TECHNOLOGY SELECTION
AT BC HYDRO'S OFFICE OF THE CHIEF TECHNOLOGY OFFICER

by

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Abstract

A technology portfolio selection process was developed for BC Hydro's Office of the Chief Technology Officer (OCTO). The OCTO's existing technology management tools and practices were assessed against those found in academic literature as well as those used at other utility firms. The report then outlines a process for valuing and prioritizing technology solutions to meet portfolio objectives of maximized value, strategic fit and portfolio balance. The final process was shaped by considerations of technological maturity, integration with existing business practices, and flexibility to respond to changes inherent in technology research and development.

Dedication

This paper is dedicated to my husband, Doug.

Acknowledgements

The author would like to thank the team at the Office of the Chief Technology Officer, especially Helen Whittaker, for their time, support and assistance. The author would also like to thank the people both within BC Hydro and at other utilities who took the time to explain their portfolio selection practices.

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Abbreviated Terms

BC Hydro	British Columbia Hydro and Power Authority
BCTC	British Columbia Transmission Corporation
BCUC	British Columbia Utilities Commission
CSAT	Customer Satisfaction Index
CTO	Chief Technology Officer
OCTO	Office of the Chief Technology Officer
SDM	Structured Decision-Making
T&D	Transmission & Distribution

1: Introduction

1.1 Company Background

British Columbia Hydro and Power Authority (BC Hydro), a provincial crown corporation, is the primary electric utility in British Columbia, serving 95% of BC residents. BC Hydro generates, purchases, distributes and sells electricity, with about 6,000 employees located throughout the province. The utility operates 31 hydroelectric generating facilities and three natural gas thermal power plants and has a network of almost 80,000 kilometres of transmission and distribution lines (BC Hydro, 2011a). Net income in fiscal 2011 (year ending March 31, 2011) was $589 million, with $2.99 billion in operating costs and revenues totaling $4.02 billion. Revenue is generated from both domestic sales and trading, which in fiscal 2011 contributed $3.44 billion and $578 million respectively (BC Hydro, 2011a).

1.1.1 Strategic Context

As demand for electricity in British Columbia grows, BC Hydro must sustain its aging assets and respond to increased environmental requirements while maintaining low rates and reliable supply. BC Hydro employs a triple bottom line approach, incorporating financial, environmental and social considerations, in planning and managing its business. As a crown corporation, BC Hydro is guided by provincial government legislation, policy and instruction (BC Hydro, 2011a). Triple bottom line considerations, combined with these government instruments, help inform corporate strategy.

Following the enactment of the 2010 Clean Energy Act, which integrated BC Hydro and the British Columbia Transmission Corporation (BCTC) and established increased environmental and energy conservation targets, BC Hydro revisited its corporate vision and strategic objectives. As articulated in the three-year Service Plan spanning Fiscal 2012 - 2014, BC Hydro is guided by six strategic objectives:

- Safely keep the lights on
- Mind our footprint
- Maintain competitive rates
- Succeed through relationships
- Foster economic development
- Engage a safe and empowered team

BC Hydro evaluates its performance against these objectives using numerous quantifiable performance measures; the 20 measures included in the 2011/12 – 2013/14 Service Plan are detailed in Appendix A.

In its upcoming three-year Revenue Requirements Application submission to the British Columbia Utilities Commission (BCUC), BC Hydro is applying for a rate increase of 9.73 percent each year over the next three years. The rate adjustment application is driven in part by the utility's planned increase in capital expenditures after a period of low investment; over the next three years BC Hydro is spending $6 billion to maintain, upgrade and expand its aging assets (BC Hydro, 2011b). In April 2011, the Government of British Columbia announced a review of BC Hydro with the objective of developing options to reduce the impact of rate increases on BC residents and businesses. A panel was appointed to examine BC Hydro's financial performance, rate structures, corporate structures, and business planning to ensure costs are minimized and benefits to the province are maximized (BC Hydro, 2011d). BC Hydro and the BCUC temporarily adjourned the Revenue Requirements Application process so that the results of the government review, scheduled for July 2011, could be incorporated in an amended BC Hydro rate application (BC Hydro, 2011c).

BC Hydro is continuing to look for opportunities to improve operating efficiencies and reduce the need for rate increases. A senior level Technology Steering Committee was formed in October 2010 to evaluate BC Hydro's use of technology in helping to achieve its corporate strategic objectives, respond to increased demand for electricity and reduce costs.

1.1.2 Office of the Chief Technology Officer

In April 2007, BC Hydro created the role of Chief Technology Officer (CTO) to guide corporate technology strategy. The CTO sits on the Technology Steering Committee and leads the Office of the Chief Technology Officer (OCTO) group. The OCTO group is responsible for assessing emerging technologies and their potential impacts on the company. The OCTO helps BC Hydro to either take advantage of business-enhancing technologies such as smart meters, or respond to potential technology-related challenges such as electric vehicle / grid interaction.

One of the OCTO's recent initiatives is the development and implementation of a technology roadmap. A technology roadmap shows current technology resources and future technology needs along a timeline and is used to shape and communicate technology strategy. With the technology roadmap, BC Hydro aims to accomplish four objectives. The first objective is to develop a high-level view of the interdependence between BC Hydro's Strategic Objectives and technologies over a 30-year timeline. The second is to provide Business Units with a common framework for evaluating the alignment of BC Hydro's strategic objectives, cascading strategies, and specific technologies. The third is to identify interdependencies between business groups and technology initiatives, highlighting technologies that require the development of a multi-group business strategy. The final objective is to assess technology priorities and identify gaps in knowledge or investment around technologies that may be critical to the organization (BC Hydro, 2011f).

Development of the first corporate technology roadmap started in September 2010, led by the OCTO team. In April 2011, the Technology Steering Committee asked the OCTO to analyze the company's existing technology portfolio to assess value and resource deployment. This analysis was conducted through the use of a portfolio matrix-type technology evaluation tool, which will be described in later Sections of this report. The OCTO would like to continue to use this evaluation tool, in conjunction with the technology roadmap, to more effectively and transparently plan and manage BC Hydro's technology activities.

1.2 Purpose, Structure and Scope

Increased utilization of new technology would help BC Hydro meet its performance objectives. However, the utility is under significant scrutiny by the BCUC, the BC government and the provincial media and must ensure that its investments are cost-effective, reliable and environmentally responsible. Additional preference is given to projects that promote local businesses or create jobs, especially in the "green" economy. For technology solutions that require significant investment, BC Hydro might also need to apply to the BCUC for approval.

As a result of external pressures and the nature of the utility industry, BC Hydro's risk tolerance for integrating new systems or devices is low. Introducing a new technology requires extensive testing and demonstration (BC Hydro, 2011f). Often technologies that have been widely adopted in the industry require significant internal analysis before BC Hydro proceeds with implementation. As the unique geography, population density and climate of the province can impact the functionality of a technology, BC Hydro must determine whether the technology is applicable or can be adapted. BC Hydro also needs to ensure that its investments can meet the long-term needs of the organization; many of the utility's assets have been in place for decades, and planning horizons extend 30 years into the future. All of these considerations indicate that BC Hydro would benefit from a structured, considered approach to technology portfolio planning.

1.2.1 Purpose

This report further develops the technology management tools and processes used by the OCTO to direct BC Hydro's technology portfolio. The report outlines best practices in technology management, focusing on technology selection. A high level process is recommended that describes how the technology selection tools can be operationalized and embedded into the OCTO's planning processes. The OCTO has requested a technology selection process that is flexible and simple to use, and that works with existing corporate practices and procedures.

1.2.2 Structure

Chapter 2 of this report reviews relevant literature on technology management, portfolio selection, and commonly used tools and practices. Chapter 3 is an external analysis of utility decision-making, and includes an investigation of technology management practices in several of BC Hydro's peers. Chapter 4 is an internal analysis of decision-making at BC Hydro and of the OCTO's technology management practices and tools. Chapter 5 looks at options for improving and enhancing the OCTO's technology valuation methods and decision support tools. Chapter 6 then outlines a technology management process that incorporates these valuation methods and tools into a structured technology selection process. Chapter 7 briefly summarizes the key recommendations from the preceding chapters.

1.2.3 Scope

This report analyzes the OCTO's existing technology management tools and practices, and makes recommendations for improving these activities and integrating them into a more effective process. The basic structure of the OCTO's current practices is maintained but suggestions to modify or enhance these activities are made based on best practices found in the literature review and interviews with other utilities. The report describes both the technology roadmap and the portfolio matrix tool employed by the OCTO, but focuses on the use of the portfolio matrix. Recommendations for modifying BC Hydro's corporate processes are not considered in this report.

2: Technology Management Literature Review

This Section summarizes academic literature related to technology management to lay the groundwork for the optimal design of a technology selection process. Organizations are increasingly reliant on technology even as the pace of technological change continues to accelerate, creating new challenges and opportunities. Yet companies report that the majority of initiatives to incorporate new technologies are failing or are not fulfilling expectations (Shehabuddeen et al., 2006). *Technology management* is the process of planning, directing, controlling and coordinating the development and implementation of technological capabilities to shape and accomplish the strategic and operational objectives of an organization (National Research Council, 1987). The literature review discusses technology management frameworks, portfolio management theory, and technology portfolio selection practices and tools.

2.1 Technology Management Frameworks

The development of various frameworks has supported the growth and practical application of technology management research. To clarify the use of several generic terms, this paper adopts several definitions from Phaal et al. (2004). A *framework* is a conceptual construct that supports the understanding and communication of structure and relationship within a system for a defined purpose; frameworks require practical devices such as processes and tools to interface with the real world. A *process* is an approach for achieving a managerial objective through the transformation of inputs into outputs. A *tool* facilitates the operationalization and practical application of a process.

One of the most widely recognized technology management frameworks, shown in Figure 1 below, was first proposed by M.J. Gregory in 1995. Gregory identified five processes of technology management: technology identification, selection, acquisition, exploitation and protection. Of particular importance to this review is the technology selection stage, which will be examined in detail in Section 2.3.

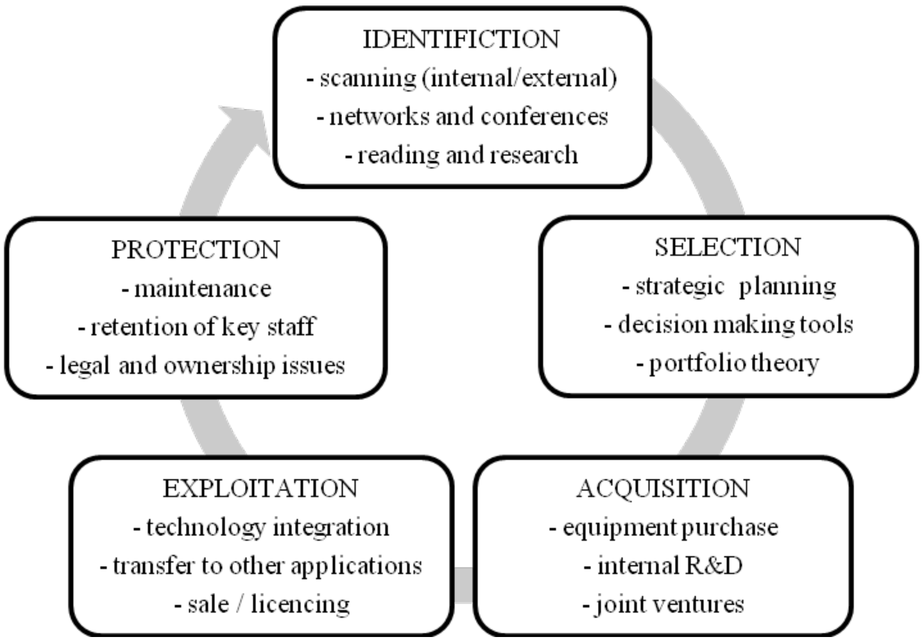


Figure 1: The Five Technology Management Processes (Gregory, 1995)

Phaal et al. (2004) expanded on Gregory's work to describe how the five technology management processes are distributed within the core business processes of the firm and are supported by knowledge flows from within the firm as well as from the operating environment (Figure 2). Technology management cannot be separated from organizational strategy and business processes as they are mutually dependent; technological issues feed into business decisions and vice versa. In addition, technology management activities are not typically performed as separate 'core' business processes but tend to be embedded within other business processes, such as strategic planning or operations. Core business processes provide the means through which the potential value of technology is realized. The goal of technology management is thus to "ensure that technological issues are incorporated appropriately into these processes, to form a technology management system that is coherent and integrated across and beyond specific business processes and activities" (Phaal et al., 2004).

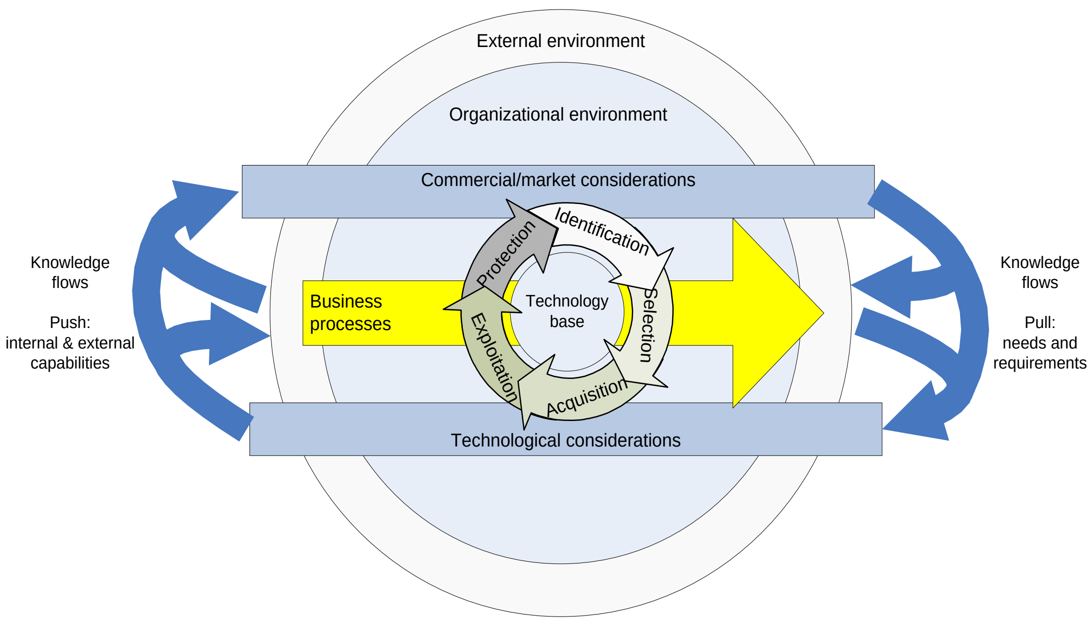


Figure 2: Technology Management Framework (Phaal et al., 2004)

Another useful technology management framework was developed by Glaxo Wellcome, a multinational pharmaceutical company, with assistance from the Cambridge Centre for Technology Management (Farrukh et al., 2004). The Glaxo Wellcome framework is based around a series of six processes that can be used as a high level methodology for structuring technology management activities.

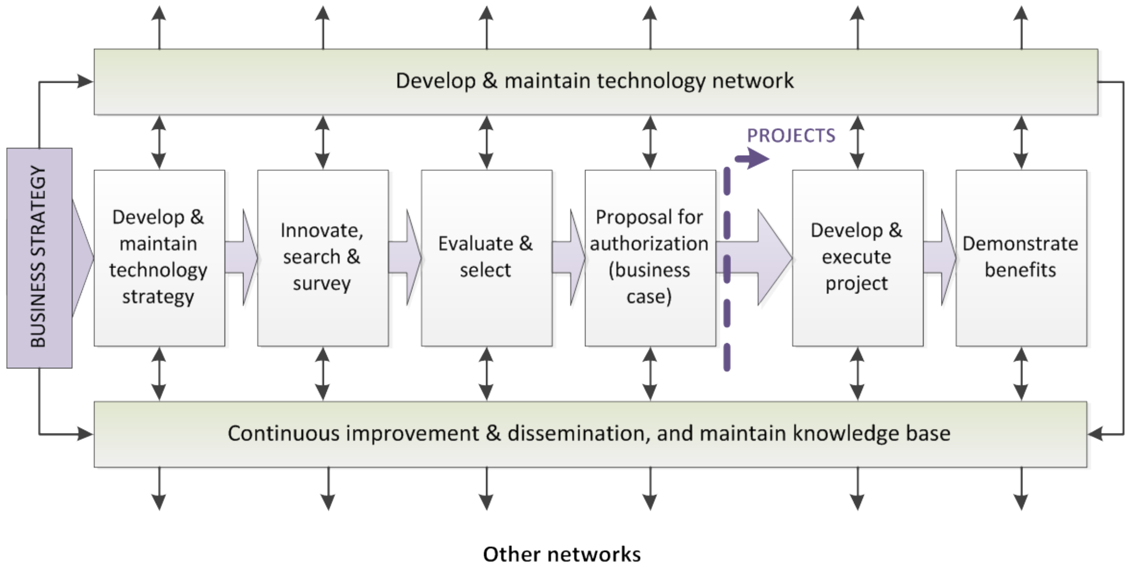


Figure 3: The Glaxo Wellcome Technology Management Framework (Farrukh et al., 2004)

The rest of this literature review will focus on the technology selection phase of technology management. Before moving on to an in depth review of technology selection processes and tools, the concept of a technology portfolio is examined. Portfolio management theory, particularly portfolio management objectives and portfolio selection, can bring an added dimension and perspective to technology selection.

2.2 Technology Portfolios and Portfolio Management

Portfolio approaches are commonly used when considering a number of technology projects with different characteristics relative to each other (Farrukh et al., 2009). A *portfolio* consists of a set of projects that share and compete for scarce resources and are carried out under the sponsorship and management of a particular organization (Archer & Ghasemzadeh, 1999). A *technology portfolio* consists of an organization's collection of active and potential technology investment projects.

Portfolio management is the coordinated management of an entire assortment of projects as a single entity (Meskendahl, 2010).

Companies realize change through new projects; thus successful projects can be considered central building blocks in implementing strategy (Shenhar et al., 2001). Project success is realized by *doing projects right* (the focus of project management) and *doing the right projects* (the focus of portfolio management) (Cooper et al., 2000). Meskendahl (2010) illustrated that effective portfolio management has a direct influence on strategy execution and business success. It is thus helpful to examine what successful portfolio management entails. Cooper et al. (2002) proposed three objectives of portfolio management: maximizing the value of the portfolio, linking the portfolio to the firm's strategy, and balancing the projects within the portfolio. These three portfolio goals have been widely adopted in academic literature, and measures associated with each goal have been proposed in various works (Meskendahl, 2010). Some of these proposed measures are listed in Table 1.

Table 1: Portfolio Management Goals and Proposed Measures

Objective (Cooper et al., 2002)	**Measures proposed** (Meskendahl, 2010)
Maximized value	• Average single project value & average success at capturing value • Use of synergies between projects and reduction of repeated efforts (i.e. in technology, marketing, human resources, etc)
Strategic fit	• Allocation of resources according to organizational objectives • Alignment of individual project objectives with strategy • Degree to which the sum of all projects (the portfolio) reflects overall strategy
Portfolio balance	• Balance between short-term, incremental improvements and long-term, radical innovations • Balance of project type, size, risk level and resource adequacy • Balance of new versus existing technologies

Most of these measures are subjective and difficult to assess, however portfolio goals should be established for each objective (Cooper et al., 2002). The targeted value of each measure will differ widely between organizations. The objectives of maximizing value and ensuring strategic fit can largely be achieved through developing and scrupulously adhering to a valuation system that aligns with corporate performance measures. Technology valuation is further discussed in the next section. For portfolio balance, each variable can be analysed using simple pie charts or more sophisticated tools such as those described in Section 2.4.

Technology firms can develop an optimal mix of projects by employing the concept of a technology funnel (Hall, 2010). New opportunities enter a funnel, and through a strategic assessment of benefits, cost and risks, a smaller subset of viable alternatives for organizational adoption emerges. Less promising options are eliminated from the funnel, typically through gating mechanisms (Cooper et al., 2002), as described in Section 2.4. Organizations must ensure that an adequate number and strategic mix of options are entering the funnel to help prepare for future shifts and demands in the operating environment. The technology portfolio will include strategic investment throughout the phases of the funnel to help select and advance the most promising technologies (Mitchell & Hamilton, 1988). A proposed distribution of long-term, early phase versus short-term, near phase projects in research and development (R&D) technology portfolios is described in Table 2.

Table 2: Balance of Technology R&D Projects and Activities (Mitchell & Hamilton, 1988)

Project type	**Description of activities**	**Resource allocation**
Knowledge building	• Basic research and monitoring encompassing wide prospects	2 – 10 %
Strategic positioning	• Exploratory development • Assessment of potential value	10 – 25 %
Business development	• Targeted development and engineering • Financial and risk-based valuation	70 – 99 %

Selecting which technologies to move through the funnel to eventual full deployment is the topic of the rest of this chapter.

2.3 Technology Portfolio Selection

The second of Gregory's (1995) technology management processes, technology selection, will be the focus of this Section and the primary focus of this report. Archer and Ghasemzadeh (1999) define *portfolio selection* as a periodic activity that draws from both available project proposals and initiatives currently underway to create a portfolio that meets the organization's stated objectives without exceeding resources or violating other constraints. The selection process can be divided into three progressive phases: strategic consideration, individual project valuation, and portfolio structuring. A number of tools are commonly used to support these activities and are discussed in Section 2.4.

2.3.1 Strategic Considerations

Cooper et al. (2000) identify the missing link between strategy and portfolio selection as significant problem in portfolio management. Prior to any valuation or decision-making, the organization must identify its technology strategy. Technology strategy includes risk tolerance, desired balance between incremental versus radical innovation, targeted technology areas for investment, and how much money should be allocated to early stage, developmental, and mature technologies. Technology roadmapping can be a useful apparatus for outlining the desired future technological state of the organization (Phaal et al., 2006; Holmes & Ferrill, 2008).

It is essential that the company be able to assess its technology portfolio against its overall strategic objectives. Corporate strategy must be operationalized on a business level, for instance through the development of metrics or criteria (Archer & Ghasemzadeh, 1999). Technology valuation measures should then be linked to these strategy metrics.

2.3.2 Technology Valuation

Technology valuation is the process of determining the current worth or future potential of a technology (Farrukh et al., 2009). Technology valuation involves gathering information from a number of sources in order to assess notions of cost, benefit and risk

(Lamb & Gregory, 1997). There are many factors upon which it is possible to evaluate individual technologies; some of these suggested by Shehabuddeen et al. (2006) are listed in Table 3. Technologies should be assessed on "soft" criteria, including organizational fit, in addition to "hard" requirements like return on investment.

Table 3: Possible Factors for Technology Evaluation (Shehabuddeen et al., 2006)

	Category	**Factor**	
Project Requirement Factors	Technical	• Quality • Reliability • Flexibility	• Repeatability • Volume
	Financial	• Capital • Sales	• Operations
	Pressure	• Environment • Regulatory	• Standards
Organizational Adoption Factors	Integratibility	• Compatibility	• Impact
	Usability	• Usefulness	• Utilization
	Supplier suitability	• Service • Integrity	• Partnership
	Strategy alignment	• Support	• Compatibility
	Risk	• Operational • Technological	• Commercial

Evaluation of individual technologies can be done in stages, using filters or screens in addition to more quantitative valuation methods described below. As the number of projects grows, time required for selection increases and ability to effectively process multiple criteria decreases, reducing the likelihood of making sound business choices (Archer & Ghasemzadeh, 1999). Thus to improve efficiency and effectiveness, unsuitable projects should be eliminated prior to undergoing more detailed valuation. Unsuitable projects might include those that do not match strategic objectives or offer a sound return on investment.

Companies often attempt to assign monetary or other quantitative values to technologies in order to impart objectivity. Technologies are typically rated along various internal measures of attractiveness, assigning a weight to each measure to come up with a final “score” (Shehabuddeen et al., 2006; Farrukh et al., 2009; Phaal et al., 2006). While some organizations have developed sophisticated formulas or models to value technology options, the conversion of qualitative data into a single number using complex mathematical functions reduces the transparency needed to make effective decisions (Shehabuddeen et al., 2006). Also, considering the uncertainty implicit in technology valuation, especially at early stages of technological maturity, the usefulness and validity of purely quantitative assessment is arguable (Farrukh et al., 2009).

A technology only gives value when linked to other assets, and can be assessed solely on its ability to enable another function or system (Farrukh et al., 2009). The future value of the asset is an estimate, and valuation is made more uncertain when factoring in the probability of successful technology implementation. The valuation of platform technologies (those that must be in place before other technologies can be implemented) adds an additional factor of uncertainty. It can be difficult to accurately capture these interdependencies and ambiguities using purely quantitative values. Firms that use both quantitative and qualitative metrics have been shown to perform better than those using purely financial valuation (Cooper et al., 2000). Nonetheless, it is important that a ‘common currency’ be used when valuing a range of different technology options. As subjectivity is unavoidable when rating uncertain or qualitative measures, “traceability of assumptions becomes of utmost importance so that they may be understood and reviewed by others” (Farrukh et al., 2009). Setting common rules, standards and definitions for valuation ensures that technologies can be compared and that there is a common understanding, if not consensus, on value assignments (Farrukh et al., 2004; Archer & Ghasemzadeh, 1999; Farrukh et al., 2009).

Different methods of valuation may be more appropriate for different classes of technologies. Factors such as technological maturity, incremental versus ‘strategic’ technology paths, and level of investment may suggest different tools and measures (Archer & Ghasemzadeh, 1999; Farrukh et al., 2009). In particular technologies in early stages of development or those that fall well outside of the current expertise of the company may not be ranked optimally through a one-size-fits-all valuation method. When assessing these types of technologies, it may be more appropriate to employ expert judgement, or ‘gut feel’, from technology experts and senior management to make strategic decisions. This approach can be supported using a technology roadmap. For well developed technologies and projects requiring large investments, quantitative or purely financial valuations are typically employed (Farrukh et al., 2009). Whatever the valuation method used, firms must have an understanding of the relative value of each technology before they can begin to select a technology portfolio.

2.3.3 Portfolio Structuring

The last stage of portfolio selection, portfolio structuring, is the stage where individual technologies are prioritized and a set of projects are selected for investment. Portfolio structuring is an iterative process requiring configuration and assessment of the selected set of technologies as a single entity. The final portfolio should prioritize technologies to maximize the objectives of value, fit and balance, as described in Section 2.2. Typically portfolio structuring benefits from input from multiple functions and disciplines, whereby multiple views are considered and adjustments are made until consensus is reached (Archer & Ghasemzadeh, 1999; Phaal et al., 2006). Resource constraints and project timing and interdependencies should also be considered during this stage.

The three stages of strategic consideration, individual valuation and portfolio structuring are iterative and interdependent. Archer and Ghasemzadeh (1999) suggest an overall portfolio selection process as illustrated in Figure 4.

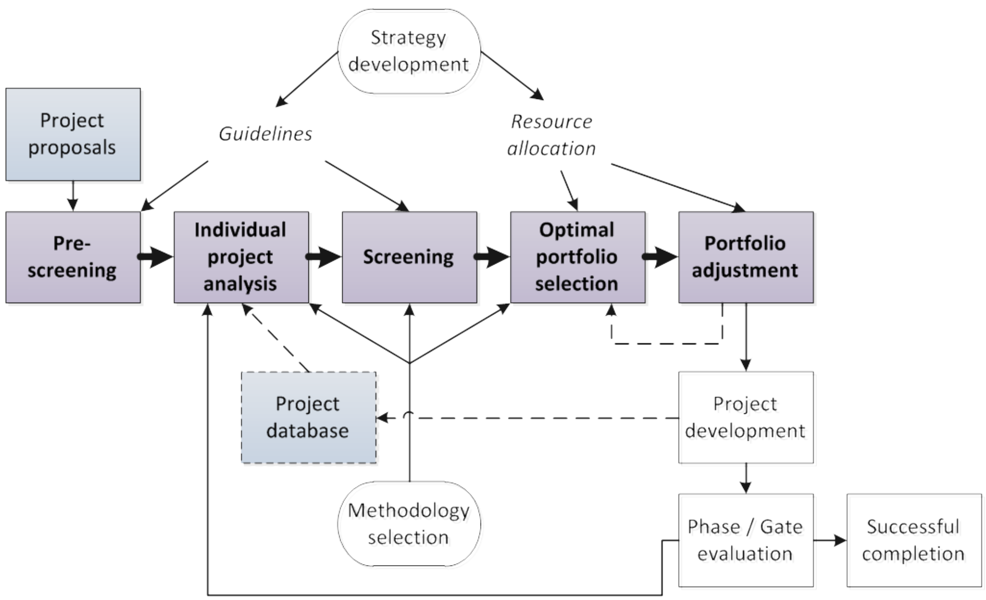


Figure 4: A Framework for Project Portfolio Selection (Archer & Ghasemzadeh, 1999)

The three stages of technology portfolio selection can be assisted through a number of decision support tools, as described in the next Section.

2.4 Technology Selection Tools

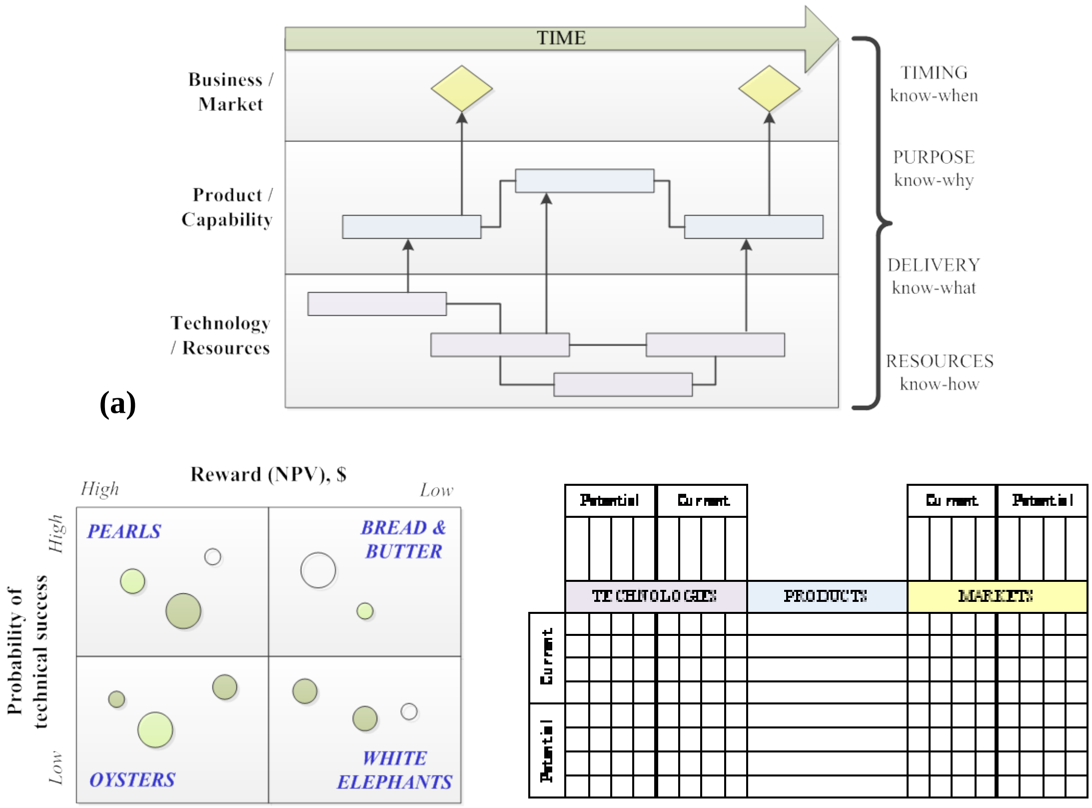
Archer and Ghasemzadeh (1999) emphasize that portfolio selection is a complex problem that requires flexibility and critical thinking, informed by but not reliant on decision support tools. To that end this Section describes some of the tools that might be useful in the technology selection process, but recognizes that each tool will have limitations and drawbacks. This report also avoids discussing techniques that require detailed quantitative modelling or complex formulas, as the uncertainties of early stage technologies, the large number of technology options available to the OCTO, and the requirements for a simple process excludes these methods as impractical.

Phaal et al. (2006) have identified some requirements of effective technology management tools. Tools should be founded on an objective best-practice model, not be mechanistic or prescriptive, be simple in concept and use, be flexible, allowing ‘best-fit’ to the current situation and needs of the company, result in quantifiable improvement, be capable of integrating with other tools, processes and systems, and support communication and buy-in. The most common and the most useful tool types for technology management, and in particular technology selection, include technology roadmaps, portfolio matrices, and linked grids (Phaal et al., 2006).

A *technology roadmap* is comprised of a series of layers and sub-layers within which the technological evolution of a business is mapped on a timeline (Phaal et al., 2004). The layers typically show different perspectives such as organizational goals, targeted sectors or markets, and required technologies or resources. The roadmap is used to show key linkages between layers, allowing the organization to capture and disseminate fundamental strategic information and relationships. While roadmaps are useful as a way to communicate long-term technology strategy, additional tools and techniques are typically required to support business decision-making (Phaal et al., 2006).

A *portfolio matrix* shows the position of different project options on a graph with axes representing key management issues. A number of measures are often incorporated into a single axis, for instance through a weighted average score assessing several strategic objectives. Companies typically assess measures such as required investment, risk, competence and business benefit, with the most common matrix type capturing risk versus reward (Phaal et al., 2006). Portfolio matrix methods enable decision-making as many different project options can be compared; however while they are useful as discussion tools the matrices do not generate a list of prioritized projects (Cooper et al., 2000).

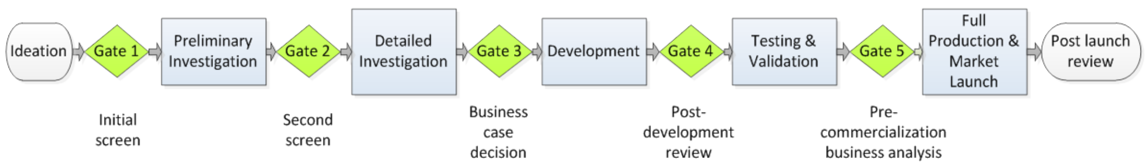
A *linked grid* is used to link one set of measures to another to further explore relationships and dependencies. The rows and columns of the grid are divided into a number of categories, often corresponding to roadmap layers or valuation measures. Provided that consistent measures are used, grids can be linked to each other, to a roadmap or to a portfolio matrix (Phaal et al., 2006). During portfolio structuring linked grids can be used to identify project interdependencies and assess portfolio balance across a range of factors. Examples of generic technology roadmaps, portfolio matrices, and linked grids are shown in Figure 5.



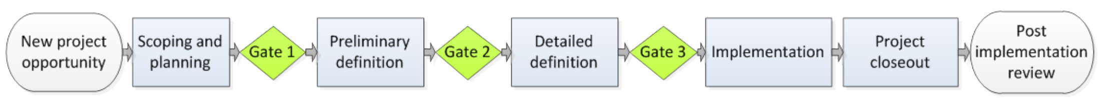
(b) (c)

Figure 5: Three Technology Management Tools: a) Technology Roadmap, b) Portfolio Matrix and c) Linked Grid (Phaal et al., 2006)

Structured decision support processes such as stage-and-gate can also assist technology selection. The stage-and-gate method introduces key tasks, activities, accountabilities and deliverables as new projects move through stages from ideation to implementation. Each stage concludes with a gate, or review, where a management team can assess the quality of the project and decide whether to move the project on to the next stage, send it back a stage to gather more information, or kill the project entirely (Cooper et al., 2000). Figure 6 illustrates two typical stage-and-gate processes. The first shows the high level stages typically associated with R&D, with gates used to ensure that a technology solution is developing to meet the technological and strategic needs of the organization. The stages typically align with the technology funnel phases described in Section 2.2. The second is a lower level process used to assess the progress of an individual project through different phases of the project lifecycle; this process can be used within each stage of the higher level R&D stage-and-gate process. The project level stage-and-gate process is more relevant to project management than portfolio management.



a) R&D Stage-and-Gate (Cooper et. al, 2000)



b) Project Lifecycle Stage-and-Gate

Figure 6: Typical Stage-and-Gate Processes in a) R&D Portfolio Management b) Project Management

During technology management processes, R&D-type stage-and-gate methods are instrumental in improving the quality of information generated from projects. The drawback of the stage-and-gate method is that it evaluate each project on its own merit, without considering the overall effect on portfolio (Cooper et al., 2000). Cooper et al. (2000) suggest two ways of incorporating a stage-and-gate process into portfolio management. The first approach is to reassess all new and on-going projects two to four times a year, creating a new portfolio at each review. Between portfolio reviews, the gates serve to ensure that projects remain financially sound and on schedule. This approach is suited for fast-paced, dynamic organizations where the portfolio has a major impact on the competitiveness of the company, and where the senior management team has the time and interest in creating a new portfolio several times a year.

The second approach is to rely on the gates to adequately screen projects; an overall portfolio review is carried out once or twice a year to check that the portfolio is on track. At the gate review for an individual project, the technology would be valued both on its own merit and on how it adds to or detracts from the existing active projects and the strategic objectives of the company. This valuation would rank the project in relation to all other active projects, and a go/no go decision could be made to proceed with the project. Projects that are moved to the bottom of the list are reassessed at their next gate reviews. At the annual portfolio reviews, the overall portfolio is checked to make sure the gates are working well and the portfolio meets the objectives of maximized value, strategic fit, and project balance. Any required adjustments are made at these reviews. This approach is suited for larger companies with lengthy project lifecycles and existing stage-and-gate processes.

3: External Analysis: Utility Technology Decision-Making Practices

Technology management literature has historically focused on new product development in high tech, competitive firms. However, as utility firms typically operate as regulated monopolies, they have much different characteristics from these competitive firms. In addition, utilities are typically technology consumers and usually partner with companies that can create tailored products rather than developing these technologies themselves. This Chapter assesses the context in which utilities make decisions, especially around technology. Section 3.1 reviews academic literature related to utility decision-making. Section 3.2 provides case studies of the technology selection practices within the corporate technology departments of three North American utilities.

3.1 Utility Decision-Making Literature Review

Electric utilities are natural monopolies. Natural monopolies form when the economies of scale and high barriers to entry make it cheaper for only one firm to operate in a specific market (Moore, 2010). Creating an electricity network comprised of generation, transmission and distribution assets requires significant up-front investment, but once in place this infrastructure can last for decades. There is no incentive for a competitor to build a parallel network, which means that utilities do not face competitive pressures that reduce prices and increase output to match the needs of the market. However, utility actions have a direct impact on the region it serves. “Ultimately, utility plans are vital to the economic health of service regions, to the well-being of ratepayers, and to the successful implementation of [regional] energy policies" (Lough & White, 1988). To ensure that utilities are acting in the best interest of energy consumers and the region overall, natural monopolies are usually highly regulated and their decision-making is highly scrutinized. In Canada, most natural monopolies, including BC Hydro, are Crown Corporations, which means that the sole shareholder is the federal or provincial government. While public utilities operate at an arm's length from the government, they are often issued directives that advance specific economic, environmental and social objectives. Public utilities thus incorporate a range of triple bottom line considerations in their decision-making and planning activities (Williams & Larocque, 2009).

Utilities usually have long planning horizons due to the high costs and long lifecycles of their assets. They also must ensure that they plan for the long-term demographic and technological shifts that will shape future demand for energy. Planning based on these demand forecasts is complicated by uncertainties around the future supply of energy resources, the availability of new energy technologies, and the public and regulatory responses to proposed plans and policies (Lough & White, 1988). These factors argue for structured planning practices supported by rigorous analysis of the costs, benefits and risks of all major alternatives along social and environmental as well as financial lines. The need to balance these varying objectives, combined with a lack of competitive pressures, typically leads to organizational cultures and practices that are risk averse, inefficient and slow to change. Under the guise of 'necessity' or misapplied corporate performance metrics, utility decision-making often reflects faulty institutional assumptions and beliefs, the pursuit of sunk costs and pet projects, and avoidance of difficult or risky decisions (Jennings, 2009).

> In organizations that are responsible for delivering utility services, the business side of the equation is often overshadowed by the technical and operational components. The reason is simple: customers notice when the lights go out or water stops flowing, but rarely take the time to question the effectiveness of the business behind the utility. That is, until there is a rate increase or some other event that prompts an investigation. For this reason, many utilities can be slow to change and often harbour basic inefficiencies that impede everything from procurement to maintenance to customer service delivery. This is especially true when it comes to ingrained business processes in the organization. As long as the process seems to function and generates some result, the impetus to take on the formidable task of change usually disappears (Jennings, 2009).

Utilities are facing increasing cost pressures and must respond to an accelerating rate of change in energy markets and technologies. Improving the decision-making process for evaluating and selecting capital projects holds the greatest potential for conserving scarce resources while enabling the organization to satisfy its objectives with maximum organizational benefits (Jennings, 2009). Utility capital projects often involve long lead times, high costs, and multiple internal and external stakeholder impacts. Capital investment decisions can affect future operational effectiveness for decades (Lough & White, 1988; Jennings, 2009). Utilities typically approach capital investment by ranking projects and selecting the top valued initiatives until a budgetary limit is reached. But project conflicts and interdependencies require a portfolio-level assessment of valuation and ranking (Jennings, 2009; Cooper et al., 2000; Archer & Ghasemzadeh, 1999). This assessment should question the validity, transparency, and relevance of underlying assumptions and business drivers to ensure that investment decisions are tied to business needs. Project selection is where business processes often break down, especially when poorly defined criteria exist and inputs and assumptions are not rigorously vetted by internal stakeholders (Jennings, 2009; Lough & White, 1988; Williams & Larocque, 2009).

Optimizing capital investments requires utilities to look beyond budget-based selection, towards a holistic portfolio decision-making process that considers utility performance and customer service, rate strategy and strategic destination, and process alignment and consistency as shown in Figure 7. The portfolio optimization process should include an assessment of portfolio balance, such as the distribution of projects by size, business driver, and category (Jennings, 2009). Monitoring and reporting of longer term trends such as budgeted versus actual spending should be undertaken to ensure the effectiveness of the overall capital portfolio.

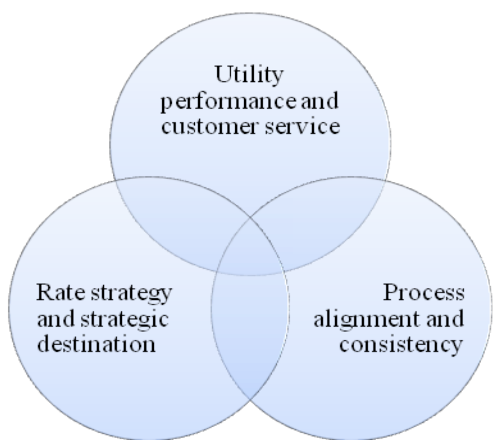


Figure 7: Utility Capital Optimization Considerations (Jennings, 2009)

3.2 Utility Technology Selection Case Studies

This section looks at the technology management practices of three North American electric utilities, focusing on selection processes. Telephone interviews, typically one hour in length, were conducted with persons responsible for technology management within a corporate-level technology group. The interviews were loosely structured around several interview questions, listed below:

- What types of technologies/projects does your group manage?
- How do you decide which technologies to pursue? Do you use any decision support tools such as roadmaps or scoring systems?
- Please describe how a technology solution typically progresses within your organization, from its initial identification to full implementation.
- What are the benefits and challenges of the technology management system you have described?

3.2.1 Utility A

Utility A operates fourteen hydroelectric, two thermal and four remote diesel generating stations, producing on average 32,000 GWh of electricity each year. Utility A also manages about 85,000 kilometres of transmission and distribution lines. The organization employs over 6,000 people and serves about 500,000 electric customers and 250,000 natural gas customers. Annual revenues for 2010 were $2 billion.

The utility's Emerging Energy Systems group consists of five persons who investigate and advance potential energy generation technologies such as bioenergy, solar, geothermal, and wind. The group engages in both applied research for internal customers and concept development to assess the readiness of a technology for corporate deployment. No formal technology roadmap is used, but there are various development plans that together guide the overall strategy for technology R&D activities.

The head of the Emerging Energy Systems group conducts a 'tech watch' every day to monitor technology trends and developments within research groups, other utilities, and electric utility industry groups[1]. He then uses his expertise about regional conditions and the technology needs of Utility A to identify where new technologies might benefit the utility. The technologies currently in use are assessed and other available alternatives are identified that could potentially provide greater benefits in areas such as cost effectiveness, ease of use, or environmental impact. New or emerging technologies are also evaluated to assess readiness for deployment.

Technologies that pass through this identification and screening phase and are selected for a demonstration project then move into a design phase. In this stage, the group determines how the technology project will be carried out, what equipment or infrastructure is needed, and which suppliers and partners are required. Utility A connects with external partners by putting the word out about the type of help they are looking for. The Emerging Energy Systems group looks for partnerships where they could provide expertise or funding in return for in kind investments of equipment or siting for a demonstration project. The group has an extensive network of contacts with universities, colleges, research groups, and industry. The project applies for money from a corporate Research and Development Fund to move to the construction phase of the project. With many different projects asking for money, proponents must also seek alternate sources of investment to fund large projects. The provincial or federal government is a significant source of funding for larger projects, and universities,

[1] Utility industry groups mentioned in all three case study interviews included CEATI (Centre for Energy Advancement through Technological Innovation) and EPRI (Electric Power Research Institute)

national research groups and industry groups also provide support in exchange for the results of the project.

Utility A has about $3 - 6 million in its corporate R&D Fund. Any group within the organization can apply to the Fund for R&D project investment. The Emerging Energy Systems group, the environmental group, and the transmission business unit are the primary applicants to the Fund, but external proponents, with the support of an internal champion, can also apply. The R&D Fund is managed by a single person, and investment decisions are made by the Research Board. The Board is made up of about 12 senior engineers and environmental experts. The internal R&D project proponent applies to the R&D Fund for investment, explaining the benefits and risks of a project in a proposal. The Board reviews the proposal and can ask the proponent for clarification or more information. The Board then votes to approve or reject the application.

In the opinion of the interviewee, the main benefit of this system is that the proponent gets an immediate answer from the Board, and often gets a cheque at the end of the review meeting. Proponents also have a lot of freedom in how they implement the project, and are not required to provide detailed updates or progress reports. The process is also flexible, so that if a proponent discovers that changes need to be made midway through the project the Board is very accommodating to modifications. This flexibility is helpful as new technologies have inherent uncertainties, and the main objective of R&D projects and activities is to better understand and resolve these uncertainties. The drawbacks of this system are that the Board tends to approve projects from proponents they are familiar with or from those that make a good presentation. Board members are familiar with the utility's current operations but may not be experts in the technology under consideration. Some projects end up getting funded that may not provide a proportional benefit to Manitoba Hydro, and less successful projects are not killed.

3.2.2 Utility B

Utility B employs over 18,000 people and serves approximately four million customers in the North America, with additional operations in Latin America. In North America, nuclear, coal-fired, oil- and natural gas-fired and hydroelectric plants have a combined generating capacity of over 35,000 MW. Electricity is distributed by almost 300,000 kilometres of T&D lines. Revenues in 2010 were $14 billion.

A staff of 12 to 15 supports Utility B`s Chief Technology Officer. The group is composed of technology subject matter experts, project managers that support field tests and pilot projects, and strategy advisors. The CTO organization looks at seven technology areas: storage, renewables, smart grid, small nuclear, water, clean combustion, and electric vehicles. High level roadmaps are created for each areas. The roadmaps are broken up into sections of 0-3 years (tactical), 3-10 years (strategic), and more than 10 years (transformational). For each technology area, the CTO group assesses the current market and economic conditions, where these will be in the future, and what developments will indicate that advances are coming that will impact the utility.

The CTO organization tries to balance investment in near term and long term technologies through both top down and bottom up methods. From a top down perspective, for each technology area the mix of projects includes those that have an immediate impact on the bottom line as well as longer term investments to prepare for the future. From a bottom up perspective, the CTO group assesses the needs of each specific

Business Unit in the near term and into the future, and investigates the direction of advances in core operational technologies. Project selection looks beyond the immediate set of projects, to investigate whether projects are being done in the right areas, and whether projects are being used to form the most worthwhile partnerships.

The CTO group does not spend a lot of money on long-term technologies, but aims to ensure that it is monitoring the most optimal mix of technologies. Projects that offer more immediate benefits, such as deployment of smart grid technologies, tend to receive the most investment. Currently most technology valuation is based on previous experiences in the industry and the intuition of experts, who decide whether the initiative increases earnings or mitigates risks. The CTO organization is also looking to develop a more sophisticated method of evaluating projects.

Utility B employs a technology funnel concept. Technologies that enter the funnel go through a first phase of monitoring and filtering. The CTO group scans for technology developments in the industry to see where early field trials are happening. Utility B aims to be a leader in energy technology, and is actively partnering with international companies that are leading new technology developments. In the first funnel stage, technologies are assessed to see if they make sense from a scientific perspective.

In the development phase, technologies are analysed to understand the stage of technological maturity as well as regulatory and other barriers to deployment. The CTO group looks for projects where it can have an impact on the advancement of a technology, for instance through the development of regulations and standards, so that early stage technologies progress to meet Utility B's specifications. The group looks for a business model that will work for the technology, and decides whether Utility C is ready to become a customer of the technology. If the technology is ready for deployment, the Business Unit takes the lead. At pre-commercial maturity, the CTO group takes the lead.

The next phase is a lab or limited field test, where the CTO staff investigates what happens when the technology is installed, what the process is for installation, and what are the major issues. Successful field tests are followed by a pilot phase. At this phase regulatory approval is often needed, and formal project budget, scope and objectives are required, as well as a description of the business model being proven. The results of the pilot phase inform the decision to deploy in a Business Unit. While there is not a formal process for killing projects, in development and lab phases projects often get shelved. By the time a technology has reached the pilot phase it is not likely to be killed.

At early funnel phases, the CTO office is less formal and more flexible in how it decides where to allocate time. As projects move through the funnel, Business Unit involvement increases and stage gating gets more formal. At early stages of technological maturity the opinion of the Business Unit might be solicited but the CTO group provides most of the resources. The Business Unit may take the lead in the pilot phase, with a CTO staff member acting as a consultant. Deployment is fully in the hands of the Business Unit. Advancing radical technologies can be difficult as Business Units are focusing on operational issues whereas the CTO is looking at longer term, strategic planning. “If we don’t get told ‘No’ a number of times, we’re not pushing the envelope”. To advance the corporate technology strategy, the CTO office must ensure commitment from Business Units and has to be creative in using the Business Unit’s time and resources.

In the opinion of the interviewee, the challenge of a technology management system is finding a balance between being disciplined enough to document and adhere to a process, but not becoming a slave to it. Following a process that includes testing and decision trees and documentation makes it easier to report and communicate the value of what the CTO office is doing, especially to senior decision makers. However by definition innovation require flexibility; if an organization becomes a slave to process then it will not be open or in a position to take on things that are not included in planning. The CTO group wants to ensure that it does not close the door on things it does not even know about yet. Another challenge is valuing technology or presenting a business case for technology to decision makers that are used to assessing mostly financial criteria.

3.2.3 Utility C

Utility C employs almost 25,000 people and serves approximately four million customers. Generating capacity from hydroelectric, natural gas-fired and nuclear plants exceeds 35,000 MW, and electricity is distributed by 145,000 kilometres of T&D lines. Revenues in 2010 were $12 billion.

Utility C`s energy R&D centre employs about 500 staff and operates as a matrix organization where scientists are grouped under expertise and form multidisciplinary research teams. The R&D centre performs primary research, as well as development for specific Business Unit requirements. The centre is divided into four R&D platforms, including production, distribution, transmission, utilization (consumer facing and energy efficiency technologies). Technology roadmaps have traditionally been developed for each platform. Roadmaps show detailed Business Unit objectives over the next 0-5 years and more general objectives over 5-20 years. For the past two years, due system-spanning technologies such as smart grid, the R&D centre has started to use a global roadmap. The four platforms have started to work together to globally coordinate and optimize resources to respond to an increase in multi-platform issues.

R&D projects come from the roadmaps, from Business Unit proposals, or from proposal from research staff. Based on the roadmaps, the R&D staff are able to rank projects. Ranking is currently done by hand and is supported by spreadsheets, but the R&D centre would like to institute a more sophisticated portfolio management system. Projects are ranked based on roadmap alignment and business unit stakes; even if a technology is not in the roadmap it needs to be ranked if it is important to the Business Unit. The ranking process also looks for linked or co-dependent projects and technologies. Other important considerations include the capacity to ensure that projects are successful, the capacity of the project to facilitate collaboration, and the capacity of the Business Unit to integrate the technology into operations.

Three to five percent of the R&D centre's portfolio is reserved for monitoring new technologies to ensure that there is active and dynamic scouting of industry and utilities. The centre's managers informally tries to ensure that projects are diversified across different research areas, but this is typically ensured based on the availability of research personnel. Often staff specialized in one area are in high demand as research areas become more urgent or move to the forefront of business concerns. The centre's managers thus finds that it must prioritize which platform has highest needs. This is an informal process. Decisions are based on business cases, however it is often "first come, first prioritized". When some projects may be in jeopardy, the centre's management try to accommodate as many projects as possible by working with stakeholders.

The R&D group employ a structured stage-and-gate process aligned with technology funnel phases, with five stages from identification to deployment. Every stage is followed by gate review, conducted by a group of directors. This group is made up of three directors from the research centre and three from Business Units. The gate review group always includes the Business Unit director that will eventually be responsible for implementation.

New R&D opportunities are documented in a project proposal one-pager that outlines the summary business case, the resources required, and schedule of execution. This one-pager is used for project ranking, with favourable projects entering stage one of the stage-and-gate process. In the initial proof of concept stage, different avenues are explored to identify all relevant technologies and solutions. The deliverable of stage one is an exhaustive report; the directory committee evaluates whether the review is adequate and gives approval to investigate the different avenues. This process takes about a year.

In the second, prototype stage, different options are characterized and explored, with the best solution put forward and gated. At stage three, industrialization, an external partner is sought to bring prototypes to an industrial level and test the system in the field. At the stage three gate, the Business Unit needs to commit to implementing the technology for the project to proceed. Gate three is the most formal review, and the Business Unit must agree to the technology deployment plan and schedule. The R&D centre has been starting to seek input from Business Units and industrial partners earlier than stage three to ensure that development is meeting all stakeholder requirements. This also helps speed technology transfer time. Stage four, homologation of a solution, assesses whether the technology solution is of adequate quality and meets standards. Gate four is the final validation of the business plan and implementation plan. The technology is deployed into Utility C's operations at stage five.

The directorial committee has a lot of flexibility to respond to project developments and changes. Three people administer the portfolio, and a flexible change authorization process helps manage changes dynamically. The directorial committee meets every two months and the portfolio research team meets every two weeks to discuss projects and assess whether there any game changers. While projects are not necessarily killed outright, projects branch off and the unsuccessful avenues are killed.

In the opinion of the interviewee, a benefit of this technology management system is that the researchers, gate reviewers, and Business Unit directors have an intimate understanding of projects, which helps during implementation. Direct and frequent directorial involvement is essential for process flexibility, however this can also mean that the gate reviewers are too close to projects. This is time consuming, and often makes it hard to kill or de-prioritize projects. Research personnel are invested in their pet projects, and it can be difficult to have an impersonal process to manage prioritization.

3.2.4 Analysis

A range of technology management practices can be seen across the three organizations in these case studies. Table 4 below summarizes the characteristics of the three different utilities and the technology management practices undertaken by their corporate technology groups. The next Chapter gives an in-depth look at BC Hydro and the OCTO, BC Hydro's main characteristics are included for comparison.

Table 4: Utility Case Study Summary, Compared with BC Hydro

	BC Hydro	Utility A	Utility B	Utility C
Number of customers	1.8 million	500,000[3]	4 million[5]	4 million
Generation resources	Hydroelectric, Natural gas-fired, Remote diesel	Hydroelectric, Natural gas-fired, Remote diesel	Nuclear, Coal-fired, Oil- & Natural gas-fired, Hydroelectric	Hydroelectric, Natural gas-fired, Nuclear, Remote diesel
Generation capacity (MW)	10,900	5,500	35,000[5]	35,000
T&D lines (km)	80,000	85,000	300,000[5]	145,000
2010 revenues	$4 billion[1]	$1.5 billion[3]	$14 billion	$12 billion
Total employees	6,000	6,000	18,000	24,000
Corporate technology group employees	10[2]	5[2]	15	500
Technology roadmap	In development	No	Yes	Yes
Other decision support tools	In development	No	In development	Yes
Stage and gate technology management process	Somewhat	No	Yes	Yes

1 Fiscal year ending March 31, 2011
2 Does not include Transmission R&D group
3 Does not include natural gas line of business
5 North American operations only

All utility technology groups relied to a large extent on the expertise and professional opinion of their staff during technology identification and valuation. Where the utilities differed was in the level of analysis and rigour in technology selection tools and processes. Utility A, the smallest of the three utilities, has the most simple technology management processes. Utility A does not appear to employ a corporate level technology development plan. Project selection is based largely on the “gut feel” of the proponent and the corporate R&D board, and does not seem to be supported by rigorous assessment of strategic impacts and interdependencies.

Utility B and Utility C have progressively larger technology groups and employ more structured management and decision-making practices. Both utilities use technology roadmaps to help guide technology planning and selection. Both utilities, and in particular Utility C, employ stage-and-gate-type processes to help ensure that projects are progressing according to plan. The gating process is used to reassess the relative values of technologies and tweak projects to better align with strategic objectives, but none of the utilities describe a mechanism for “killing” or eliminating technology solutions from the portfolio completely.

The technology group at Utility C is the only one that uses valuation and ranking tools and techniques. It should be noted that all utilities are interested in or actively investigating more rigorous decision support tools. Utility C is also the only one that mentions a formal mechanism for ensuring Business Unit engagement and commitment. Utility B appears to undertake the most comprehensive assessment of portfolio balance, looking from both a “top down” and “bottom up” perspective to ensure the best mix of technology investment.

In all three organizations there was an emphasis on ensuring that flexibility was built into the system to allow for the uncertainties and changes inherent in technology research and development projects. All three technology groups also stressed the importance of identifying and cultivating the right strategic partnerships, and leveraging internal and external networks for project funding and support.

4: Internal Analysis: BC Hydro and the OCTO

Effective technology management and portfolio selection processes are consistent with and embedded in other business processes within the organization (Phaal et al., 2004; Jennings, 2009). Chapter 4: assesses relevant processes at BC Hydro, starting with corporate Structured Decision-Making practices. Section 4.2 describes the OCTO and its current technology management and selection processes. Section 4.3 then outlines the portfolio matrix tool being developed to assist the OCTO in technology valuation and selection.

4.1 Structured Decision-Making at BC Hydro

BC Hydro uses technology to enhance its existing business functions and capabilities. The OCTO identifies and promotes technologies that will impact one or several Business Units in the organization, and must work with different corporate groups to get technologies implemented within BC Hydro. It is thus important that the OCTO understand how Business Units make decisions such as whether to make a major investment in new technology. BC Hydro's financial approval process, its formal decision-making process, and its use of business cases to document and communicate project benefits and risks are discussed below.

Throughout BC Hydro, the corporate Financial Approval Procedure determines the level and type of approval needed for a project, depending on the investment required. The CTO can approve project costs of up to $500,000. Higher levels of spending are guided by the requirements of the corporate procurement process. Organization-wide technology adoption usually necessitates tens of millions of dollars in capital investment and requires a highly detailed business case, a sponsoring Business Unit, senior executive-level signoff and, in some cases, BCUC approval.

To provide managers and executives with the information needed to make effective decisions, BC Hydro has developed a formal Structured Decision-Making (SDM) approach. As mentioned in Section 1.1.1, BC Hydro incorporates triple bottom line considerations when evaluating its corporate performance. SDM "outlines a structured approach to making decisions which integrate multiple objectives (such as financial, social, and environmental impacts)" (BC Hydro, 2010b). Business cases are used to document the outcome of the SDM process, recommending a course of action to decision makers based on an analysis of all relevant strategic factors. Business cases are required "for any project (or program or initiative) requiring investment, expenditure or commitment which has a significant impact on business operations, creates material risk, and/or where there are credible alternatives to a recommended course of action ... including capital investments, operating initiatives, contracts and commitments" (BC Hydro, 2010b). Additionally, an updated business case may be required as the project moves through a project level stage-and-gate type process as illustrated in Figure 6b of the literature review.

Business cases describe how a project aligns with BC Hydro's six strategic objectives and provide an estimate of the project's impact on relevant performance measures. In the business case, project managers are also required to present alternatives to the project being proposed, including the alternative of 'doing nothing'. Additional

SDM documents, tools and techniques have been developed to support effective analysis and evaluation of competing triple bottom line considerations. After a case has been made for the best alternative, all forecasted expenditures are summarized and potential risks to both the project and to the overall business are described. At project close out, the initiative is assessed against the budget, schedule and impact on performance objectives estimated in the business case. Surveys of Generation, Transmission & Distribution, and Power Smart[2] Business Units revealed that additional business group-specific governance processes, metrics and tools supplement the SDM process.

4.1.1 Analysis

An analysis of Structured Decision-Making practices at BC Hydro shows that the organization has invested significant effort into its processes and tools. Employing the basic SDM principles and techniques to document the benefits and risks of new technologies will assist Business Unit and executive-level decision makers in thoroughly evaluating possible investments. However, Business Units must compare investment in new technology with capacity upgrades or maintenance projects that ensure the basic safety and reliability of existing assets. With limited funds, it may be difficult to convince these groups to invest in demonstration projects of uncertain benefit, or in game-changing technologies that cost considerably more than maintaining the existing system. It is thus important that the OCTO work with the Business Units to understand the needs and practices of operations and help them identify and make use of the technologies that will provide the most value.

[2] Power Smart is BC Hydro's demand side management group, dedicated to helping BC Hydro meet its conservation targets. T&D, Generation, and Power Smart Business Units, as well as the Office of the Chief Information Officer, are the main technology consumers at BC Hydro.

4.2 The OCTO's Technology Management Practices

The 10 staff of the Office of the Chief Technology Officer monitor and advance a large and diverse portfolio of technologies. The portfolio is grouped into seven themes, which, at the time of this report, include 118 unique technology solutions. Many of these technologies are years, if not decades away from being of value to BC Hydro due to technological, commercialization or regulatory barriers. The portfolio includes technologies that affect the whole organization, such as enterprise information systems, as well as Business Unit specific solutions, such as remotely operated live-line robots for T&D Field Operations. The seven technology themes are:

- Automation & Control
- Energy Resources
- Power System Components
- Robotics & Tools
- Modelling, Analysis & Simulation
- End Use Technologies
- Information Technology & Telecommunications

The OCTO's activities generally fall into three categories: monitoring technology developments, facilitating demonstration or proof-of-concept projects, and assisting Business Units in implementing new technology solutions. The OCTO team uses a 'tech watch' process to continuously scan the environment for new technologies or technological developments to identify potential benefits or challenges to BC Hydro's operations. The OCTO monitors technologies as they advance to assess readiness for support or demonstration projects. Every two weeks the team meets to discuss potential opportunities for new or existing projects. In this meeting, a team member has the opportunity to present a 'one-pager' that outlines a mini-business case for new investment in a technology, summarizing information on the benefits, costs and strategic impacts of the project. The one-pager often includes information on potential or existing opportunities for joint funding with an external agency or internal Business Unit. The team discusses the project's value to the organization, and considers whether the technology needs help to reach the next level of maturity and whether the team has the ability to assist. At the end of the tech watch meeting, the team decides whether the technology is suitable for additional investment or should be put on hold until more information is available.

If the OCTO determines the technology is of value to BC Hydro, the next step is to determine the appropriate type of assistance. For early stage pre-commercial technologies, the OCTO may become actively engaged in the development of the technology to meet BC Hydro's needs. The OCTO can provide valuable expertise, helping companies and research groups identify the requirements for successful commercialization within the province of British Columbia.

As technologies progress, the OCTO may decide to help further the development of high value technologies by co-funding or facilitating a demonstration project. For pre-commercial technologies, the OCTO team sponsor writes a business case for a demonstration project and oversees project execution. The outcome of the project is used to confirm or adjust the technology's estimated value to BC Hydro and to further identify possible impacts to the organization. Demonstration projects test proof-of-concept in the field, assessing how the technology interacts with BC Hydro's system and identifying any required design modifications. Commercialized technologies may move to a pilot project if previous demonstrations indicate that the potential value to the organization is large. Pilot projects test the technology in real-world operations, on a small scale, to verify benefits and costs and identify the infrastructure required for organization-wide adoption. For technologies that are closer to being ready for adoption, the OCTO helps the Business Unit write a business case for a pilot project and assists in project execution. Successful pilot projects can be selected for full scale deployment. While technology solutions go through different development stages of initial identification, tracking, active engagement, demonstration, pilot and implementation, the OCTO does not have a stage-and-gate process to manage this technology lifecycle. Rather technologies advance as project opportunities present themselves, and there does not appear to be a structured plan to advance the most valuable technology solutions. However, while there is not a technology lifecycle stage-and-gate process, projects requiring a business case are subject to project lifecycle gate reviews at the completion of planning, initiation and definition stages.

As described in Section 4.1, the corporate Financial Approval Procedure determines the level of approval needed at the gate review. The OCTO has an annual budget of about $2 - 3 million, and the CTO can approve project costs of less than $500,000. The OCTO, similar to the other utility technology groups interviewed, leverages funding for demonstration projects as much as possible through partnerships with government organizations, universities, industry groups, other utilities, or other interested parties. Once the technology reaches the pilot stage, the Business Unit is typically the primary investor. As funding for different projects comes from various internal and external sources, it is difficult for BC Hydro to quickly ascertain its overall technology spending. BC Hydro and the OCTO do not appear to track the total level of investment in technology development across the organization.

4.2.1 Analysis

The benefits of the OCTO's technology management practices are that they are flexible and they work with the existing business processes within the company, such as the Financial Approval Procedure and project lifecycle business case requirements. However, there is no strategic plan for technology, no way of ensuring that overall investments in technology are being optimized to meet the organization's objectives, and no formal process for valuing and comparing technologies or weeding out low value projects. Without a strategic plan for investment in place, supported by consistent technology portfolio selection and evaluation processes, there is a risk that the technologies being pursued will be limited to those that the OCTO team are comfortable or familiar with, or those that seem exciting, at the expense of more valuable and strategically important initiatives. The literature review in Chapter 2 makes the case for a portfolio selection process that includes setting technology strategy in alignment with corporate objectives, rigorously valuing and comparing options, and choosing the optimal mix of projects to maximize current benefits while preparing for the future. The more sophisticated utility technology groups described in Chapter 3, specifically Utilities B and C, have established more formal technology management processes to ensure technology investment is optimized.

The OCTO team has been working to create a technology roadmap and a portfolio matrix tool to help guide technology planning and investment. These are still in development, and the OCTO needs to fine-tune the tools and develop business processes around the use of these tools to support decision-making. Section 4.3 will describe the current state of the OCTO's technology management tools at the time of this report.

Then Chapter 5: will assess where the tools can be improved to align with best practices identified in the literature review. Chapter 6: will recommend a comprehensive technology selection process that draws from technology portfolio management processes identified in the literature review and the external case studies.

4.3 The OCTO's Current Technology Selection Tools

The previous section identified three tools the OCTO currently uses or is developing to assist in technology selection: the one-pager, the technology roadmap and the portfolio matrix. The one-pager is a short summary of a new technology opportunity, and is used to document and communicate benefits, costs and other relevant information. Business cases are more formal and detailed versions of the one-pager, however are corporate tools and not OCTO-specific, and are therefore not included in the scope of this report.

The technology roadmap and the portfolio matrix tools are still in development at the time of this analysis. The technology roadmap shows each technology solution over a 30 year timeline, and, for high value, more mature technologies, sets timeline targets for business case identification, demonstration, pilot, and full deployment. The technology roadmap will help set technology strategy at the OCTO, and will be a valuable input into the selection process. However, the focus of this section is the portfolio matrix tool. The portfolio matrix tool was initially created to help assess the value of BC Hydro's existing technology portfolio during the 2011 Government Review. The OCTO would like to modify it so it can be used to support decision-making and portfolio selection. The rest of this section describes the existing portfolio matrix tool in more detail.

4.3.1 The OCTO's Portfolio Matrix Tool

The OCTO's portfolio matrix tool plots each technology in the OCTO's portfolio on a graph of 'value' versus 'time to begin realizing value'. A technology's value is determined by its impact on BC Hydro's performance measures. Eleven performance measures were grouped into seven categories of safety, reliability, customer satisfaction, conservation, environmental, economic development and financial criteria. The basis value for each performance measure was set equal to BC Hydro's actual fiscal 2010 results. A technology's potential impact on the basis value of each performance measure was assigned a rating from 0 (no significant or positive impact) to a maximum of 4. The rating system is best described through the following example.

Table 5: Valuation along Safety Performance Measures

Rating	4	3	2	1	0	
Performance Measure	**Value**					**F2010 Basis**
Severity (days lost to injury / 200,000 hours worked)	5	1	0.1	<0.1	No significant impact	18.8 days
All Injury Frequency (# of lost time injuries / 200,000 hours worked)	0.5	0.1	0.05	<0.05		1.2 injuries

Table 5 shows two measures that BC Hydro uses to evaluate its safety performance, Severity and All Injury Frequency. In fiscal 2010, BC Hydro's Severity performance was 18.8 days lost due to injury per 200,000 hours worked, and All Injury Frequency was 1.2 lost time injuries per 200,000 hours worked. According to the rating system above, a technology that reduces Severity by at least 0.1 days (rating of 2) and Frequency by a minimum 0.5 injuries (rating of 4) would be valued the highest rating, achieving an overall rating of 4 in safety. The rating scale is quasi-logarithmic so that each increase in the rating roughly relates to an order of magnitude difference in the value. Appendix B shows the values assigned to each rating for all 11 performance measures. The final value of each technology is determined by the top rating achieved in any category; for example a technology with a rating of 3 in reliability and a rating of 2 or 1 for all other categories will have a final overall value of 3.

For each item in the OCTO's portfolio, the OCTO staff (or other BC Hydro expert) most familiar with the technology estimated its value. Similarly, these experts estimated how long it would take before BC Hydro would begin to realize the value of a given technology. This time estimate is highly correlated to technological maturity and stage of commercialization, but also includes regulatory, social, and other factors that could hold back BC Hydro's adoption of a technology.

Figure 8 shows a plot of the OCTO's current pool of 118 technologies on the portfolio matrix. It should be noted that technologies rated at a value of 0 were removed from the data set. The variable associated with bubble size can be changed depending on the type of information needed. The size of the bubbles in this case represents the 'effort level', or resources, currently being applied to each technology, with larger bubbles indicating larger resource allocations. Colours can also be used to represent other variables, such as the strategic objective or Business Unit most impacted by the technology.

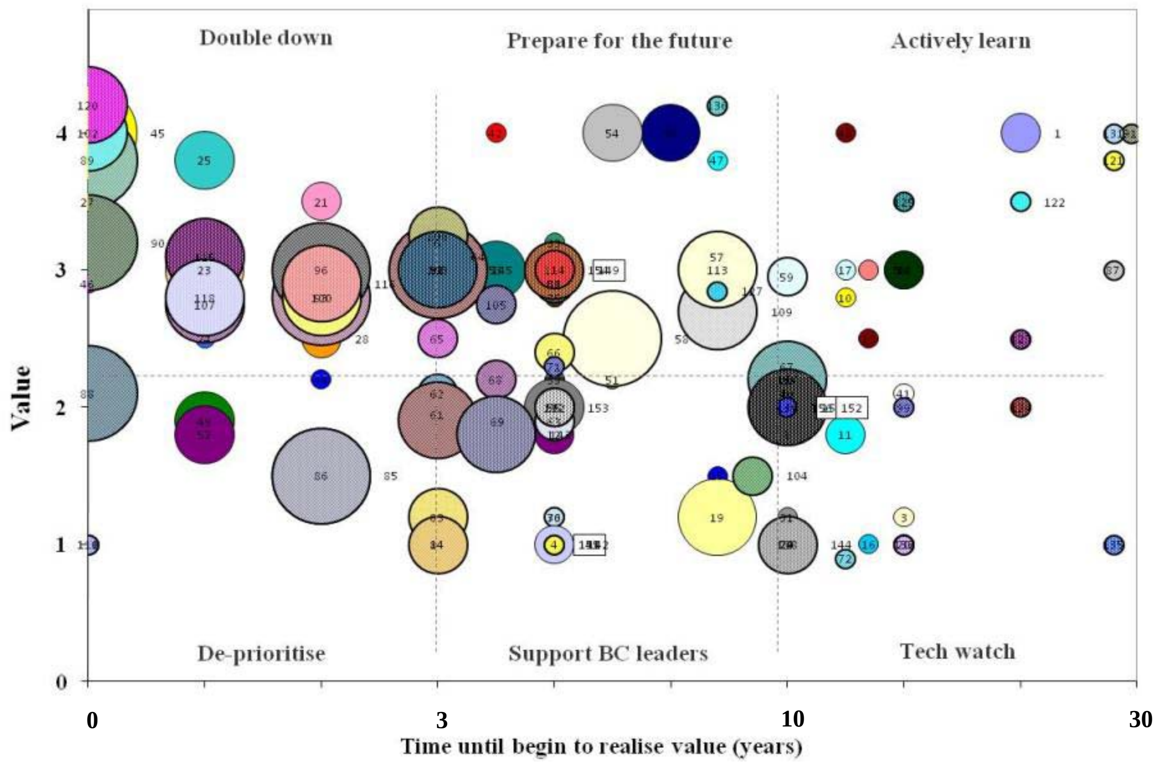


Figure 8: The OCTO's Technology Portfolio Matrix

The OCTO has grouped the portfolio matrix into six segments, dividing the horizontal time axis into 0-3, 3-10 and 10-30 year increments and the vertical value axis into high and low ranges. The strategy appropriate for the technology value and timeline is labelled on the graph. These strategies have not yet been finalized by the OCTO, but a brief description of each segment is provided here.

For Actively learn and Tech watch categories, technical, economic, regulatory, social and/or organizational barriers prevent the technology from being of use to BC Hydro for at least 10 years. The OCTO monitors these technologies for reduction or elimination of barriers. For technologies with the potential for high value (Actively learn segment) where BC Hydro is able to assist in removing obstacles, the OCTO may take a more active approach and offer strategic support.

For Prepare for the future and Support BC leaders categories, technologies have often been commercialized but have not yet been validated under operating conditions relevant to BC Hydro. At this phase demonstration or pilot projects are required to assess the benefits and challenges to integration and to test the business model for adoption. Lower valued technologies (Support BC leaders segment) of sufficient social value may receive very limited amounts of support such as access to BC Hydro expertise.

For the Double down and De-prioritize categories, the technology has few technical, market, or regulatory barriers to adoption at BC Hydro. Typically demonstration or pilot projects have been completed and the value to BC Hydro has been estimated with more certainty, with low value projects falling into the De-prioritize segment. BC Hydro might look to the high-value technologies for full-scale deployment. The OCTO's proposed technology development funnel is illustrated in Figure 9.

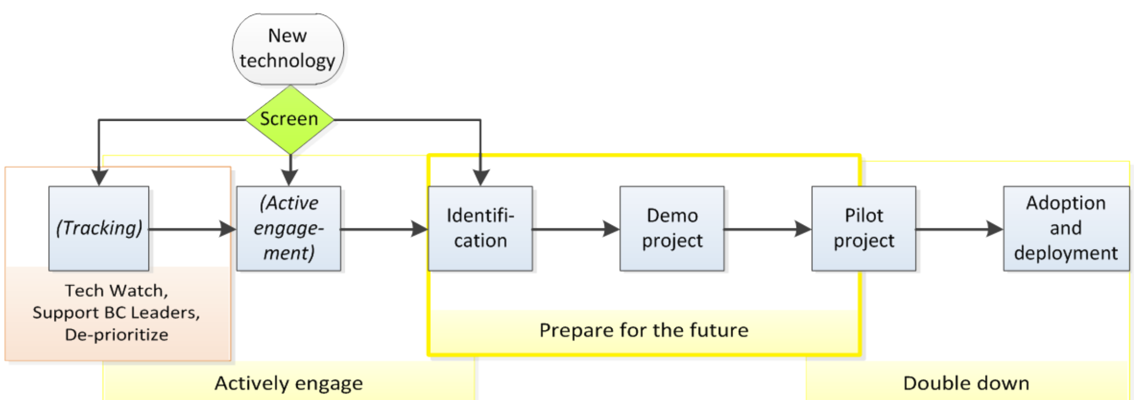


Figure 9: The OCTO's Proposed Technology Development Funnel

4.3.2 Analysis

The current technology portfolio matrix tool has a number of positive attributes that align with best practices in technology valuation and tool design as described in

Sections 2.3 and 2.4. It is able to equitably assess technologies along multiple competing strategic objectives through the development of a simple rating system. It is flexible but still offers a consistent way of evaluating technologies that vary widely in terms of technological maturity, scope and complexity. By avoiding the use of weighted formulas, decision makers can clearly identify which performance measure the technology impacts, improving the ability to balance the portfolio across strategic objectives. Valuation by performance measure aligns with SDM requirements as described in Section 4.1 and is a useful precursor to building a business case. Additionally the tool can be customized through the assignment of different bubble sizes and colours to enable the analysis of different variables, which is important in assessing portfolio mix. Presenting data in a graphical display, as opposed to using numbers or tables, promotes effective communication of the portfolio characteristics.

However the OCTO's portfolio matrix could be modified to incorporate some additional best practices in technology valuation and tool design described in the literature review. For example, valuation could be more consistent with corporate performance measures to ensure alignment with BC Hydro's strategic objectives. The portfolio matrix could be designed to integrate with additional tools that can assist in decision-making. And different valuation methods, supported by different tools, could be used at different stages of technological maturity. These potential improvements are discussed in the next Chapter.

5: Improving the OCTO's Technology Valuation Practices and Technology Selection Tools

This Chapter draws on the technology management literature reviewed in Chapter 2 to outline a number of improvements for the portfolio matrix tool, especially with respect to the valuation method employed. This chapter also describes how the portfolio matrix can be used in combination with other tools to assist in technology portfolio selection. Then Chapter 6: outlines a simple process that uses these tools and valuation techniques to select a technology portfolio that achieves the desired portfolio objectives of maximized value, strategic fit and portfolio balance.

5.1 Aligning Technology Valuation with Business Strategy

Technology valuation and selection must be informed by business strategy and objectives (Farrukh et al., 2004; Phaal et al., 2004; Meskendahl, 2010). For OCTO's portfolio matrix tool, it is essential that the seven valuation categories (safety, reliability, customer satisfaction, conservation, environmental, economic development and financial) be clearly linked to BC Hydro's strategic objectives. As described in the previous section, ratings for these categories are roughly based on performance measures taken from the Fiscal 2010 Annual Report. However, only eight of the 20 performance measures from the Annual Report are included in these ratings, and additional measures such as hazardous spill mitigation have been added. This inconsistency, as well as the fact that no internal consensus was sought as to the numeric values associated with each 0 to 4 rating, might lead to questions about the legitimacy of how technologies are valued during portfolio selection. Creating a better alignment of valuation to the performance measures will ensure that technology investment is helping BC Hydro achieve its strategic objectives. It will also help foster greater buy-in for and communication of the technology portfolio across the organization. Additionally, improving the rigor of the rating system and aiming for standardized interpretations of each category that are aligned with the most recent corporate performance measures will result in better valuation data and thus more effective decision-making.

As described in Section 1.1.1, BC Hydro recently updated its strategic objectives and associated performance measures. In Appendix C, the seven valuation categories used in the portfolio matrix are compared to the new performance measures outlined in BC Hydro's 2011/12 - 2013/14 Service Plan. For each category, the impact of any inconsistencies with the new plan is assessed. From this analysis, some suggestions for modifying this tool can be made. To overcome inconsistencies and improve the current valuation measures, the OCTO should add measures of Clean Energy (%), Winter Generation Availability Factor (%) and Billing Accuracy (%) to the categories of Environment, Reliability and Customer Satisfaction, respectively. Also the categories of Environment and Conservation should be combined. These potential improvements are discussed below.

In the 2010 Clean Energy Act, the provincial Government set specific Clean Energy targets. However many sources of clean energy require additional support and technological development before they are fully economical and fully functional with the electric grid. To help meet BC Hydro's Clean Energy targets, the OCTO is currently assessing and supporting many alternative energy sources and should continue to do so.

Clean Energy considerations should be added to the Environment category to reflect these activities.

The security of supply is an important utility concern, and is measured through the Winter Generation Availability Factor. Investment in capacity- or reliability-enhancing generation technologies is one of the most effective ways to improve this performance measure. The reliability performance measures currently included in the valuation ratings are more directly related to T&D technologies. At least one measure directly related to supply and the Generation Business Unit should be included in the valuation ratings.

There is only one performance measure in the Customer Satisfaction valuation category out of a possible four found in the Service Plan. The performance measure used, Customer Satisfaction Index or CSAT, is measured via customer surveys and reflects the percentage of customers who are 'satisfied' or 'very satisfied' with their overall interactions with BC Hydro. As the overall CSAT percentage is based on many different factors, it is difficult to accurately assess a technology's potential impact on this measure. A BC Hydro Customer Satisfaction performance measure that could be more directly correlated to technology investment is the Billing Accuracy measure. Also, as the CSAT has been high for a number of years, the CSAT ratings could be modified as "preventing a reduction in CSAT" as opposed to "improving CSAT".

In addition to including the three performance measures of Clean Energy, Winter Generation Availability Factor and Billing Accuracy, the categories of Conservation and Environment should be combined. The performance objectives associated with these two categories are already grouped together under BC Hydro's strategic objective "Mind our footprint". Trimming down the number of categories under evaluation from seven to six would help reduce some of the time needed in valuation and portfolio analysis.

If the ratings-based valuation method is to be used to make investment decisions and promote one technology over another, the OCTO needs to ensure that the numeric values associated with each 0 to 4 rating are fair and balanced. For example, the strategic impact of a reliability rating of 2 should be consistent with the impact of an environmental rating of 2. Since it is difficult to "compare apples to oranges", the OCTO might want to start by putting a financial value on each performance measure. SDM resources at BC Hydro offer some suggestions for how to do this. As many of these measures are difficult to value financially (for instance in the safety category), the OCTO's final ratings will not be completely objective. For these ratings to be accepted, the OCTO must meet with stakeholders to review all valuation performance measures and their associated ratings. The final ratings vetting should come from the technology steering committee, as they can best assess the relative values of the competing objectives. The stakeholder consultation process will help Business Units, executive decision makers, and the OCTO better understand the use of the valuation technique as well as its limitations. As a final note, if BC Hydro's performance measures change drastically, for instance in a new Service Plan, the OCTO should reassess its ratings.

5.2 Incorporating Additional Portfolio Selection Tools

The portfolio matrix tool alone is not sufficient to support decision-making (Phaal et al., 2006; Cooper et al., 2000). Other tools that complement the portfolio matrix, such as roadmaps, linked grids, and simple screens or checklists, can help form a better picture of the technology portfolio during the selection process. The previous chapter described the technology roadmap, the portfolio matrix, and the one-pager currently in use or in development at the OCTO. This section describes how the existing tools can be used, in combination with other tools, to help inform portfolio selection.

A technology roadmap forms the basis of the technology strategy for an organization, and thus helps informs the strategy for technology selection. The OCTO is currently developing a technology roadmap as described in Section 4.2. Aligning the roadmap with the same performance measure-based criteria used in valuation will ensure that the two tools can be used together more effectively. The roadmap can be used as a tool to understand and communicate technology timelines and plans, both during the selection process and afterwards when defending the prioritized projects. The roadmap is especially useful for identifying the key enabling projects and activities necessary to achieve BC Hydro’s long-term objectives. Enabling or foundational technology projects identified in the roadmap can be flagged for prioritization in the selection process.

Prior to detailed valuation, simple screens and checklists should be used as a way of weeding out technologies that are of low value or poor strategic fit. A checklist is also a useful way of incorporating ‘soft’, or highly qualitative, criteria in the OCTO’s technology evaluations. As described in the literature review (specifically in Table 3), valuation criteria such as organizational capability, supplier suitability and integratability should be considered along with traditional financial or technical measures. These qualitative considerations are difficult to include in the portfolio matrix tool rating system. However qualitative criteria may come into play when comparing different technology projects during portfolio selection, and a checklist is a useful way to document these benefits. The existing one-pager is a less structured template that serves the same purpose as a checklist. An example for a more structured checklist template is given in Appendix D. At the very least, a using a checklist prior to more detailed, time consuming valuation techniques ensures that the technology experts on the OCTO staff spend time only on the most valuable of the 100+ possible technology solutions. Again, checklist criteria should be aligned with the valuation measures used in the portfolio matrix so that projects can be easily compared.

When checking for portfolio balance, linked grids can be useful tools. Grid columns can represent the various strategic objectives, business groups, technology platforms, and so on. A moderately valued technology that spans multiple columns may be more worthwhile than a technology that has a very high value in only one specific area. Linked grids can also be used to check if the type of activity underway is appropriate for the value and time to realizing value. An example of this type of linked grid is given in Figure 10.

Grids can be linked together to show the relationships between different areas, as long as common axis values are used. The linked grid tool can be supported through simple Excel spreadsheets, filters and pivot tables. Analysis of linked grids will be most useful to the OCTO at later stages of portfolio structuring when assessing the appropriate mix and balance of projects to meet different objectives. The technology roadmap, portfolio matrix and linked grids can all be used together if common language is employed.

Time to realize value		Highest Rating						Technology (Energy Resource theme)	Current					By 2015				
		Safety	Reliability	Customer satisfaction	Conservation&Environment	Economic development	Financial		Monitor	Actively Engage	Demo	Pilot	Deploy	Monitor	Actively Engage	Demo	Pilot	Deploy
		Strategic Impact							Activity									
Time to realize value	0 - 3						2	Storage for diesel optimization				x					x	
	3 - 10				1			Emerging biofuels	x									
							1	Integrated power systems for remote assets	x									
						1		Distributed generation sources	x					x				
			2					Customer Energy storage systems	x									
					2			Emerging geothermal energy	x					x				
				3				Integrated renewable systems for remote communities			x						x	
			3					Community clean energy sources				x					x	
							3	Storage for distributed renewables integration			x						x	
							3	Substation energy storage systems			x					x		
							3	Storage for seasonal renewables			x					x		
							4	Community distributed energy storage systems			x					x		
	10 - 30				1			Algae						x				
					1			Next generation solar energy						x				
			2					Building scale solar or wind for DG						x				
					3			Emerging wind energy						x				
							3	Advanced energy storage systems		x					x			
						3		Fuel cells as distributed generation source		x					x			
					4			Marine renewable energy		x					x			
					4			Fusion		x					x			

Figure 10: Example of a Linked Grid

5.3 Adapting Valuation Methods to Technology Uncertainty

It is impractical and potentially inaccurate to use a single method of valuation across a range of technological maturities (Farrukh et al., 2009). With the large number of technologies on the OCTO's radar, rather than applying the rating system to all technology solutions, it is more suitable to adopt increasing levels of analytical rigour with increasing investment requirement or imminent feasibility. For example, a technology that is expected to have a moderate value impact to one of BC Hydro's business units in a decade's time should not be afforded the same level of analysis as one that is expected to produce substantial value to the whole organization within three years, and requires significant investment.

As described in Section 4.3.1, the time-based horizontal axis of the portfolio matrix is highly dependent on technological maturity, although other factors such as political and social barriers are also factors. The OCTO has divided the matrix into six segments of value and time, as shown in Figure 8. This Section proposes valuation strategies that are appropriate for projects within the six segments of the portfolio matrix. These strategies are summarized in Table 6; a more detailed description follows the table.

Table 6: Valuation Method by Portfolio Matrix Segment

<table>
<tr><th rowspan="2">Portfolio Matrix Segment</th><th colspan="2">Description</th><th colspan="2">Valuation method</th></tr>
<tr><th>Time to realizing value</th><th>Value</th><th>Preliminary valuation</th><th>If investment required is greater than…</th></tr>
<tr><td>Tech watch</td><td rowspan="2">> 10 years</td><td>< 2
Low</td><td rowspan="2">Use a checklist to assess value, cost, strategic fit, and organizational capability for a 'high' (Actively learn) or 'low' (Tech watch) valuation</td><td></td></tr>
<tr><td>Actively learn</td><td>> 2
High</td><td>$500k (CTO approval limit):
Use the valuation method for 'Prepare for the Future'</td></tr>
<tr><td>Support BC leaders</td><td rowspan="2">3 - 10 years</td><td>< 2
Low</td><td rowspan="4">Use the rating system developed for the portfolio matrix tool, assessing all categories and performance measure values on a scale from 0 to 4</td><td></td></tr>
<tr><td>Prepare for the future</td><td>> 2
High</td><td>$1M (business case required):
Develop a business case incorpor-ating SDM valuation techniques</td></tr>
<tr><td>De-prioritize</td><td rowspan="2">< 3 years</td><td>< 2
Low</td><td></td></tr>
<tr><td>Double down</td><td>> 2
High</td><td>$1M (business case required):
Work with the Business Unit to develop a business case incorpor-ating SDM valuation techniques</td></tr>
</table>

For technologies over 10 years from being of value to BC Hydro, a simple checklist summarizing potential value, cost, fit and organizational capability is a sufficient tool. A checklist can also be used at any stage of the technology lifecycle prior to a more detailed analysis, as described in the previous Section. The uncertainties involved when assessing a technology that will only become feasible 10 to 30 years in the future makes a detailed analysis impractical and imprecise. The existing one-pager should also meet the valuation requirements of this stage. Since the OCTO's level of investment in this stage of technology is typically low and the expected value so uncertain, the evaluation does not need to provide a specific numerical rating. Instead the checklist can simply describe whether the technology is of high or low value (Actively learn or Tech watch categories on the portfolio matrix plot in Figure 8). The OCTO should continue to actively monitor the readiness of the technology to move to the next stage, and whether the technology is suitable for levels of assistance of less than $500,000, which is within the OCTO's approval limit. The expert judgement of the relevant technology specialist is sufficient to make a high or low value assessment, but the OCTO team should still review the final valuation. If greater investment is being considered, the OCTO team should move to the next level of valuation. However the limitations and risks of valuing early stage technologies should be kept in mind when making large investment decisions.

For technologies that are ready for more significant investment from BC Hydro, the OCTO should use the 0 to 4 rating method developed for the portfolio matrix tool to assess value. During valuation the OCTO technology expert should solicit Business Unit input in order to get the corporate end users on board early and ensure that the OCTO's technology valuation is realistic. If the results of this more detailed valuation show that the technology would provide a high level of value to BC Hydro, opportunities for demonstration or pilot projects should be identified. For project costs exceeding $1 million, valuation must align with the tools and techniques established in SDM practices. At this point involvement from a sponsoring Business Unit may also be required. The OCTO can provide support for the valuation efforts driven by the Business Unit. Previous valuations using the rating method, supported by hard evidence from any previous demonstration projects, will provide constructive input into the business case.

6: Technology Portfolio Selection Recommendations

As described in Chapter 2, technology valuation is just one of three steps involved in technology portfolio selection. This chapter outlines a technology portfolio selection process that follows the three stages of setting technology strategy, individual project valuation, and portfolio structuring (Meskendahl, 2010; Archer & Ghasemzadeh, 1999). Setting technology strategy is addressed first as this strategy will inform technology valuation and portfolio structuring decisions. Then a process for valuing individual technologies and prioritizing a portfolio, based on a stage-and-gate methodology, is introduced. The enhanced valuation techniques and supporting tools described in Chapter 5 are used to support the selection process.

6.1 Setting Technology Strategy

Before individual technology valuation and portfolio structuring activities commence, it is necessary to clearly identify the objectives of the portfolio (Meskendahl, 2010; Archer & Ghasemzadeh, 1999; Farrukh et al., 2004). The three common objectives of portfolio management are maximized value, strategic fit, and portfolio balance. The organization must define for itself what these three objectives mean, taking into account both short-term and long-term goals. The first two objectives can be met through the considered development and use of valuation methods. The enhanced valuation techniques described in the previous Chapter are more aligned with corporate strategic objectives, and have been tailored to provide an appropriate level of rigor for the maturity and potential value of the technology investments under consideration.

However the technology portfolio must be more than the sum of its parts. The final prioritized portfolio must take into account not only the value and strategic impact of individual technologies, but also how the set of selected projects balance and complement each other. Without a strategy in place to guide portfolio mix, the impact of technology investments is reduced and the organization may find itself unprepared for the future (Mitchell & Hamilton, 1988).

Achieving optimal portfolio mix requires investment in a range of different types of projects. Portfolio balance considerations include the mix of activities across all strategic objectives, technology themes and Business Units, as well as the relative mix of project sizes, technological maturities, short-term versus long-term investments, and incremental versus radical technologies (Cooper et al., 2000; Meskendahl, 2010). BC Hydro should define how it will balance its technology investments across all of these categories. The specific distribution within each category will depend on BC Hydro's risk tolerance, short-term and long-term priorities, and external and internal pressures. However, underinvestment in one area may leave the company unprepared for sudden changes. Diversification reduces portfolio risk.

The technology roadmap offers a useful starting point for creating a technology strategy, and is also a good tool for assessing gaps in portfolio mix. The OCTO is developing the roadmap as a tool for identifying interdependencies between technologies, corporate strategic objectives and Business Unit needs, and communicating priorities and gaps to stakeholders. However the roadmap is still in development, and the OCTO is still determining how it will use the information to select and advance technologies. The OCTO should use the roadmap to help define targets for investment across the seven different technology themes (Automation & Control, Energy Resources, Power System Components, Robotics & Tools, Modelling, Analysis & Simulation, End Use Technologies, and Information Technology & Telecommunications).

BC Hydro must also identify and advance a mix of incremental and radical technologies so that it can respond to immediate operational needs while at the same time preparing for the future. One challenge for the OCTO team will be making a case for investment in radical, game-changing technology. Even though BC Hydro has a conservative, risk averse attitude towards the adoption of new technology, it still needs to be able to respond to external threats posed by radical innovation. The electric vehicle is an example of a game-changing technology that the OCTO has incorporated into its planning. It is important to keep scanning the environment and industry for significant game-changing technologies. A specific strategy for monitoring and responding to these technologies should be set to ensure that major technological opportunities and threats are on the OCTO's radar.

One approach for identifying both incremental and radical technologies, as practiced by Utility B in the utility case studies (Chapter 3), was to take both a top-down and bottom-up assessment of technology requirements. The top-down approach was based on the roadmap objectives, as described above, which includes technologies that are more radical and may be decades away from adoption. A bottom-up approach is focused on the immediate and medium term needs of the Business Units. The OCTO must identify and advance a constant stream of both short-term, incremental and long-term, radical projects in its technology development funnel, as illustrated in Figure 9 in Section 4.3. Using the six time- and value-based categories described in the portfolio matrix and comparing these to the resource allocations suggested by Mitchell & Hamilton (1988) and the utility case studies, funnel targets are proposed in Table 7.

Table 7: Proposed Technology Funnel Mix

	Description		**Funnel mix**	
Portfolio Matrix Segment	**Time to realizing value**	**Value**	**% of Total Number of Technologies in the Funnel**	**% of Overall Corporate Technology Investment**
Tech watch	> 10 years	< 2 *Low*	50	0 – 1%
Actively learn		> 2 *High*		5%
Support BC leaders	3 - 10 years	< 2 *Low*	35	0 – 1%
Prepare for the future		> 2 *High*		15%
De-prioritize	< 3 years	< 2 *Low*	15	0 – 1%
Double down		> 2 *High*		80%

While investment should heavily favor the higher value categories of Actively learn, Prepare for the future and Double down, it is important to continue to monitor the lower value technology solutions. If an area of the portfolio mix is lacking, targeted, low level investment in a lesser-value technology might improve overall balance. Although these technologies do not offer the big strategic gains of higher value options, they might still offer incremental improvements within a specific function or Business Unit. Portfolio balance requires a mix of small and large projects and, provided investment is small, lower valued technologies might help achieve this balance.

It should be noted that the final column in Table 7, % of Overall Corporate Technology Investment, assumes that BC Hydro tracks the total amount of money spent on technology development. From the internal analysis in Chapter 4, this did not appear to be true. It will be difficult for the OCTO to accurately assess portfolio balance and the overall effectiveness of its technology investments if the total level of technology spending is not tracked.

Table 7 only partly addresses a strategy for technology mix. The OCTO should evaluate the other measures of balance, including mix of activities by impact on strategic objective or Business Units, project size, risk level, and so on, to come up with targets within each theme as well as across the whole portfolio. The technology strategy should be approved by senior executive level management at BC Hydro and communicated to business groups that are involved in technology investment decisions (Farrukhet al., 2004). Only after a technology strategy is in place can the OCTO identify current gaps or over-commitments in resources using analytical tools such as the technology roadmap, portfolio matrix and linked grid. These analytical tools are also useful for communicating the technology strategy to stakeholders.

6.2 Stage-and-Gate Technology Valuation and Selection

The literature review identified the benefits of using a stage-and-gate process to structure technology decision-making activities. This finding was supported by the review of external utility technology management practices in Chapter 3. However both reviews revealed that in order for a stage-and-gate process to be successful, it must be flexible enough to provide the freedom required for technology development, and it must work with existing business processes. BC Hydro already has many processes and procedures that govern investment and guide decision-making, as described in the internal analysis in Chapter 4. A portfolio selection process for the OCTO should provide an overarching structure that ties different technology management activities together and allows for periodic assessment to ensure overall value and strategic alignment.

The process that offers a best fit for the OCTO's requirements is similar to that proposed by Cooper et al. (2000), where the existing, project lifecycle-oriented stage-and-gate process required through the SDM practice described in Section 4.1 is supplemented by portfolio assessment one to two times each year. Thus the next two Sections propose a stage-and-gate process that uses the valuation and selection tools described in Chapter 4.3, and a process for periodic portfolio review and adjustment.

The stage-and-gate process map is shown in Figure 11. The stage-and-gate process is designed to be used at any of the six phases of the technology development funnel (Tracking, Active engagement, Identification, Demonstration project, Pilot project, and Adoption & deployment) as illustrated in Figure 9. The level of analysis and preparation at each stage, and the level of scrutiny and rigour at each gate, will increase as the technology moves through the funnel phases and required investment increases. At any gate, the technology can be moved to the next stage, put on hold until more information is gathered, or shelved until conditions change that may make it more valuable to BC Hydro.

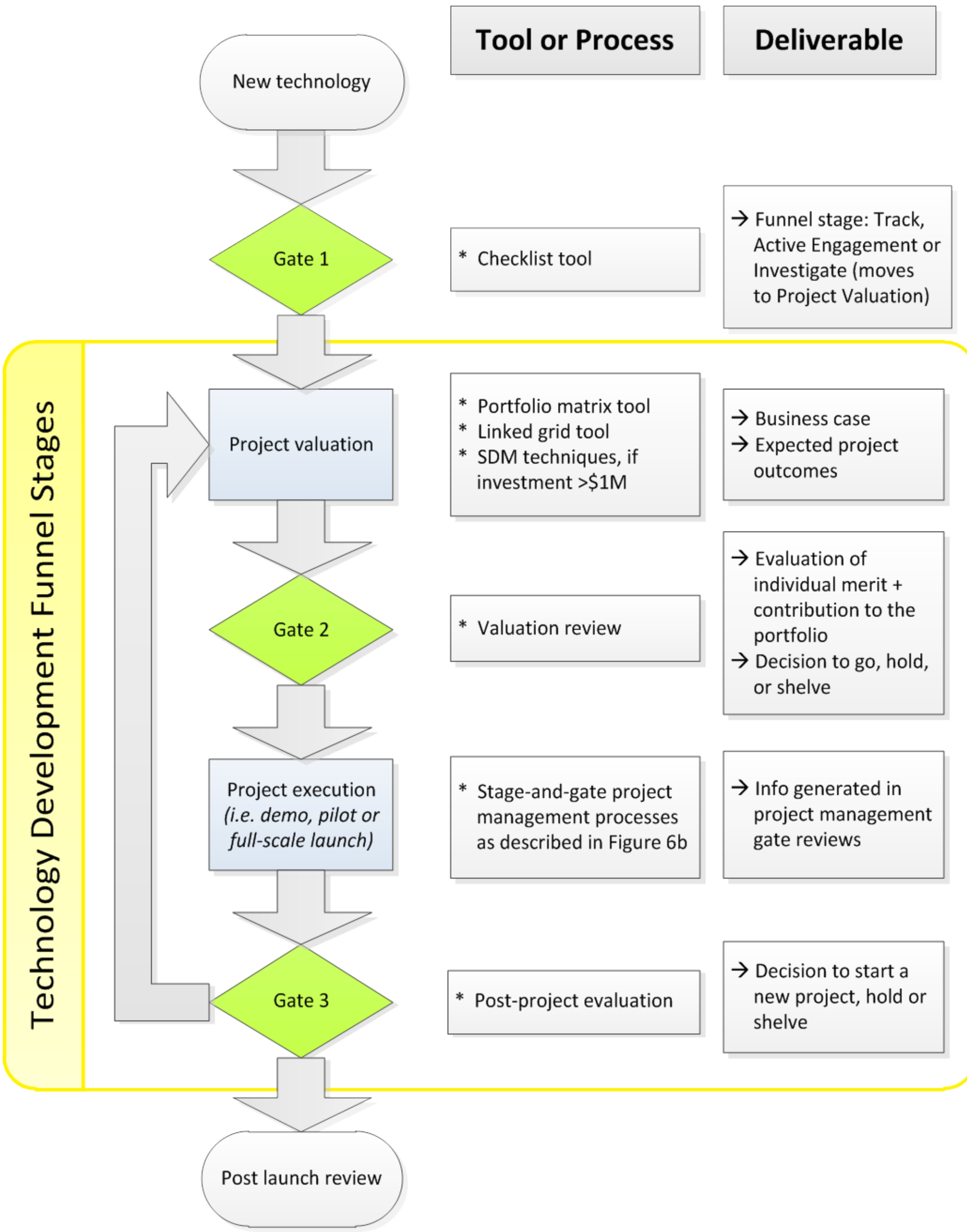


Figure 11: Stage-and-Gate Technology Selection Process

The technology selection stage-and-gate process outlined above is initiated when a new technology solution is identified by the OCTO staff through their networks or scanning activities and introduced into the technology development funnel. The technology may be at a very early stage of technological maturity, or it may be only a few years from being ready for adoption. At Gate 1, the checklist described in Section 5.2 and presented in Appendix D is used to assess the potential value to the organization. Based on the approximate value and time to realizing value, the gate review will allocate the technology to the funnel phase of Tracking, Active engagement or Investigation. The checklist can be used with or without an actual project at hand. If the checklist indicates that the technology is of potential high value to BC Hydro, the OCTO should look for a project opportunity to test the benefits and advance the development of the technology through the funnel. The checklist should be completed by the relevant OCTO technology expert and reviewed by the OCTO team at the regular tech watch meeting.

Technologies in the Investigate funnel phase should move to the next stage of Project Valuation for more detailed and rigorous assessment. As described in Table 6, for a technology more than 10 years from realizing value, the checklist is enough to assign a ‘high’ or ‘low’ valuation, moving the technology into the funnel phase of ‘Active engagement’ or “Tracking’ respectively. Unless a project costing more than the OCTO’s approval limit of $500,000 is being considered, the more detailed Project Valuation stage of the process above is not required.

In the Project Valuation stage, the technology should be valued using the 0 to 4 rating method developed for the portfolio matrix and described in Section 4.3. Depending on the level of investment, a formal business case, supported by SDM analysis, may be required. **In addition to the evaluation of the technology solution on its own merits, the project should be assessed on its contribution to the technology portfolio strategy.** The portfolio matrix and linked grid tools can be used to visualize the position of the technology in relation to the rest of the portfolio. At Gate 2, the valuation review, the business case is analysed to see how it contributes to the portfolio objectives of maximized value, strategic fit and portfolio balance, as defined in the technology portfolio strategy described in Section 6.1. The portfolio matrix and linked grid tools can help assess how the project contributes to the portfolio mix. Linked grid assessment can also reveal projects that enable or otherwise impact other technology solutions. If the OCTO is not the final project approver, the team can help make the case for investment in projects that contribute to the overall value, strategic fit, and balance of the portfolio. Likewise if the technology does little to add to the overall portfolio, the team can recommend that the project be shelved and tracked until the value proposition to BC Hydro improves.

Projects that are approved continue on to the next stage of Project Execution. In this stage internal project management processes take over as the project moves from planning to progressive stages of definition, implementation, and closeout, as described in Figure 6b in the literature review. The SDM-mandated gate reviews at each stage generate additional, and progressively more detailed, analyses of value and strategic impact. After the project has been completed, Gate 3 evaluates the success of the project in achieving its objectives. These project-specific objectives were outlined as a requirement of the business case and measure the technological and strategic impacts of the technology. The OCTO can decide in this review whether the technology: should continue on to the next funnel phase (i.e. pilot stage or organization-wide launch), should repeat the same phase under different conditions to obtain more information, or should be shelved until any barriers (technological, market, social, regulatory) are lifted.

As can be seen in Figure 11, if at the end of Gate 3 another project is recommended, the stage-and-gate process cycles back through Project Valuation and Project Execution stages. This can be repeated as many times as is necessary as the technology moves through the funnel towards eventual adoption and deployment. It should be noted that Gate 3 can be compared to the gates of a traditional R&D stage-and-gate process that aligns with the technology development funnel, such as the one illustrated in Figure 6a.

6.3 Technology Portfolio Review

If the stage-and-gate selection process described above is working correctly, the most valuable technologies should be moving through the technology funnel. This is due to the built-in consideration of portfolio impact at the Gate 2 review. However, a periodic portfolio review can help ensure that the stage-and-gate process is effectively promoting the best mix of projects, and that no areas are under- or over-invested (Cooper et al., 2000).

A Technology Portfolio Review should be conducted at least once a year, or after significant changes to the organization such as a new service plan or new directive from the government. The CTO leads the Review. Before the Review can begin, the CTO and the OCTO team must reevaluate the technology strategy (see Section 6.1: Setting Technology Strategy) and decide if any adjustments need to be made. Significant changes to the technology strategy should be approved by the Technology Steering Committee.

Once the technology strategy has been reviewed, the entire portfolio of technology solutions should be evaluated. This includes technologies that have not received OCTO support due to low value ratings. If the technology has not recently been valued, then the relevant OCTO technology specialist should complete a valuation using the appropriate technique described in Table 6. When all the valuations are up to date, the entire portfolio can be displayed on the portfolio matrix tool, with bubble size representing total investment to date. Low value technologies that have received high levels of investment should be flagged for further review. High value technologies that have not received any investment should be put on a priority list to find suitable projects.

The OCTO team evaluates whether the current investment has adequately achieved the targets of the technology portfolio. Each parameter of technology mix (i.e. project size, strategic objective, radical technology) should be assessed to see if the technology strategy targets are being achieved. Different portfolio matrix views that show specific areas of interest, such as impacted Business Unit or technology theme, can help assess whether the portfolio is maximizing value, fit, and balance. The linked grid tool can reveal more detailed breakdowns of portfolio balance.

If the OCTO discovers that an area is out of balance, it can look for ways to adjust the portfolio until it meets all the targets of the technology strategy. Say, for example, the portfolio has many active projects impacting the reliability category, to the point where additional investment in new technologies produces diminishing returns. The OCTO could decide to de-prioritize select reliability-oriented technology solutions such as those with lower values, those that do not enable other technologies, or those that do not offer many other strategic benefits. Or say a certain theme is in danger of not meeting its long-term technology roadmap goals due to under-investment the in early phases of the technology funnel. To help achieve the targets, the OCTO could decide to add extra resources to supporting ‘Actively engage’ solutions within that theme.

This assessment and adjustment process continues until the OCTO team is satisfied that the portfolio objectives have been met. The CTO then approves the list of adjustments. If major changes need to be made, especially those that impact other Business Units, the CTO should review the portfolio adjustments with the Technology Steering Committee and communicate the reasoning for changes with the impacted stakeholders. The OCTO team is responsible for ensuring that the required adjustments are made. The Technology Portfolio Review process is outlined in Figure 12.

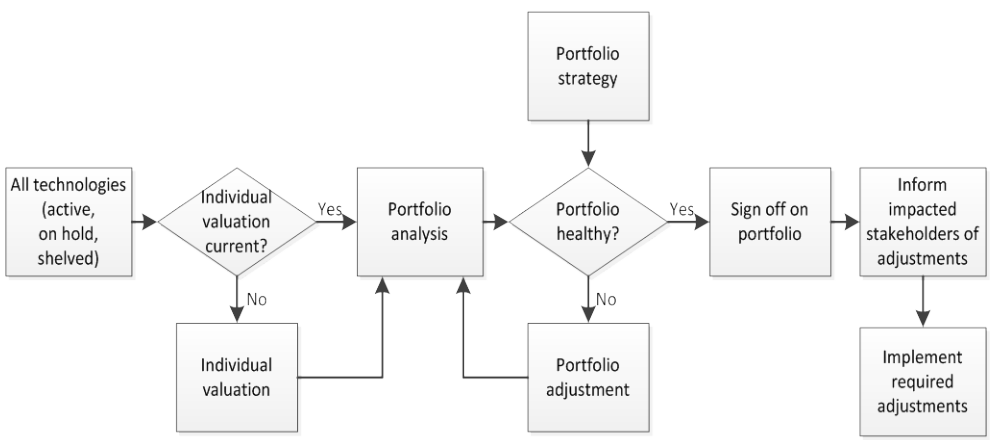


Figure 12: The Technology Portfolio Review Process

7: Conclusions

This report evaluated the OCTO's current practices and compared these to relevant academic literature and the technology management practices at other utilities, with a focus on technology portfolio selection processes. Based on these reviews, the following actions are recommended for the OCTO to improve its selection practices.

The OCTO should develop and communicate a technology strategy outlining how BC Hydro will maximize its technology portfolio investments to achieve the objectives of high value, strategic fit, and portfolio balance. This strategy should be drawn from the technology roadmap and the needs of the different Business Units, and should inform technology valuation and portfolio structuring processes. Technology project selection should follow a stage-and-gate approach, as described in Figure 11, that considers individual project value as well as impact on the entire portfolio.

The OCTO should use a range of analytical and communication tools to support decision-making, including the roadmap, portfolio matrix, linked grid, and checklist tools as described in Chapter 5. The rigor of individual valuation should be appropriate for the time to realizing value and level of investment required. To ensure that the portfolio is aligned with the technology strategy, the OCTO team should hold an annual or semi-annual portfolio review meeting to identify any required portfolio adjustments.

7.1 Going Forward

Technology selection is just one part of an integrated technology management process that includes identification, selection, acquisition, exploitation and protection (Lamb & Gregory, 1997). Technology selection, the focus of this report, is not a distinct process but is impacted by and in turn impacts other technology management processes.

A key feature of technology management practices are that they are integrated into existing business processes (Phaal et al., 2004). The selection processes outlined in Chapter 6 are designed to work with existing practices within BC Hydro. However for technology management to be successful, technology considerations must also be embedded in Business Unit and corporate business processes such as setting strategy and resource planning. As the OCTO continues to advance and refine its technology management activities, it should assess its other practices as well as the corporate and business unit processes "to form a technology management system that is coherent and integrated across and beyond specific business processes and activities" (Phaal et al., 2004).

Appendices

Appendix A: BC Hydro's 2011/12 - 2013/14 Service Plan Performance Objectives

Table 8: Performance Measures per Strategic Objective

Strategic Objectives	Guiding Principles (Used prior to F2012)	Performance Measure	F2010 Actual	F2011 Target	F2011 Actual	F2012 Target
Safely keep the lights on	Safety	**Zero Fatalities and Serious Injuries** *# fatalities or injuries*	2	1	1	0
		Severity *# days lost to injury / 200,000 hours worked*	18.8	20	22.2	17
		All Injury Frequency *# injury incidents / 200,000 hours worked*	1.2	1.3	1.7	1.5
	Reliability (Customer)	**CAIDI (hours)** *# interrupted hours / interrupted customer*	2.28	2.15	2.20	2.35
		SAIFI (frequency) *# interruptions / customer / year*	1.52	1.22	1.49	1.50
		CEMI-4 (%) *% customers with 4+ outages*	13.09	8.00	13.56	12.00
	Electricity Security (Supply)	**Winter Generation Availability Factor (%)** *% units >20MW available for generation*	97.6	96.4	94.4	96.4
Succeed through relationships	Customer Satisfation	**Customer Satisfaction Index (%)** *% satisfied or very satisfied*	90	83	89	83
		Billing Accuracy (%) *% accurate*	98.5	98.2	98.5	98.2
		First Call Resolution (%) *% resolved*	74	71	73	71
		Progressive Aboriginal Relations Designation *Bronze / silver / gold*	silver	silver		silver
Mind our footprint	Energy Conservation & Efficiency	**Demand Side Management (GWh)** *Cum. gigawatt hours/year savings since 2008*	1,778	2,300	2,348	3,500
	Climate Change & Environmental Impact	**Electricity Production GHG Emissions (CO_2e kt)** *CO2-equiv. kilotonnes from electricity generation*	1,318	1,000		860
		Carbon Neutral Program Emissions (CO_2e kt) *CO2-equiv. kilotonnes from building & vehicle use*	30	30		29
		Clean Energy (%) *% from clean/renewable resources*	93	93	95	93
Foster economic development		**Performance measure tbd in F12** *(will include direct and indirect impacts on provincial GDP and job creation)*				
Maintain competitive rates	Financial	**Competitive Rates** *Quartile of North American utilities*	1st	1st		1st
		Net Income ($ mill) *$ millions*	447	569	589	611
		Operating Costs ($ mill) *Includes personnel expenses, materials & external services, included in income, less recoveries & capitalized costs*	785	830	788	908
		Debt to Equity *ratio*	80/20	80/20	80	80/20
Engage a safe and empowered team	People	**Employee Engagement (%)*** *% engagement*	62	n/a	n/a	62

* As a result of the integration of BCTC to BC Hydro in July 2010 and Government Review of BC Hydro in the spring of 2011, the full company-wide employee engagement survey process has been deferred until the fourth quarter of fiscal 2012

Appendix B: The OCTO's Technology Portfolio Value Ratings

Table 9: Rating Valuation by Performance Measure

	Rating*	4	3	2	1	0	
Category	**Performance Measure**	**Value**					**Basis**
Safety	Reduction in **Injury Severity** (days lost / 200k hours worked)	5	1	0.1	<0.1	No significant impact	18.8 days
	Reduction in **Injury Frequency** (injuries / 200k hours worked)	0.5	0.1	0.05	<0.05		1.2 injuries
Reliability	Reduction in **CAIDI** (interruption hours / customer)	20mins	5 mins	1 min	<1 min		2.28 hrs
	Reduction in **SAIFI** (interruptions / customer / year)	0.2	0.05	0.01	<0.01		1.52 interr.
Customer Satisfaction	Increase in **Customer Satisfaction Index** (% satisfied or very satisfied)	10	2	0.5	<0.5		90 %
Conserv -ation	Increase in **Demand Side Management** (GWh conserved / year)	250	50	5	<5		50 TWh
Environment	Reduction in **GHG Emissions** (TCO_2e reduced / year)	100k	20k	2k	<2k		
	Impact on **Significant Hazardous Spills**	Avoided	Mitigated	Facilitate adaption / clean up	N/A		N/A
Economic Dev'ment	Impact on **Provincial Economy**	Create X jobs	Tech company relocates	Attracts grants >$1m	Attracts grants <$1m		N/A
Financial	Reduction in **Operating Expenditure** ($ annual)	5m	1m	100k	<100k		$720m
	Reduction in **Capital Expenditure** ($ one time)	50m	10m	1m	<1m		$2.4b
Other	Impact of comparable magnitude against another BC Hydro strategic target (e.g. land usage, First Nations relationships, etc)						

* The rating assignment indicates that there is a plausible scenario in which the technology/initiative in question has *at least* the associated impact. Where possible, values are measured as *net* of costs.

Appendix C: Analysis of Value Ratings

Table 10: Portfolio Matrix Valuation Compared to BC Hydro's Performance Measures

Category	**Consistent with F2012 Performance Measures**	**Inconsistent with F2012 Performance Measures**	**Impact of Inconsistency (Low, Medium, High)**
Safety	Includes *Severity* & *Frequency* measures	Omits *Fatalities/Serious Injuries* measure	**Low** – these 2 measures are adequate to value safety.
Reliability	Includes *CAIDI* & *SAIFI* measures	Omits *CEMI-4* measure	**Low** – these 2 measures are adequate to value customer reliability, although technology investment can also improve CEMI-4 results.
Customer Satisfaction	Includes *Customer Satisfaction Index* (CSAT) measure	Omits *Billing Accuracy*, *First Call Resolution* & *PAR Designation* measures	**Medium** – the correlation between a technology and CSAT is difficult to assess. Billing Accuracy is more directly impacted by technology use and would be a more appropriate performance measure.
Conservation	Includes *Demand Side Management* measure	The value basis (50 TWh) of the conservation measure is not related to BC Hydro's performance measure target (1,778 GWh in 2010).	**Medium** – values should be clearly linked to an internal basis to ensure consistency and objectivity in valuation. If a value other than the BC Hydro performance measure is used, this should be clearly explained.
Environment	Includes *GHG Emissions* measure	GHG emission objectives are separated into *Electricity Production-* and *Carbon Neutral Program-related Emissions*	**Low** – one measure is adequate.
		The value basis of the emissions measure is not given	**Medium** – values should be linked to an internal basis (such as the 2010 target of 1,348 kt CO2e) to ensure consistency and objectivity.
		Omits *Clean Energy* objective	**High** – a significant portion of BC Hydro's clean energy targets, especially in the long term, will be enabled by investment in clean energy technology. This should be included in the ratings system.

		Includes *Significant Hazardous Spills* measure	**Medium** – this is not included in BC Hydro's performance measures. Its inclusion may be a point of contention during portfolio selection. Also values associated with this measure are qualitative, whereas all other measures are quantitative.
Economic Development		Includes economic development measures even though these have still not been released at BC Hydro	**Medium** – measures should be updated when BC Hydro sets internal objectives.
Financial	Includes *Operating Cost* measure	Includes *Capital Expenditure* measure	**Low** – capital costs are a better reflection of the financial impact of a technology than the omitted measures.
		Omits *Net Income, Debt to Equity* & *Competitive Rates* measures	
		The value bases of the financial measures are not clearly related to BC Hydro's performance targets. For instance 2010 Operating Costs were $785M, not $720M.	**Medium** – values should be linked to an internal basis to ensure consistency and objectivity in valuation. This is especially important for financial values, as described previously in this section.
Other		Omits *Employee Engagement* measure	**Low** – the correlation between technology and employee engagement is low.
		Omits electricity security measure *Winter Generation Availability Factor*	**High** – security of supply is an important utility concern and can be directly impacted by technology investment. At least one measure related to supply should be included in valuation.
		Includes the option to include additional strategic considerations such as land usage, First Nations relations, etc	**Low** – while this category is not linked to specific internal measures, it can be used if accompanied by a detailed description of the benefit to BC Hydro.

Appendix D: Technology Checklist

Technology Solution:		**Date:**	
OCTO sponsor:		**Relevant BU:**	
Technology Theme:		**Years to realizing value:**	
Description:		**Enabling Technology?** ☐ Yes ☐ No	

Strategic Impact

Category	**Potential Value ***	**Comments**
Safety	☐ High ☐ Low	
Reliability	☐ High ☐ Low	
Customer Satisfaction	☐ High ☐ Low	
Conservation & Environment	☐ High ☐ Low	
Economic Development	☐ High ☐ Low	
Financial	☐ High ☐ Low	
Overall strategic value	☐ **High** ☐ **Low**	

Project Benefits (if project is being considered)

- ☐ Strengthens strategic relationships
- ☐ Utilizes / builds key organizational competence
- ☐ Builds on / complements ongoing technology projects
- ☐ Aligns with other regulatory / shareholder interests
- ☐ Other

Comments:

Potential Risks

- ☐ Safety
- ☐ Reliability
- ☐ Environmental
- ☐ Financial
- ☐ Reputational
- ☐ Other

Comments:

Costs & Resources (if project is being considered)

Estimated project costs:	
Estimated resource requirements:	
Joint funding opportunities:	

Recommended Action

- ☐ Proceed with project
- ☐ Hold for more information
- ☐ Not attractive at this time

Comments:

*** Example Baselines for 'High' Potential Value**	
Category	**Performance Measure at a Rating of 3 or higher**
Safety	• Reduces **Injury Severity** by ≥ 1 day lost / 200k hours worked • Reduces **Injury Frequency** by ≥ 0.1 injuries / 200k hours worked
Reliability	• Reduces **CAIDI** by ≥ 5 interruption minutes / customer • Reduces **SAIFI** by ≥ 0.05 interruptions / customer / year • Improves Winter Generation Availability Factor by ≥ 1%
Customer Satisfaction	• Prevents a decrease in **CSAT Index** of ≥ 2% • Improves **Billing Accuracy** by ≥ 0.2%
Conservation & Environment	• Increases **Demand Side Management** by ≥ 50 GWh / year • Reduces **GHG Emissions** by ≥ 20 kt CO_2e / year • Increases **Clean Energy** by ≥ 1%
Economic Development	• Creates ≥X jobs per year
Financial	• Reduces **Operating Expenditure by** $ 1 million • Reduces **Capital Expenditure** by $ 10 million

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