5.4.2 On-site Sources

Rainwater and groundwater are two sources of water on campus. Greywater, the water from sinks and showers is another water 'source'. There are also a number of treatment and management systems that could be added for wastewater and stormwater on-site. These include an on-site traditional treatment system, or alternative treatment systems such as solar aquatics. Storm drainage can be accommodated through natural and alternative drainage and treatment systems.

5.4.3 Off-site Sources

The Greater Vancouver Water District (via the University Endowment Lands) presently provides 100 percent of the campus water supply.

5.5 Preferred Resource Portfolio

The resource options were evaluated in the second stakeholder workshop and again more formally, using the evaluation criteria that were also developed in the workshop. Appendix A outlines the resource portfolio analysis for transportation energy resources, building and infrastructure resources, and water resources. The results are summarized on the following pages.

High Priority

FOCUS AREA	CATEGORY	OPTIONS
Transportation	Demand Management	• Telecommuting • Goods movement • Travel reduction
	Capacity Expansion	• Buses • Vanpools • Bicycles • Pedestrian facilities
	Land-use Coordination	• Optimize site design
Buildings & Infrastructure	Renewable Electricity Resources	• Solar • Small hydro • Wind (demo)
	Electricity Suppliers	• Local, community-based
	Direct Combustion Thermal Fuels	• Natural gas
	Direct Application Renewables	• Solar • Building integrated photovoltaics • Geothermal
	Demand Management	• Building controls • Recommissioning buildings • Energy policy • Heat recovery • Office equipment controls • Steam metering • Lighting upgrades • Efficient motors • Adjustable speed drives
	Land-use Coordination	• Site design
Water	Supply Sources	• Rainwater • Greywater
	Distribution System Maintenance	• Leakage survey
	Demand Management	• Efficient fixtures • Metering • Xeriscaping
	Treatment & Disposal	Wastewater: • Solar aquatics • Constructed wetland Stormwater Drainage: • Constructed wetland • Natural drainage systems • Alternative systems

Medium Priority

FOCUS AREA	CATEGORY	OPTIONS
Transportation	Alternative Fuels	• Natural gas • Propane • Electricity • Hydrogen
	Capacity Expansion	• Park and ride
	Land-use Coordination	• Optimize site selection • End-use mix and density • Parking supply
Buildings & Infrastructure	Non-Renewable Electricity Resources	• Natural gas (co-generation)
	Renewable Electricity Resources	• Biomass
	Electricity Generation Technology	• Small distribution facilities
	Electricity Suppliers	• Regional
	Direct Combustion Thermal Fuels	• Propane
	Direct Application Renewables	• Biomass • Ocean thermal
	Land-use Coordination	• Optimize site selection • End-use mix and density
Water	Supply Sources	• Groundwater
	Demand Management	• Cooling towers
	Treatment & Disposal	Wastewater: • On-site conventional treatment

Low Priority

FOCUS AREA	CATEGORY	OPTIONS
Transportation	Conventional Fuels	• Gasoline • Diesel
	Alternative Fuels	• Methanol • Ethanol
Buildings & Infrastructure	Non-Renewable Electricity Resources	• Oil • Coal • Nuclear
	Renewable Electricity Resources	• Ocean tidal
	Electricity Generation Technology	• New construction of large central facilities
	Electricity Suppliers	• Out of region

	Direct Combustion Thermal Fuels	• Fuel oil
Water	Supply Sources	• Greater Vancouver Water District

Chapter 6: Targets

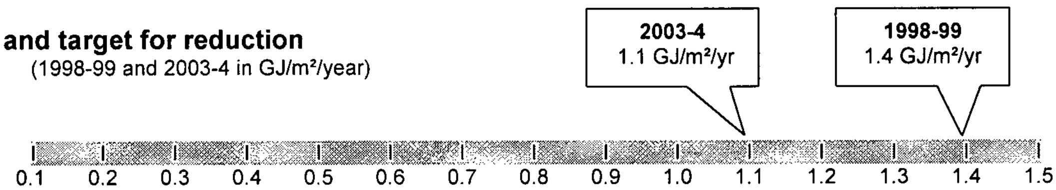
This chapter highlights existing UBC water and energy efficiency targets and establishes new targets for energy and water supply and demand at UBC.

6.1 Existing Demand Reduction Targets

6.1.1 Energy

The UBC energy management plan has a target of 1.1 GJ per square metre per year by the 2003-2004 academic year for core and ancillary facilities. This is a reduction of 0.3 GJ per square metre per year, or 20% lower than the 1998-99 energy use levels of 1.4 GJ/m²/year.

Baseline and target for reduction
(1998-99 and 2003-4 in GJ/m²/year)

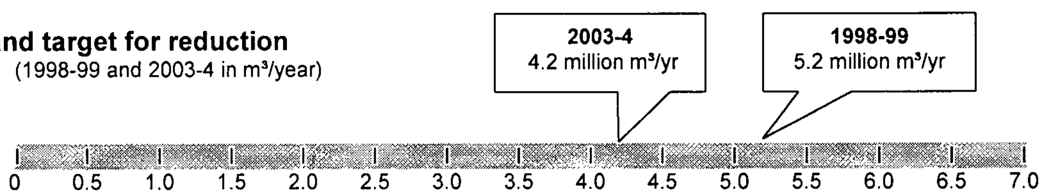


Source: UBC Energy Management Plan

6.1.2 Water

The UBC energy management plan has set a water use reduction target of 1 million cubic metres of water per year for core and ancillary facilities. This is a reduction of 20% of the 1998-99 levels of 5.2 million cubic metres to reach 4.2 million cubic metres by 2003-4.

Baseline and target for reduction
(1998-99 and 2003-4 in m³/year)



Source: UBC Energy Management Plan

6.1.3 Single Occupancy Vehicle Trips

The target of the Strategic Transportation Plan is to reduce single occupancy vehicle trips by 20% by 2002 by increased transit ridership, cycling, car and vanpooling, and walking.

6.1.4 Carbon Dioxide Emissions

The target for carbon dioxide reduction is 10% from 1998-99 levels by 2003-4. This is well beyond the Kyoto Framework Agreement (6% from 1990 levels by between 2008 and 2012).

6.2 Sustainable Resource Strategy Demand Reduction Targets

The Sustainable Resource Strategy has set targets that are consistent with the overall goals of the Energy Management Plan and Strategic Transportation Plan. New targets are set for demand reduction for 2005, 2010 and 2020, from 1998-99 levels. These targets are outlined in Tables 19 and 20.

Table 19: Energy and Water Consumption Targets

Target	Measurement	Percentage of 1999 Baseline		
		2005	2010	2020
Energy use	GJ per square metre	70	60	40
Water use	Cubic metres per square metre	80	60	40
Sewage volume	Cubic metres per square metre	80	60	40
Stormwater volume	Cubic metres	80	60	40
Transportation trips	Single occupancy vehicle trips	80	60	40
Transportation energy use	GJ per capita	80	60	40

Table 20 shows the five-, ten- and twenty-year targets for energy and water supply sources for the UBC campus, as well as targets for wastewater treatment and/or disposal. The targets are shown as a percentage of the total energy and water supplied to the campus, or as a percentage of the total wastewater generated on campus.

Table 20: Energy and Water Supply Targets

Target	Measurement	Percentage of Total Supply		
		2005	2010	2020
Energy supply source	Percentage on-site supply	10	25	40
Energy supply renewability	Percentage renewable supply	10	25	40
On-site water supply	Percentage water supplied on-site	10	25	40
Sewage treatment	Percentage sewage treated on-site	10	25	40
Stormwater treatment	Percentage of stormwater filtered or reused on-site	15	30	40

With the exception of storm water volume, each of these targets takes into account either changes in building area and/or the campus population.

6.3 Future Enhancements

This document is the outcome of a relatively short planning process over the summer of 1999. It is intended to lay the groundwork for further research on renewable energy and sustainable water management opportunities at UBC. Areas where limited research has been undertaken are highlighted in Section 7.3, Education Synergies. The Sustainable Resource Strategy is intended as a work in progress, to be refined and developed with further research on sustainable resource management in the Lower Mainland and at UBC.

Some of the future enhancements of the Sustainable Resource Strategy could include:

- Detailed technical and quantitative evaluations of resource options to support a more rigorous ranking in the portfolio.
- Further refinement of the end-use breakdown for water and energy (within facilities) at the University, and identification of efficiency opportunities. The end uses at the UBC research units should be determined.
- Expansion of the geographic scope of the Sustainable Resource Strategy. Further research into regional and provincial renewable opportunities and how UBC can support those initiatives is needed.
- Identification of Strategy Zones where opportunities for energy and water synergies are identified spatially.
- An Ecological Footprint, measuring the land area required to provide the resources and assimilate the waste of the campus population, should be calculated. It will be used to monitor the progress in sustainable resource management on campus.
- Research into the transportation energy use associated with alternate land use for different campus areas. The energy use for the South Campus area could be compared depending on the amount of residential and commercial space. The utilization efficiency (the load factor for electricity) of the infrastructure could be compared under different development scenarios.

Chapter 7: Implementation

This chapter explores implementation of the Sustainable Resource Strategy such as education synergies, municipal and regional linkages, and compatibility with existing UBC planning initiatives.

7.1 Intended Use of Resource Portfolio

The resource portfolio outlined in Section 5 is intended to be a flexible strategy to guide campus planning and development into the new millennium. This document also highlights where more research is needed. As more information is collected about sustainable resource options, these opportunities for renewable strategies can be further developed and incorporated into the Strategy.

A steering committee should be established to oversee the implementation of the Strategy. It will consist of the Director Sustainability, Director UBC Utilities, CEO UBC Properties, Director of Planning, Campus Planning and Development, Director, Transportation Planning, a faculty representative and a student. This committee will meet intermittently to monitor the implementation of the Strategy and develop specific initiatives that meet the objectives of the Strategy.

The Strategy shall be reviewed by this committee at least once a year and updated as necessary.

7.2 Core Plan Implementation Measures

Section 3 outlined other UBC planning initiatives, such as the Planning Principles, the Official Community Plan and the Comprehensive Community Plan, that contain measures that are directly applicable to sustainable energy and water opportunities on campus. Measures contained in these documents support the energy and water savings and promotion of renewable, more sustainable options. It is through the development and implementation of these related planning initiatives that sustainable development will take place.

7.3 Education Synergies

The University of British Columbia is one of the top research institutions in the world. Renewable energy and sustainable water management demonstrate an opportunity for the University to become both an 'incubator' and a 'laboratory', contributing to regional economic development opportunities. Sustainable resource management incorporates academic opportunities for research and training. There are also clear links for community cooperation by leveraging resources and sharing systems. Recently the National Research Council program on South Campus was awarded $30 million in fuel cell research funding.

During the development of the Sustainable Resource Strategy, a number of potential student projects were identified:

- Solar survey of campus
- Campus survey of wasteheat potential
- Groundwater survey
- Wind speed appraisal study
- Investigation of suitable mini- or micro-hydro applications near campus
- Mini-hydro development at the North Campus spiral drain, linked to a fuel cell for power storage
- Characterization and mapping of buildings that have been adapted or built with efficiency improvements
- Field survey of leaks in the campus water distribution system

These projects could form the basis for a rejuvenated Greening the Campus program.

7.4 Creation of an Energy Chair

One outcome of the Sustainable Resource Strategy has been the recognition of the value of a chair in sustainable energy systems for UBC. The creation of an interdisciplinary chair in sustainable energy is key to further integrating and coordinating the related work in energy research at UBC. There are energy research endeavours in a number of departments including Mechanical and Civil Engineering, the School of Community and Regional Planning, the Institute for Resources and Environment, and Architecture.

7.5 Creation of a Water Chair

The creation of an interdisciplinary chair in sustainable water is key to further integrating and coordinating the related work in water research at UBC. There are water research endeavours in a number of departments including Mechanical and Civil Engineering, the School of Community and Regional Planning, the Institute for Resources and Environment, Landscape Architecture, and Architecture.

7.6 Opportunities for Municipal and Regional Cooperation

There are clearly opportunities to link UBC's role as an innovator and incubator of sustainable resource management to municipal and regional initiatives. The UBC Sustainable Resource Strategy has focused on campus renewable energy and efficiency opportunities but there is a wide spectrum of options beyond the borders of the University lands. Table 21 shows some opportunities for municipal and regional cooperation that have already been identified.

Table 21: Opportunities for Municipal and Regional Cooperation

Opportunity	Benefit for Community and/or Municipality	Benefit to UBC
Development of on-site wastewater treatment	Offset cost of new off-site sewage treatment facilities	On-site treatment and replenishing of aquifer; job creation
Support (power purchase) for Lower Mainland renewable energy development	Support for regional renewable energy opportunities	Supports sustainable development policy and helps to achieve renewable energy targets
Harvesting of on-site water supplies	Less burden on regional system and educational opportunity	Achieve on-site capture rate target
Increased on-site stormwater treatment	Reduced cliff erosion via discharged water; recharged aquifer	Recharged aquifer; achieve on-site treatment target
Recharging the watershed water supplies	Increased health and viability of watershed (for salmon and other species) for the region	
Research and development of renewable energy; development of demonstration projects	Long-term societal benefit in sustainable development; educational benefit	Opportunities to apply research in the community

Chapter 8: Monitoring and Evaluation

This chapter outlines how the Sustainable Resource Strategy will be monitored, and includes the monitoring schedule.

8.1 Monitoring Progress

Monitoring progress towards the goals set in this Strategy is very important and a feedback loop needs to be created. At the time that this Strategy was created, it was discovered that more complete and specific records of energy and water use need to be kept. This Strategy is coordinating the sustainable development goals of several campus plans, and their achievement must be ensured through a developed and active feedback loop.

8.2 Key Indicators and Monitoring Schedule

Table 22 illustrates the indicators that will be monitored to gauge progress towards the goals set for the Sustainable Resource Strategy, and the timeframe in which they will be monitored.

Table 22: Key Progress Indicators

Indicator	Measurement	Schedule
Energy use	Energy use per square metre Energy use per capita Gross energy use	Annually Annually Monthly
Water use	Water use per square metre Water use per capita Gross water use	Annually Annually Monthly
Stormwater production	Stormwater per capita Stormwater per square metre of building area	Annually Annually
Energy expense	Dollars spent	Monthly
Air pollution and greenhouse gas emissions	Air pollution and greenhouse gas emissions produced on campus	Annually
Efficiency gains and renewable energy sources	Percentage of supplies from efficiency and renewables vs. non-renewables	Annually
On-site water supply	Percentage of water supply from on-site sources vs. percentage transported from off-site	Annually

Chapter 9: Moving Forward

This chapter has been added to reflect on how the Sustainable Resource Strategy has moved forward since the first draft was completed, to highlight challenges to its implementation, and to outline strategies to facilitate its implementation.

This chapter focuses on how the Sustainable Resource Strategy has moved forward since the first draft was completed in November of 1999, what the constraints are on its implementation, and what can be done to overcome some of the roadblocks that are identified. Two short case studies, on the CK Choi Building and a proposed faculty housing co-generation project, are also included.

9.1 Where are we now? *March 2000*

Since the first draft of the Sustainable Resource Strategy was completed in November of 1999, it has been implemented in only a limited way. The document has not been released to the stakeholders who participated in the two workshops. It cannot be released until it has senior administration approval, which has not been given. It was scheduled to go before the Board of Governors for approval in November of 2000, but this was delayed until the March 2001 Board meeting. It is unclear whether it will be presented as a report for information only, or as an action plan under the Sustainable Development Policy. This will influence how it moves forward. As a report, it will raise the profile of the Strategy, but as an action plan it may need more "teeth".

9.2 Constraints on Implementing the Strategy

Understanding what the barriers are to moving the Sustainable Resource Strategy forward is the first step in refocusing on implementation. There are a number of constraints and roadblocks to implementing the Sustainable Resource Strategy that were identified through interviews with stakeholders involved in the development of the Strategy. These are outlined below. Box 1 illustrates a case study of a UBC energy project that had difficulties with implementation.

Cost Cost is one of the biggest roadblocks to implementing the Sustainable Resource Strategy. It is difficult for senior administration to endorse new initiatives if the cost or savings are not known in concrete terms. One of the concerns at the forefront of UBC's senior administration is delivering quality education with limited resources, and budgetary constraints are pressing.

Standard Engineering Practice Best practices in engineering are slow to change, and it is often easiest to stay with the status quo. There is also a concern that departure from the norm could expose the University to liability.

Untested Technology There are concerns with using new technology that is relatively untested as UBC Utilities and the University have to provide a reliable, uninterrupted service.

Perception of 'Progressive' Sometimes sustainable practices are seen as a negative movement 'backwards' by an industrialized society.

Time Time can present challenges to the implementation of the Sustainable Resource Strategy in a number of ways. The process through which the Sustainable Resource Strategy was developed was on a compressed time scale. Time was also identified as important with the implementation of new technology. There needs to be sufficient time to work out how the technology can fit with the existing system. If not enough time has been allotted, then it is possible the sustainable innovation cannot be accommodated.

Overloaded Faculty and Staff The University has many initiatives vying for the time of faculty and staff. Often people have very little time and energy to put into a new project, as worthwhile and promising as it might be.

Transitional Community Getting the student body on board to new sustainability initiatives can be a challenge in the University community, where students come and go. Harnessing their energy while they are here has been identified as a challenge to moving initiatives forward.

Measuring Progress It is difficult to gauge how the Sustainable Resource Strategy and other initiatives are moving forward in concrete terms. Campus faculty and staff who have been involved in working towards sustainability for a number of years find it difficult to measure progress that comes in tiny increments.

Public Involvement Public participation in planning initiatives is a challenge that goes beyond the Sustainable Resource Strategy. Campus Planning and Development has struggled with how to conduct adequate and engaging public consultations. The campus community has not been very involved in campus planning.

Confusion There is not a good overall understanding of what it is to be sustainable and this presents a challenge for coordinating the Sustainable Resource Strategy.

Perception of Plentiful Resources Sustainable approaches to resource management can be a tough sell in British Columbia, as the perception that water and energy are cheap and plentiful is pervasive. This can be a barrier to moving conservation and renewable approaches forward.

Shifting Role of University There is the perception that if UBC implemented some sustainability initiatives (such as grey water recycling) then the University may have to take on the role of monitoring the water quality to ensure high quality.

Box 1: Faculty Housing Co-generation Project

A recent energy initiative that was undertaken at UBC was a co-generation project for a new faculty housing project. A micro-turbine that runs on natural gas to produce electricity was donated by BC Hydro, and Natural Resources Canada provided a heat recovery unit. The project encountered some stumbling blocks when it turned out the turbine was designed for outdoor use in an isolated location. The technical adjustments that were needed resulted in close to $50,000 additional input into the project, before the initiative was halted. UBC Utilities is looking for another location for the turbine.

Some lessons from the project:

- The leading/bleeding edge can be risky- housing needs heat and electricity that works!
- The project should capitalize on its educational benefits and make it a learning experience. Involve campus engineering students and faculty in the data collection associated with the project.
- Despite the challenges here, this scale of project may be easier to implement than a bigger project with a large capital input.
- The support for the project is there but the unit was not right for the application. It will happen in another location.
- Timing is an issue in implementation. If there had been more time, applications could have been submitted for grant money to support the project.
- The costs of the project should be measured in terms of full costs (environmental and social costs), for instance including the benefits of not expanding the dam, the benefits of not having transmission.

9.3 Strategies to Facilitate Implementation

A number of strategies that could facilitate implementation were identified through interviews. They include:

Shifting the Key Decision Makers Buy-in and involvement of key decision makers is seen as being very important to implementing sustainability at UBC, because the power to implement is seen to lie with top administration and the Board of Governors. The key decision makers have to be brought to the point where they feel it is important to move forward with sustainability initiatives. Lack of buy-in by the decision makers was identified by one key stakeholder as a 'meta-constraint' to be overcome.

Increasing buy-in can be done through the provision of both 'top-down' (external) pressure and 'bottom-up' (internal) information. If the sustainability reputation of UBC's campus was seen as drawing top students to the University, this could create external pressure for the senior administration to support campus sustainability. If the staff and student body at UBC vocally support sustainability on campus, then this is a 'bottom-up' pressure on administration to commit their support to sustainability initiatives.
Some ideas to promote campus sustainability:

- Inclusion of 'Sustainability' as a criterion in the annual Macleans magazine rating of Canadian universities.
- Invitation of an 'outside expert' such as David Orr to speak to senior administration about the benefits of campus sustainability initiatives.
- The Annual Report of UBC should feature a 'Triple Bottom Line' measuring progress on environmental, social and economic sustainability.
- A small group of campus sustainability indicators is needed that can be measured easily and well.

Shifting Public Acceptance Education, social marketing and awareness will help shift public attitudes to accept new technology and innovation in the move towards a more sustainable society. If the public is willing to pay more for societal benefits than they have in the past, there will be more willingness on the part of developers to implement these projects.

Senior Administration Champion A senior administrator needs to take on the cause of championing campus sustainability. No one is taking that role on at the present, and upper level support could move the Sustainable Resource Strategy forward at a much faster pace.

Communications Plan Communications around campus sustainability need to be prioritized. There are Sustainability Coordinators in many departments on campus, and current initiatives could be publicized through these contacts. It may be advantageous to strategize who the Sustainable Advisory Committee (SAC) reports to. If the SAC became a standing committee of the Presidents Property Planning Advisory Committee their projects might reach a wider audience. The Sustainability Office could be written into the academic plans of each department, as it is important that these ideas permeate more widely across campus.

Strategize for Long-Term Engagement Recognizing that community involvement and participation takes time to meaningfully involve people and the academic community, a long term strategy could be developed that transcends individual planning initiatives. This will help develop trust between the academic community, surrounding communities, Campus Planning and Development and UBC Properties.

Link to TREK 2000 To sell the Sustainable Resource Strategy to the Board of Governors, a balanced approach must be taken. Many of the priorities and initiatives of the Sustainable Resource Strategy can be directly linked to goals of UBC's Trek 2000 vision. Framing the SRS in this context will help bring UBC players on-board who are behind Trek 2000.

Understanding Sustainability One of the challenges that was outlined in terms of implementing sustainability is the confusion about the meaning of the term itself. Education and dialogue will help more people to understand what sustainability means on the campus and to position the debate so people understand it. It is also important to position the debate so people understand that these initiatives can help to further their own goals.

Differentiating the Product Sustainable initiatives can be tied into a marketing strategy for new campus development, to 'differentiate the product'. New housing on South campus can be marketed as lower impact, cost saving and green, as a marketing technique that is congruent with the University experience.

Box 2: Lessons from the CK Choi Building

The CK Choi Building on the UBC Campus, is considered a model of green building in North America. It was recently included in the American Institute of Architects Awards as a top ten example of viable architectural design solutions that protect and enhance the environment.What made the CK Choi planning process a success?

- All the key players in the project, from the design team to the client, were very committed to doing a demonstration green building. Since the CK Choi, other projects intending to incorporate sustainable building practices have been hindered by a lack of consensus among the project team.

- A planning workshop began the process. The project members explored the ideas and opportunities of sustainable building practice, which facilitated participant buy-in.

- Specific targets for green buildings were set by the design team (i.e. 50% recycled material) . No penalty or rewards were associated with the targets but they were very important for keeping the team on track.

- The project had a non-compressed schedule which meant that the project team had more time and flexibility to research innovative design options.

9.4 The Power to Implement

In response to the question about where the power lies to implement the Sustainable Resource Strategy, several key bodies were identified.

The Board of Governors The Board of Governors sets the priorities for UBC as an institution. Adoption of the principles of the Sustainable Resource Strategy by the Board of Governors would be a top-down approach to moving the Strategy forward. The Associate Vice-President of Land and Building Services has an important role to play in selling the Strategy to the Board. There also needs to be a broad level education process about the benefits of sustainability for board members.

UBC Utilities If UBC Utilities took the Sustainable Resource Strategy to the heart of their planning it could move forward significantly.

UBC Properties Part of the Comprehensive Community Planning process should include broad level water and energy planning that complements the Sustainable Resource Strategy.

Committee of Deans The Committee of Deans as an academic group has not taken an active role in campus sustainability. There has not been a discussion of how the academic mission is being and could be supported through involvement in initiatives such as the Sustainable Resource Strategy. The Strategy highlights potential links to academic research.

9.5 Reflections on the Process

It is important to reflect on the process through which the Sustainable Resource Strategy was developed and to identify what could have been done differently that would facilitiate implementation of the SRS. The key stakeholders who were interviewed were asked for their input on how the process could have been designed differently. The results are as follows:

Range of Participants An even wider range of participants could have been included in the workshops if there had not been the constraints of time to organize and to inform the participants about the process and intended product.

Consistency of Participation Many stakeholders were only able to be present for part of the workshops, in part because the workshops were put together over a very short period of time.

Senior Administration not Represented In the workshops to give input to the Sustainable Resource Strategy, the senior administration of UBC was not represented. Their presence could have contributed to administration buy-in (this was identified previously with the need identified for a senior administration champion). More education and awareness is needed so that senior administration realize sustainability on campus is worth their commitment. Also if the workshop was organized earlier then the timing might have worked better for administration.

More Time The planning of the workshops was tight, as it began just over a month before the first workshop. The entire Strategy had to be completed in a three month timeframe. Had the time and resources been available, a third workshop to get feedback on the resource portfolio would have been an effective follow-up to the process, and more time would have allowed for more full and effective public participation.

Meaningful Input Both workshops had more than 30 people present. Getting each participants' input in a meaningful way is a challenge, especially when information provision needs to be included so that everyone is at the same informed level. A challenge in public participation is when the participants feel that their inclusion was tokenistic and their input ignored. Every effort must be made to include stakeholder input.

Process Redesign An alternative to the '2 workshop design' would have been to have interviews with key stakeholders to inform them of the project, and to get feedback from them on their potential level of engagement. The participants could gauge how relevant it is for them. If they choose not to participate, or are not able to, their key concerns could be communicated in the interview.

Document Distribution The draft of the Sustainable Resource Strategy was never distributed to the workshop participants, because it did not get internal approval from senior administration. Distribution of the materials is important and necessary follow-up for engaging stakeholders in the implementation of the Strategy.

Timing Had the workshops taken place in April and May, before people at the University took holidays and became busy with summer projects, then involvement in the process might have been improved.

Broader Discussion, With More Detail A more focussed discussion on the existing energy systems and how they could be retrofitted to become more efficient would have been useful for UBC Utilities efficiency planning.

Plan for Implementation From the conception of the Sustainable Resource Strategy, the steps that the Strategy must undergo in order to be implemented should be clearly outlined. At the beginning there needs to be strategizing for how it could move forward.

Idealists and Pragmatists The University is a breeding ground for ideas. The idealism in the planning process needs to be incorporated into practical, on the ground initiatives. Pragmatists and idealists should both be included into the planning process.

Fundamental Objectives This process did not allow for in-depth exploration of the fundamental objectives that underlay the Sustainable Resource Strategy. Many of the options that were considered were based on assumptions. For instance it was assumed that using on-site water is a more desirable option than bring water in from Vancouver in pipes, but this was not explored to determine if it is a more desirable outcome, based on a set of criteria. Determining the fundamental objectives at the beginning of the process would have given a more focused and meaningful outcome.

Full Range of Consequences This work did not consider the full range of consequences for the each of the resource options, as only limited information was available and time was a constraint on the process. The intent of this work was to identify broad strategies that could be researched, discussed and addressed in more detail later.

Meaningful Targets Targets for water and energy supply and reduction were established for the Sustainable Resource Strategy. While these targets were thought to be aggressive yet achievable, more time would allow for the development of justifiable and meaningful targets.

Appendices

Appendix A: Energy Resource Profiles

Appendix B: Water Resource Profiles

Appendix C: Resource Profile Evaluation

RESOURCE: Solar energy

Solar energy can be used for:

1. Passive solar
2. Active solar
3. Power generation

Quantity

Total Hours of Bright Sunshine (hrs)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
54.4	81.9	129.5	168.1	235.2	228.8	291.3	249.7	179.1	122.6	69.1	52.5	1862.4

Source: UBC Climate Station (1957–1993)

Mean Daily Global Solar Radiation (rfl) (MJ/m²) mean

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
2.854	5.491	10.094	15.086	19.822	21.363	22.377	18.624	13.356	7.488	3.544	2.356	11.871

Source: UBC Climate Station (1957–1993)

Quality

- Moderate
- Environmentally benign

Location

- Buildings across campus

Additional Information Needed

- Investigate potential for industry partnerships to demonstrate technology
- A solar access inventory of campus is needed
- This would include the geometry of sun angles to shading and a calculation of excellent solar access
- This could provide the groundwork for regulations to protect solar access

Applications

Passive Solar

- All buildings receive energy from the sun; with a passive solar design approach it's a matter of maximizing the efficiency of energy capture
- In addition to reducing the heating requirements, passive solar design can in many cases supply most of the building with natural light and natural ventilation, thus greatly reducing the electricity usage
- The approach is very simple and fairly easy to execute
- The approach works year round – it cools in the summer and heats in the winter
- Once constructed the system functions with no potential of breakdown
- In the Vancouver climate, according to CMHC research, very simple techniques such as southward orientation and a large amount of glazing can be incorporated to reduce space-heating requirements by at least 25%
- These same simple techniques can be extended to modify the overall form of the structure to create an extremely energy efficient structure. Buildings can save over 60% on energy
- The main constraints are the dense tree cover and building density that limit sun access
- The majority of glazing should be on the south facade and a minimum on the north facade

Active solar

- Photovoltaic cells capture the energy from the sun
- Solar panels are being considered for the Liu Centre for Global Studies, at present under construction
  - This proposal has 16 kW of photovoltaics. This allows for a peak output of about 16kW.
  - It is estimated that installation will meet about 50% of the peak electrical demand and provide just under 20% of the building's total electric energy requirement.
  - The 16 kW of paneling for the Liu Centre is estimated to cost $210,000 excluding consulting fees and taxes

Source: Campus Planning and Development, 1999.
CMHC, 1998.
McKirdy, A.R. 1999.

RESOURCE: Wasteheat

Wasteheat can be captured from the following campus sources:

1. Boilers
2. Condensate
3. Campus buildings
4. Swimming pool
5. Ice rink
6. Wasteheat production at big units (i.e. TRIUMF)
7. Air conditioning
8. Compost – divert from landfill, capture heat

Quantity

- Insufficient data, quantity unknown

Quality

- Moderate
- Steady, reliable supplies

Additional Information Needed

- More research and data needed on wasteheat potential on campus
- Survey of sources and quantity and quality of waste heat: temperature, hours/year, media (condensate, air etc.)
- More information on infrastructure requirements

Comments

- The energy requirements for heat pumps are measured in Coefficient of Performance (COP), the ratio of energy out to energy in
- Heat pumps have high maintenance

Source: Campus Planning and Development, 1999.
BC Hydro, 1999.

RESOURCE: Geothermal

There are different kinds of Geothermal Heat Pumps (GHPs):

1. High-temperature for power generation
2. Moderate-temperature for direct uses at 100-200 °F
3. Low-temperature for heat source below 100 °F. This is the type of GHP that could be used at UBC
   - A GHP can bring groundwater to the surface to run through the system to capture the heat; the water then has to be returned to the aquifer
   - The working fluid can also be run into the ground through the groundwater in a closed loop
   - There are groundwater GHPs and also earth-coupled resources that capture the heat in the soil with either a horizontal or vertical piping system

Quantity

- Limited study of campus groundwater has been conducted – it is known that its distribution is highly variable
- Need to consider the Coefficient of Performance to ensure that the ratio of captured energy is high enough

Quality

- The main parameters for GHPs are the groundwater flow (volume), the groundwater temperature, and the water chemistry
- Year round non-fluctuating access
- Less space is used inside the building than by conventional heating and cooling systems, thus allowing greater space for other purposes

Location

- Dependent on groundwater and geology but more appropriate for smaller buildings

Additional Information Needed

- The groundwater on campus needs to be characterized
- Temperature of groundwater needs to be characterized
- The soil and geology need to be characterized for areas where earth-coupled systems could be used

Source: Campus Planning and Development, 1999.
Criterion Planners/Engineers, 1999.
McKirdy, A.R. 1999.

RESOURCE: Wind

General points to consider:

- The threshold for wind generated power is dropping – it is approx. 17-21 kph..
- There was a UBC wind demonstration project in the 1980s on top of the Mechanical Engineering Building
- In terms of small scale wind energy for discrete buildings or neighbourhoods, individual wind generators on the market commonly produce electricity at a minimum wind speed of 12 kph (7.5 mph)
- The power in wind increases as a cube of the wind speed – small variations in wind speed have great implications for the possibility of getting power from the wind

Quantity

Mean Hourly Wind Speed (kph)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
7	7	8	7	7	7	7	7	7	7	7	8	7

Source: UBC Climate Station (1957–1993)

- The average annual wind speed measured at the UBC climate station is 7 km/hour (4.38 mph) with a maximum monthly average of 8 km/h (5 mph) in March and December

Quality

- Very poor
- Aesthetic and noise considerations
- Potential impact on wildlife, including bird strikes
- Excellent in terms of cleanliness and renewability

Location

- Very site-specific
- Must be placed where wind speeds are high enough – further research needed on preferred sites

Additional Information Needed

- Accurate wind readings from the specific location of possible wind generators
- More research into wind power generation feasibility at lower wind speeds

Comments

- Good potential for demonstration project

Source: McKirdy, A.R. 1999.
UBC Climate Station Data, 1957-1993.

RESOURCE: Biomass

Two types of solid waste generated on campus suitable for biomass energy sources are:

1. Paper
2. Food waste

Quantity

Estimated Annual Waste Going to Landfill

Type of Waste	Tonnes (± variance)
Compostable food	796.6 ± 207.2
Residual paper	536.8 ± 160.3
Other compostables	222.7 ± 34.00
Wood	24.5 ± 32.0
Residual Plastic	277.4 ± 122.0
Misc.	1.6 ± 3.1
Metals	52.2 ± 32.0

Source: Felder, M. (1999)

Quality

- Moisture content low
- Minimal hazardous materials content

Location

- Campus collection points and transfer station

Additional Information Needed

- Acceptability of on-site combustion

Source: Felder, M. 1999.

RESOURCE: Sewage

Energy potential in:

1. Harnessed methane gas
2. Heat exchange from sewage influent (untreated sewage)

Quantity

- Sanitary flow from campus approx. 5 million cubic metres per year
- Needs refining before it becomes energy

Quality

- Dependant on sewage temperature – winter: mid-50s; summer: mid-60s

Location

- The heat exchanger is located where the influent pipe is biggest and the flow volume highest
- South Campus and neighbouring communities

Additional Information needed

- Flow volume of sewage
- Information on other systems (Seattle sewage system used for wasteheat)

Comments

- Could work with a pre-treatment plant – if a sewage treatment plant is developed in the future it could be a 'package plant' facility
- The temperature of influent is higher but the heat exchangers have to be cleaned more frequently – Germany has developed this application, but there are few examples in North America
- Good community service, public relations and educational opportunity

Source: Criterion Planners/Engineers, 1999.
UBC Utilities data, 1999.

RESOURCE: Micro-hydro

Run of the River Micro-hydro Project

- Water is diverted from the river to a powerhouse where it powers a series of turbines: there must be significant elevation drop between diversion point and the powerhouse
- All water is re-routed back to the stream, and the intake and return must be well above fish habitat area
- Power would be transmitted through BC Hydro grid

Quantity

- No naturally occurring streams on campus but potential in areas surrounding campus

Quality

- Function of volume of water and variability of flow (tends to be highly variable)
- Seasonal (summer), however seasonal flow could be regulated through BC Hydro power grid

Location

- Potentially in areas surrounding UBC – streams need to be identified
- Would likely be generated off-site and transmitted through BC Hydro

Additional Information Needed

- Explore local streams potential (need significant elevation drop)

Comments

- Large amounts of capital needed (because of current market rates)
- Some habitat disruption for diversion – not as much as with large-scale dams
- At a regional scale, one potential project for UBC partnership already identified on Rutherford Creek near Pemberton

On-Campus Micro-hydro Project

- A micro-hydro project could be linked to the spiral drain (NorthCampus) and/or South Campus drain

Quantity

- Stormwater drainage for large area of the campus

Quality

- Seasonal flow levels vary with rain volume

Additional Information Needed

- Volume flow numbers for both drains and seasonal variance

Comments

- Demonstration project potential – link to student research
- Could be linked to fuel cell storage for energy storage

Source: McKirdy, A.R. 1999.
UBC Campus Sustainability Office, 1999. Proposal for a Run of the River Micro-hydro Project.
Campus Planning and Development, 1999.

RESOURCE: Ocean thermal

- Heat pump is used to capture energy from the ocean

Quantity

- Unlimited

Quality

- Ocean temperature (43-46 F approx.)
- Moderate source of heat based on temperature
- Steady
- Low emission
- Reliable

Location

- Perimeter of campus
- Infrastructure required: 2 pipes, one for intake and one for return

Additional Information Needed

- Further research into feasibility and cost
- Information needed on:
- Depth around point
- Shipping channels
- Easements that allow infrastructure over park land
- More information about existing storm pipe that runs to the beach

Comments

- There is potential to develop a dual heating/cooling system

- Canada Place and Science World have titanium heat exchangers (titanium because of saltwater) for cooling applications
- Ocean thermal technology is also widely used in Sweden

Source: Criterion Planners/Engineers, 1999.
BC Hydro, 1999.

RESOURCE: Tidal power

- Electricity is generated from the natural daily fluctuations in ocean levels
- Harnessed most simply by constructing a dam across the entrance to a tidal bay or inlet

Quantity

- Unlimited

Quality

- Mediocre, not commercially viable
- Sechelt Inlet and Howe Sound have been identified as potential tidal power sites in B.C.

Additional Information Needed

- More information on active successful tidal power developments in B.C.

Comments

- Tidal power development should be monitored in the long term to see if it becomes more feasible

Source: Criterion Planners/Engineers 1999.

RESOURCE: Natural gas

Quantity

- No supply shortfalls seen for at least 80 years

Quality

- Good
- Non-renewable and some air emissions

Location

- Used on campus for steam generation and direct uses
- Campus distribution system

Source: BC Gas, 1999.
UBC Utilities, 1999.

RESOURCE: Petroleum products

Common fossil fuels:

1. Oil
2. Gasoline
3. Diesel

Quantity
- No supply shortfalls in short term

Quality
- Non-renewable
- Air pollution produced during combustion

Location
- Oil used for steam production on campus when natural gas supply is interrupted (very cold days)
- Diesel is used for emergency generators

Source: BC Gas, 1999.

HIGH-EFFICIENCY TECHNOLOGY: Proton exchange membrane fuel cells

- Vancouver based Ballard Power Systems is a leader in developing proton exchange membrane (PEM) fuel cells for use in electricity generation
- Fuel cell technology is being developed for stationary power systems

Quantity
- High

Quality
- High
- Need to make transition to a renewable energy source for hydrogen production. Most fuel cells are using natural gas

Location
- Potential sites on campus include: substations, steam plant, new housing on South campus

Comments
- Research linkages with UBC: a new $30 million research facility was awarded by the federal government to the National Research Council on South Campus in August 1999

Source: Ballard Fuel Cells, 1999.

RESOURCE: Building energy management

- Highly building specific

Applications for new buildings:
- Envelope
- Space conditioning
- Lighting
- Building management system
- Plug load
- Domestic hot water

Applications for retrofit buildings:
- Lighting
- Ventilation

- Environmental management systems
- Controls
- Meters
- Utilization in-fill

Quantity

- If not much has been done: 20-30% could be captured
- If efforts already made: 5-10%

Quality

- High-efficiency improvements

Location:

- Need to characterize and map the buildings that have been retrofitted and built with efficiency improvements (finished, partial, not touched)

Source: UBC Utilities, 1999.

RESOURCE: Land Use

Land-use co-ordination

- Integrated multimodal street network: pedestrian, bicycle, transit, high occupancy vehicle
- Land use density and land use mix
- Contiguous development – avoiding development on the perimeter before the core
- Pavement minimization
- Parking supply – minimization and siting

Quantity

- Amount of unused and developable land and redevelopable land and in-fill

Quality

- Spatial relationship of land to other resource opportunities

Location

- Need to map spatial relationships (Strategy Zones)
- Need to map co-location with wasteheat sources
- Need to locate and map locations with excellent solar access

Source: Criterion Planners/Engineers 1999.

RESOURCE: Alternative Fuels

- Could be encouraged in private vehicles, also for UBC Fleet of 300-400 vehicles

Fuel	Quantity	Quality	Location
Methanol	Moderate	High	1 refueling station in Vancouver
Ethanol	Moderate	High	4 refueling stations in Vancouver
Hydrogen	Moderate	High	R&D
Natural gas	High	High	City
Propane	High	High	City
Bio-oil from waste	Unknown	Unknown	City
Technology			
Electric car (an electric car is in use for the summer on campus)	High electricity quantity available; moderate feasible technology available	High	City, but especially appropriate for short distances on campus
Solar car (prototype in development at Engineering Physics)	Limited	Moderate	R&D

Additional Information Needed

- Infrastructure opportunities for refueling, recharging
- Potential to develop procurement policy for the UBC Fleet

Comments

- Research and development and industry linkage opportunities

Source: Criterion Planners/Engineers, 1999.

TRANSPORTATION ENERGY STRATEGY: Capacity expansion

There are a number of ways to increase capacity:

1. Bus
2. Vanpooling
3. Light rail
4. Facilities
5. On-campus end of trip bicycle facilities (lockers, showers)
6. Pedestrian
7. Park/ride

Quantity

- High potential for capacity expansion on campus and to and from campus

Quality

- High

Location

- Need to map spatial relationships of development and transportation capacity expansion (Strategy Zones)

Additional Information Needed

- Capacity expansion

Source: Criterion Planners/Engineers, 1999.

TRANSPORTATION ENERGY STRATEGY: Demand management

There are a number of transportation demand management initiatives:

1. Trip reduction measures
2. Goods movement
3. Telecommuting
4. Traffic calming measures – fewer signals, more roundabouts

Quantity

- High

Quality

- High opportunities to increase efficiency, reduce energy use, and reduce emissions

Location

- Campus-wide opportunities to integrate transportation demand management strategies into planning

Source: Criterion Planners/Engineers, 1999.

RESOURCE: Groundwater

- A system of wells tapping into groundwater supply and distribution system

Quantity

- Ill-defined but thought to be a shallow groundwater table
- Source for irrigation water, harvested at sustainable rate

Quality

- Good quality for irrigation – unchlorinated water is better for vegetation and land
- Accessible – the groundwater is shallow on most of campus (6-7 feet)

Location

- Across campus, but have to consider where irrigation is used the most, and how the water will be distributed
- There are problems with flooding (potential locations for wells) at Totem Park, Main Mall, near the War Memorial Gym and several other locations

Additional Information Needed

- Identification of potential campus sites – close to end use
- Feasibility study needed and more specific information about groundwater such as the recharge rate when the aquifer is depleted
- Groundwater management study needed so that the recharge rate is not exceeded

Comments

- Could be a dual function system where the water is run through a heat pump
- System would result in reduced quantity of water imported to campus
- A well system is used by the City of Vancouver for irrigation- local expertise available
- The system has to be drained in the winter so the more simple the distribution system the less maintenance involved

Source: UBC Utilities, 1999.

RESOURCE: Greywater

- Greywater: water from sinks, showers (toilet water = blackwater)
- Biofiltration systems treat greywater when is piped through trench or pools of aquatic plants, bacteria on roots cleanse the water

Quantity

- High – many potential sites

Quality

- Biofiltration is a natural treatment system which produces irrigation water of quality comparable to beach water
- Assessment of greywater quality
- Contaminants restrain the reuse of water

Location

- Everywhere, but need a common collection point as greywater cannot be piped far between buildings
- Could be used to treat greywater all over campus, with existing buildings and new development
- Potential to make use of left-over spaces such as verges and road allowances for biofiltration

Additional Information Needed

- Number of gallons produced
- Regulations for use. Can treated water be piped back into system for toilets etc.

Comments

- Outflows could be used to restore the natural spring water table and augment flows to the Musqueam stream in Pacific Spirit Park
- Outflow could be used for irrigation
- Need to ensure adequate maintenance and adequate water flow to keep plants alive once natural filtration system is set up
- Land use siting should consider water-use applications such as greywater
- C.K. Choi is a pioneer demonstration building at UBC

GREYWATER HEATING APPLICATION: Greywater Heat Exchange

- Low technology, low cost
- Can be used to get preheat with a heat 'boost' from heated water

Source: UBC Utilities, 1999.

RESOURCE: Rainwater

- Rainwater collection requires a catchment system, conveyance system, storage facilities, treatment system

Quantity

- Large amounts available seasonally

Precipitation: Total Rainfall (mm)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
157.2	129.5	112.4	81.0	63.8	49.1	37.1	50.0	66.3	129.0	182.8	170.6	1228.9

Source: UBC Climate Station (1957–1993)

Precipitation: Total Snowfall (cm)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
17.9	8.4	3.3	0.4	0.0	0.0	0.0	0.0	0.0	0.2	2.5	19.1	51.8

Source: UBC Climate Station (1957–1993)

Total Precipitation (mm)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
175.1	137.9	115.7	81.4	63.8	49.1	37.1	50.0	66.3	129.2	185.4	189.7	1280.6

Source: UBC Climate Station (1957–1993)

Days with Precipitation (mm)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
20	17	17	14	12	10	7	8	10	16	20	21	171

Source: UBC Climate Station (1957–1993)

Quality

- Good
- Could be used for greywater uses, irrigation

Location

- All over campus, catchment needed- building rooftops could be used
- Rainwater collection should be considered at design stage of building to maximize collection potential and reduce costs
- Impervious courtyards can be adapted for rainwater collection

Additional Information Needed

- Cistern, storage capacity feasibility
- Feasibility for some research purposes

Comments

- A study of rainwater collection was undertaken for the new Lui Centre

Source: UBC Climate Station, 1957-1993.
UBC Utilities, 1999.

RESOURCE: Water efficient plumbing fixtures

Various types of efficient plumbing fixtures include:

1. Composting toilets, low-flow toilets
2. Faucets, washing machines
3. Showerheads

Quantity

- High efficiency gains

Quality

- Efficiency technology is low maintenance
- Composting toilets: use demonstrated in C.K. Choi building – low water use, a very small amount of compost produced, no smell

Location

- Could be built into new buildings

Additional Information Needed

- Feasibility in single family dwellings
- Number of litres saved

Comments

- Also look into related technology – source separation toilets developed in Sweden, and Clivus Multrum also has a 'wet' composting toilet with some water that may have residential applications

Source: UBC Campus Sustainabilit y Office, 1999.
UBC Utilities, 1999.

RESOURCE: Alternative water treatment

On-site appropriate water treatment electro-technologies:

1. Ultra-violet light, ozonation, oxidation
2. Application for groundwater and rainwater

Quantity

- System could be developed for UBC site to treat rainwater, greywater post-biofiltration
- Large quantities

Quality

- High-quality post-filtration

Location

- Could be treated at one location and piped through campus

Additional information needed

- Treatment cost
- Infrastructure
- More research on most appropriate treatment technology

Source: UBC Utilities, 1999.

RESOURCE: Sewage treatment

On-campus Sewage Treatment Facility

Quantity

- Sanitary flow: 5,000,000 cubic metres per year

Quality

- Potable water after it is treated – if tertiary treatment on-site
- Need to determine chemistry and temperature of sewage

Location

- Could be located on campus property
- Need to map the vicinity of the big interceptors where influent is collected

Additional Information Needed

- Sewage treatment plant cost
- Infrastructure costs for routing water to treatment plants
- Land area required and value of land – sewage treatment can be land intensive

Comments

- Potential to avoid the cost for the regional sewer system of upgrading GVRD trunk to Iona- could be cost effective if a partnership is developed

Solar Aquatics

Quality

- This system mimics the natural ecosystem biological filtering process in three stages
- It utilizes aquatic plants and animals to purify contaminated water – it can be used for blackwater treatment (toilet waste)
- Conditions are controlled – the system is in a greenhouse
- Efficient system: requires 1 m^2 per person

Location

- Needs to be enclosed in a greenhouse facility

Additional Information Needed

- Investigation of scale of application

Comments

- Demonstration projects at Oberland College, Pamona College in the U.S. and Vancouver Island
- Education and demonstration potential

Constructed Wetland

Quantity

- Bioremediation and stormwater applications
- Flow reductions of 50-80% reported in drainage basins with artificial wetlands

Quality

- Different types of constructed wetlands: shallow marshes, ponds, extended detention wetlands, pocket wetlands and fringe wetlands
- Moderately to highly effective at removing pollutants

Location

- Across campus, applicable in most developments

Additional Information Needed

- Identification of potential campus sites
- Design of emergent marsh and pool habitat, hydraulic capacity, residence time, travel routes
- Siting need to consider how a constructed wetland woulddisturb the existing ecosystem

Comments

- Can provide very good wildlife habitat

Source: Condon, P and J. Proft. 1999.
UBC Utilities, 1999.

RESOURCE: Storm Water Retention Facilities

- Can range from constructed wetlands to concrete, pool-like structures
- Designed to hold water for 1-3 days after a storm and slowly release it through an outlet structure

Quantity
- Storm water flow: 4 million cubic metres per year

Quality
- Storm water will contain some road residue (i.e. oil)
- Retention facilities do little to enhance base flows of water and are not effective at treating or removing pollutants

Location
- Map location of sewer outflows

Additional Information Needed
- Appropriate siting
- Incorporating biofiltration into collection ponds
- Incorporating ponds into irrigation storage

Source: Criterion Planners/Engineers, 1999.

RESOURCE: Water Distribution System Maintenance

Leakage survey of water distribution system
- There is little known about the leakage in the water distribution system
- Potential to identify problem areas in distribution system and increase water distribution efficiency

Quantity
- Unknown but suspected to be large

Quality
- Excellent

Location
- Campus-wide
- City of Vancouver has good field techniques to estimate leakage – partnership opportunity

Additional Information Needed
- Field survey needs to be undertaken

Source: UBC Utilities, 1999.

RESOURCE: Xeriscaping

- Using low water, native plant species in landscaping

Quantity
- Heavily landscaped campus

Quality

- High

Location

- All over campus

Additional information needed

- Regional resources on native plant landscaping need to be identified

Source: Criterion Planners/Engineers 1999.

RESOURCE: Stormwater alternatives

Natural Drainage System

- Development designed to allow for a natural drainage system, returning water to the watershed
- Could incorporate open channels
  - *Drainage channel*: designed to handle peak discharges, allowing some water to infiltrate to soils below
  - *Grassed channel*: can remove some sediment and hydrocarbons- less expensive than curbs/gutters
  - *Dry swale*: highest water removal rate, designed to prevent standing water but also allows some percolation
  - *Wet swale:* function as linear wetland- need saturated soil conditions

Quantity

- High

Quality

- High (see options above)

Location

- Across campus, but focused on new developments

Additional information needed

- Input, expertise from UBC Landscape Architecture, involved in the development of a natural drainage system in Surrey
- Effect of pollutants (oil etc.) when returned to watershed – i.e. on fish-bearing streams

Source: Criterion Planners/Engineers 1999.

RESOURCE: Water metering

- Main campus is essentially unmetered for water use (the meters that exist are not maintained)
- Introducing water metering would provide an economic motivation within buildings and departments to reduce water consumption

Quantity

- High

Quality

- Excellent

Location

- Metering could be introduced across core campus

Additional Information Needed

- Cost of installing metering for core campus buildings
- Expected water savings and payback period
- Feasibility for departmental/building billing

Source: Criterion Planners/Engineers, 1999.

RESOURCE: Cooling towers

- Cooling towers could be used for campus water cooling applications (to cool condensor) for the recycling of water in the system rather than a one-way flow
- At present most of the water used for cooling is dumped into the sewage system

Quantity

- High

Quality

- Excellent

Location

- Cooling towers need to be located near cooling needs
- Cooling towers have been put in at TRIUMF and TEF

Additional Information Needed

- Amount of water now being put into sewage system from cooling applications
- Location where water is used for cooling
- Further costing

Source: UBC Utilities, 1999.

Building & Infrastructure Energy Resource Matrix

Resource Evaluation Criteria	Electric Generation Fuels & Resources									Electric Generation Technologies			Electric Purchases		
	Non-Renewable Fuels				Renewable Resources					Large Central Facilities					
	Oil	Natural Gas	Coal	Nuclear	Solar	Micro Hydro	Wind	Biomass	Ocean Tidal	Repower Existing	New Construction	Small Distributed Facilities	Out-of-Region	In-Region	In-Community
Relative quantity/abundance	Moderate	Moderate	Low	Moderate	★	Moderate	Moderate	Moderate	Moderate	---	Moderate	Moderate	★	★	Moderate
Magnitude of local benefits	Low	Low	Low	Low	★	★	★	★	★	---	Moderate	Moderate	Low	Moderate	★
Lifecycle cost effectiveness	Low	★	Low	Low	Moderate	★	Moderate	★	Low	---	★	★	Low	Moderate	★
Flexibility: increased choices/diversity	Low	Moderate	Low	Low	★	★	★	★	Low	---	Low	★	Moderate	Moderate	★
Conversion efficiency	Low	★	Low	Moderate	★	★	★	Moderate	Moderate	---	Moderate	★	Low	Moderate	★
Technological maturity/practicality	★	★	★	Moderate	★	★	★	★	Low	---	★	Moderate	★	★	★
Durability/reliability	★	★	★	Low	★	★	★	★	Low	---	★	★	★	★	★
Short lead time	Moderate	Moderate	Moderate	Low	★	★	★	Moderate	Low	---	Low	★	Moderate	Moderate	Moderate
Risk avoidance	Moderate	★	Moderate	Low	★	★	★	★	---	---	Moderate	★	Moderate	Moderate	Moderate
Equitable benefits/burdens	Moderate	Moderate	Moderate	Low	★	Moderate	Moderate	Moderate	Moderate	---	Moderate	Moderate	Low		★
Environmental acceptability	Low	★	Low	Low	★	★	★	Moderate	Moderate	---	Moderate	★	---	---	---
Academic/R&D potentials	Low	★	Low	Low	★	★	★	★	★	---	Moderate	★	Low	Moderate	★

Resource Evaluation Criteria	Direct Combustion Thermal Fuels			Direct Application Renewables				Demand-Side Management					Land-Use Coordination		
	Natural Gas	Propane	Fuel Oil	Solar	Biomass	Geothermal	Ocean Thermal	Space Conditioning/Ventilation	Lighting	Appliances/Equipment	Water Heating	Motors	Locational Efficiency	Use Mix and Density	Site Design
Relative quantity/abundance	★	Moderate	Moderate	★	Low	Moderate	Moderate	★	★	★	★	Moderate	Moderate	Moderate	★
Magnitude of local benefits	Moderate	Low	Low	★	★	★	★	★	★	★	★	Moderate	Moderate	Moderate	★
Lifecycle cost effectiveness	★	Moderate	Low	★	Moderate	★	Moderate	★	★	★	★	★	---	---	★
Flexibility: increased choices/diversity	Moderate	Moderate	Moderate	★	★	★	★	★	★	★	★	★	Moderate	Moderate	Moderate
Conversion efficiency	★	Moderate	Low	★	Moderate	★	Moderate	---	---	---	---	---	---	---	---
Technological maturity/practicality	★	★	★	★	★	★	★	★	★	★	★	★	---	---	★
Durability/reliability	★	★	★	★	★	★	★	★	Moderate	Moderate	★	★	★	★	★
Short lead time	★	★	★	★	Moderate	★	Moderate	★	★	★	★	★	Moderate	Moderate	Moderate
Risk avoidance	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★
Equitable benefits/burdens	Moderate	Moderate	Moderate	★	★	★	★	★	★	★	★	★	Moderate	Moderate	★
Environmental acceptability	★	★	Low	★	★	★	★	★	★	★	★	★	★	★	★
Academic/R&D potentials	Moderate	Low	Low	★	★	★	★	★	★	★	★	★	Low	Moderate	★

Criteria applicability:

★ High
Moderate
Low
--- Not applicable

Transportation Energy Resource Matrix

	Conventional Fuels		Alternative Fuels						Demand Mgmt.			Capacity Expansion					Land-use Coordination			
Resource Evaluation Criteria	Gasoline	Diesel	Methanol	Ethanol	Hydrogen	Natural Gas	Propane	Electricity	Travel Reduction	Goods Movement	Telecommuting	Bus	Vanpooling	Park & Ride	Bicycle	Pedestrian	Locational Efficiency	Use Mix & Density	Site Design	Parking Supply
Relative quantity/abundance	Moderate	Moderate	Low	Low	Low	★	★	★	★	Moderate	★	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	★	Moderate
Magnitude of local benefits	Low	Low	Moderate	Moderate	★	Moderate	Moderate	Moderate	★	★	★	★	★	★	★	★	Moderate	Moderate	Moderate	Moderate
Lifecyle cost effectiveness	Moderate	Moderate	Moderate	Moderate	Low	★	★	★	★	★	★	★	★	★	★	★	---	---	★	---
Flexibility: increased choices/diversity	Low	Low	★	★	★	★	★	★	★	★	★	★	★	★	★	★	Moderate	Moderate	Moderate	
Conversion Efficiency	Low	Low	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	---	---	---	---	---	---	---	---	---	---	---	---
Technological maturity/practicality	★	★	Moderate	Moderate	Low	★	★	Moderate	★	★	★	★	★	★	★	★	---	★	★	★
Durability/reliability	★	★	Moderate	Moderate	---	★	★	★	Moderate	Moderate	Moderate	★	★	★	★	★	★	★	★	★
Short lead time	---	---	Moderate	Moderate	Low	★	★	★	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
Risk avoidance	Low	Low	Moderate	Moderate	Low	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★
Equitable benefits/burdens	Low	Low	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
Environmental acceptability	Low	Low	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	★	★	★	★	★	★	★	★	★	Moderate	★	★
Academic/R&D potential	Low	Low	Moderate	Moderate	★	★	★	★	★	★	★	Low	Low	Low	Low	Low	Low	Low	★	Low

Criteria applicability:

- ★ High
- Moderate
- Low
- --- Not applicable

Water Resource Matrix

Resource Evaluation Criteria	Supplies				Distribution System Maintenance	Demand Management				Treatment/Disposal			
		On-Site								Wastewater		Stormwater	
	GVRD	Groundwater	Greywater	Rainwater		Efficient Fixtures	Metering	Xeriscaping	Cooling Towers	On-site Traditional Systems	On-site Alternative Systems	Natural Systems	Alternative Systems
Relative quantity/abundance	★	▤	▤	▤	★	★	★	★	▤	▤	★	★	★
Magnitude of local benefits	▤	★	★	★	★	★	★	★	▤	★	★	★	★
Lifecyle cost effectiveness	▤	▤	▤	▤	★	★	★	★	★	▤	▤	★	▤
Flexibility: increased choices/diversity	◪	★	★	★	★	★	★	★	★	★	★	★	★
Technological maturity/practicality	★	★	★	★	★	★	★	★	★	★	★	★	★
Durability/reliability	★	★	★	★	★	★	★	★	★	★	★	★	★
Short lead time	▤	▤	★	★	★	★	★	★	★	▤	▤	★	▤
Risk avoidance	▤	★	★	★	★	★	★	★	★	★	★	★	★
Equitable benefits/burdens	▤	▤	★	★	★	★	★	★	★	★	★	★	★
Environmental acceptability	▤	▤	★	★	★	★	★	★	★	★	★	★	★
Academic/R&D potential	◪	★	★	★	◪	★	★	★	▤	▤	★	★	★

Criteria applicability:

- ★ High
- ▤ Moderate
- ◪ Low
- --- Not applicable

The ABC's of Sustainability: Implementing the Sustainable Resource Strategy at the University of British Columbia

Principal Investigator: Professor Anthony H.J. Dorcey
School of Community and Regional Planning

Co-Investigator: Margaret Julian
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SAMPLE QUESTIONS

Sample Interview Questions re: UBC Sustainable Resource Strategy

1) What does sustainability mean to you? What does it mean in the UBC campus context?
2) To what extent have you participated in developing or implementing sustainability strategies at UBC? In what capacity were you involved?
3) Who could make the most difference in the implementation of the SRS? Who has the power to implement the recommendations of the plan?
4) To what extent do you feel that UBC is open to the involvement of the community in its activities? In its decision-making processes?
5) How would you describe the types of issues that are encountered in the management of energy and water at UBC?
6) What are the constraints and barriers on implementing the Sustainable Resource Strategy (and other sustainability initiatives) at UBC?
7) What strategies could work to overcome these constraints?
8) How could the process through which the Strategy was developed have been designed differently to facilitate implementation of the Strategy?

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Contact Information for Data Sources		
Data	**Source**	**Contact**
UBC Climate Station Records (1957-1993)	UBC Climate Station	Geography Information Centre 822-3048
UBC Utilities Information	UBC Utilities	Gord Apperley Director 822-0971
Energy Efficiency	UBC Energy Management Coordinator	Jorge Marques jorge.marques@ubc.ca
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