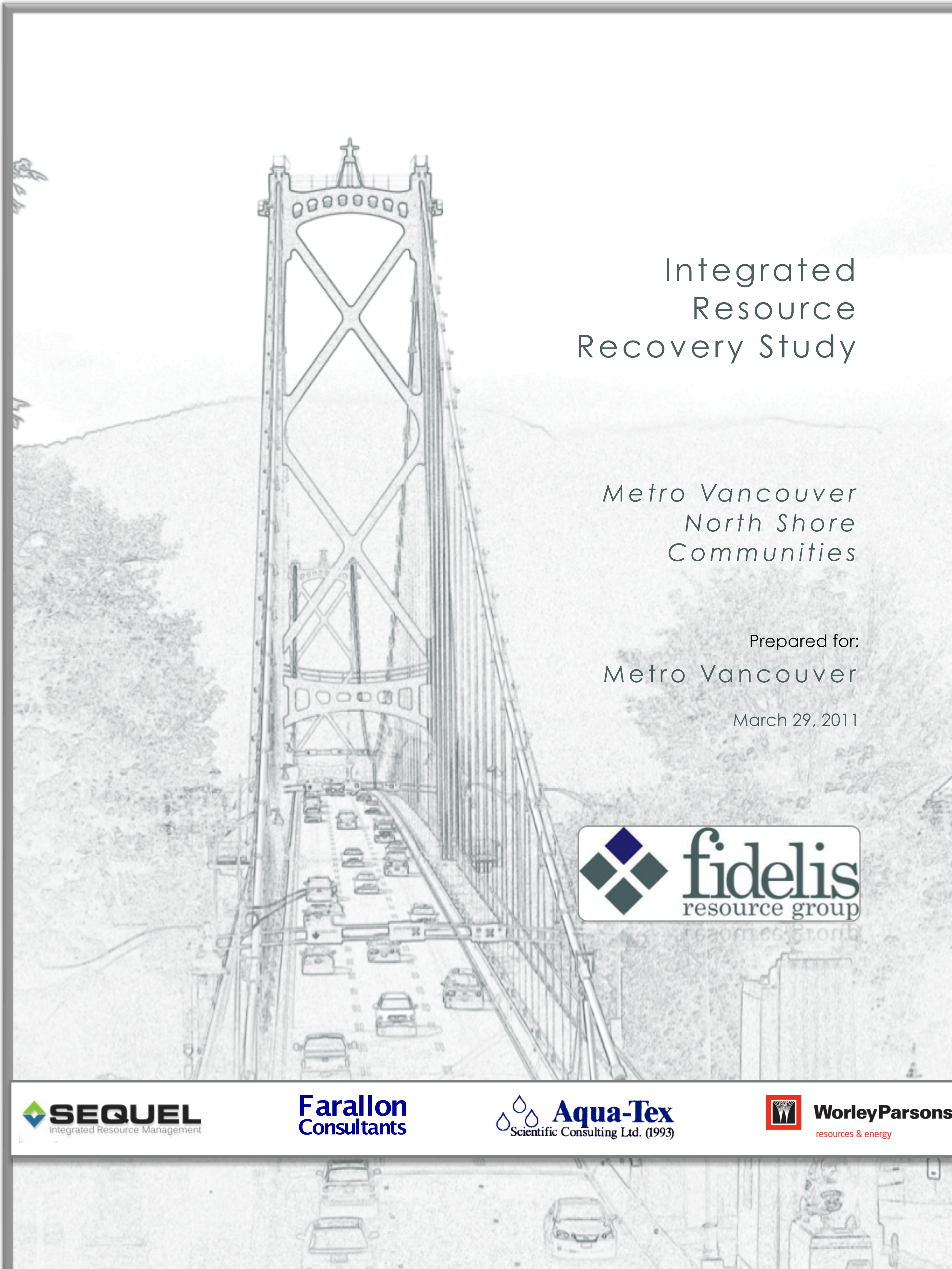

Integrated Resource Recovery Study

Metro Vancouver North Shore Communities

Prepared for:

Metro Vancouver

March 29, 2011

fidelis resource group

SEQUEL Integrated Resource Management

Farallon Consultants

Aqua-Tex Scientific Consulting Ltd. (1993)

WorleyParsons resources & energy

Mr. Fred Nenninger
Division Manager, Regional Utility Planning
Policy Planning Department, Metro Vancouver
4330 Kingsway
Burnaby B.C. V5H 4G8

March 29, 2011

Dear Mr. Nenninger

NORTH SHORE INTEGRATED RESOURCE RECOVERY STUDY

We have pleasure in submitting our final report of how Integrated Resource Recovery may be implemented for Metro Vancouver's North Shore. We also provide separately a Technical Appendix to the study, which provides supportive detail on our conclusions as well as our analytical methods and sources of information.

In this final report, we have responded to the comments on the draft report received from Metro Vancouver and the North Shore municipalities as well as at the workshop organized by the District of North Vancouver held on January 21, 2011.

As analysed in the report, IRR for the North Shore is entirely consistent with Metro Vancouver's liquid and solid waste plans and its Sustainability Framework. We also conclude that the preferred IRR Scenarios are superior to alternatives, and IRR is therefore recommended.

A final decision on IRR should be based on a number of further steps. We recommend that the first step is the development of a work plan to assess in more detail, opportunities for phasing the development of IRR and assessing the risk elements highlighted in our report. We also feel that an assessment of governance options for procuring IRR should be included in this initial phase.

We commend Metro Vancouver in having the vision to support IRR in its plans and to shift to an integrated design for future infrastructure for liquid and solid waste management in the Region. We encourage Metro Vancouver to pursue these goals with vigour and purpose.

We appreciated the opportunity to undertake this work over the past year. We have benefited from Metro Vancouver's commitment to IRR throughout this project.

Should there be any further questions or clarification required please do not hesitate to contact us.

Yours truly,

Dr. Jon O'Riordan
Fidelis Resource Group Inc.

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1 Executive Summary

Metro Vancouver proposes to implement resource recovery from both liquid and solid waste streams consistent with its solid and liquid waste management plans. The existing Lions Gate wastewater treatment plant must be compliant with new Federal environmental standards by 2020, and at least 70% of all solid wastes must be diverted from landfills by 2015. Fidelis Resource Group was thus asked to evaluate opportunities for Integrated Resource Recovery ("IRR") from organic solid and liquid wastes on the North Shore.

IRR integrates economic, ecological and social values associated with recovering energy from waste. In an IRR approach, energy recovered from treated wastewater and organic solid waste could be distributed through a district energy system serving the main population centres of the North Shore. Electricity would also be generated from a gasifier and sold to BC Hydro; treated wastewater would be reused to enhance the ecological health of creeks and wetlands, nutrients would be recovered, and the water recycled. Other resource benefits include the potential to displace fossil fuels, reduce Green House Gas emissions, and reduce NO_X emissions.

Several IRR scenarios were evaluated:

- Distributed wastewater treatment plants combined with solid waste management (Scenario 1);
- A centralized wastewater treatment plant also combined with solid waste management (Scenarios 2-5).
- Wastewater treatment alone with heat and biosolids recovery without solid waste management (Scenario 6);

The recovered resources would be sold, generating new revenues for government to help pay for capital and operating costs of waste treatment and resource recovery infrastructure. Fourteen potential new revenue streams were reviewed to reduce taxpayer cost.

Implementation of IRR requires a new approach to designing urban infrastructure, its governance and its procurement. This report outlines the business case for this new infrastructure.

The main conclusions are:

- All six resource recovery scenarios are financially superior to wastewater treatment alone. The best four scenarios combine centralized wastewater treatment at McKeen Avenue with an integrated energy centre for processing organic solid waste at the Maplewood Industrial park.
- A single treatment plant and high solid waste diversion volumes outperform distributed treatment plants and low diversion rates. In other words, progress towards zero waste minimizes tax burden and maximizes value. It also reduces impact on the environment.
- A 50-year life cycle valuation was assessed. In total, the preferred IRR Scenarios are projected to generate between \$2.8 and \$3.2 billion in new revenues, but will require additional capital and operating expenditures. The revenue for the best performing Scenarios has the potential to exceed the additional cost however.
- For the best scenarios, it may be possible to yield dividends to the taxpayer from IRR, after tax-based support to fund initial capital costs. Since liquid waste treatment is currently fully taxpayer supported; this is a significant change.
- The Triple Bottom Line analysis indicates that the best financial model, Scenario 4, is not preferred. Scenario 4 requires that some organic waste will continue to be transported to the North Shore from other parts of Metro Vancouver. This increases risk and is considered inequitable once IRR is implemented elsewhere in Metro Vancouver to generate revenues for those communities, *e.g.* in Vancouver and Burnaby.
- The preferred model is Scenario 3, which is based on 90% diversion of all solid organic waste on the North Shore. The dividend after finance over a 50-year projection is estimated in the order of \$44million (2010 constant dollars, after finance). As it takes time for revenues to be generated, initial taxpayer support for the North Shore is estimated at ±\$177 per residence per year, with an annual average of ±\$41 per residence in the short term. Replacing Lions Gate treatment plant with resource recovery provides revenue that offsets treatment plant costs over the 50-year projected life cycle.
- Solid waste is the dominant contributor to generating revenues which are used to offset the costs of resource recovery from liquid waste. We project it will be approximately \$108m cheaper (2010 constant dollars, after finance) for the taxpayer if separation and diversion of organic solid waste can be increased from an average of 70% to 90% to help meet Metro's goal of moving towards zero waste.
- For the preferred scenarios, IRR has the potential to reduce greenhouse gas emissions by 23-27% below 2007 levels for the North Shore.

- Initially approximately 10% of water can be recycled, with capacity for further savings. This has potential ecological benefits in supporting ecosystem rehabilitation through demand reduction and potential for stream, wetland, and ecosystem enhancement.

Our main recommendations are therefore:

1. Implementation of the IRR systems approach presented in this report should be approved in principle and pursued in a number of incremental steps.

2. The first step is for the North Shore municipalities, in conjunction with the First Nation Bands, Metro Vancouver, and the Province, to develop and implement a work plan that examines opportunities for phasing IRR infrastructure development to optimize net revenues and reduce risk.

3. Examination of appropriate governance and procurement options to implement IRR should be included in this initial phase on the North Shore.

2 Assumptions & Limiting Conditions

This analysis was compiled to provide a preliminary assessment of Integrated Resource Recovery for the Districts of North and West Vancouver, the City of North Vancouver, Squamish and Tsleil Waututh First Nations. The analysis was undertaken for Metro Vancouver, on behalf of the municipalities and First Nations ("The Client").

The analysis comprises a main report and technical appendix, and related memos and subsidiary documents, which must be read as an indivisible whole ("the report"). The authors have prepared this report at the request of Metro Vancouver solely for this purpose.

IRR requires an inter-disciplinary approach. As a result, components of this report were prepared by professionals in one field who are not necessarily qualified in all the other fields of study. While diligence has been applied to integrate between disciplines, the scope of this report did not allow for full cross-verification of all analyses.

The report includes screening-level estimates which should not be relied upon for design or other purposes without detailed feasibility studies. A systematic process was used for Integrated Resource Recovery, evaluated through a comprehensive and integrated engineering and financial model, to project possible value. Reliance on the conclusions of this study without use of this process and model will result in outcomes including, but not limited to, sub-optimization of recovered resources and/or reduced financial net results with a consequent increase in taxpayer cost.

Information in this report, from which conclusions have been derived, has been provided by third parties. While reasonable diligence has been exercised to assess the information acquired during the preparation of this report, no guarantees or warranties are made concerning the accuracy or completeness of this information. This document, the information it contains, the information and basis on which it relies, and factors associated with implementation of resource recovery may be subject to changes which are beyond the control of the authors.

The authors do not accept responsibility for the use of this report for any purpose other than that stated herein and do not accept responsibility to any third party for the use or reliance, in whole or in part, of the contents of this report. Any use by Metro Vancouver, other government entities, sub-consultants or any third party, or any reliance on decisions based on this document, is the responsibility of the user or third party.

The study considers potential areas for resource recovery infrastructure, but areas are discussed in the context of a conceptual study only. Detailed investigation into the suitability of individual locations has not been undertaken, except as stated in the report. The inputs to the study were grounded as much as possible through fact-finding efforts that are described in the report. This study is conceptual however, and therefore has limitations concerning the certainty of estimates of the value of resources that could be recovered from waste, as well as the costs of resource recovery.

Estimates of revenues from resources in this report do not consider questions of ownership of those resources. Availability of waste streams over which there is government control has been assumed and transfer of such waste streams, resources, demand, supply and revenues streams as defined in this report are assumed. The availability and estimates are included to allow options to be compared. No firms or other entities identified herein have endorsed or agreed to proposed options that would require their participation except as specifically noted in the report. Resources identified from industry or other sources may be required by those sources for internal purposes, and therefore may not be available for the uses proposed in this study.

Third parties should not rely on this report without first satisfying themselves as to the accuracy and extent of the contents, which have been prepared for the specific purposes of the Client. The authors' sole responsibility is to the Client for the scope, nature and extent of this report, as described in the report.

Cost, revenue, capacity, demand, supply, and qualitative information provided to us is based on specific dates. If the supplied information or dates are not accurate, it may affect some of the conclusions.

This report does not provide, nor should it be interpreted to provide, a legal opinion or opinion as to the statutory compliance of the proposed works. This report is prepared on the premise that the statutory capabilities noted herein are feasible as at the date of this report.

Specific caution is provided concerning legal and contractual aspects underlying this report. Compliance with statutory, regulatory, bylaw and other legal, quasi-legal, contractual and other impacts governing IRR have been subjected to reasonable due diligence, within the restrictions of the scope and budget, to confirm practicality of an IRR system, consistent with the principles and definitions of highest and best use and value. They have not been subjected to legal review and confirmation. Statutes, regulations etc can change and not all such constraints may be apparent or have been disclosed to the authors. Subsequent to the report's completion, regulatory and contractual changes may affect the availability of waste streams and/or revenues, affecting the analysis and conclusions of the report. No responsibility is implied or accepted for compliance or conformity, which must be confirmed as a subsequent step to assure the viability and feasibility of the chosen approach.

The authors are not qualified land surveyors and no legal survey concerning properties noted herein has been provided. No investigation has been undertaken with the local zoning office, the fire department, the building inspector, the health department, engineering departments or any other government regulatory agency, unless such investigations are expressly represented to have been made in this report.

2.1 Consulting Team

Fidelis Resource Group Inc. was formed to analyze resource recovery. The founding members and related team members assembled for this study include:

Primary Authors:

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3 Scope of Work & Methodology

Metro Vancouver commissioned the Fidelis Resource Group to undertake a conceptual level analysis of applying principles of integrated resource recovery (IRR) to organic solid and liquid waste streams and treated water for the three North Shore municipalities and two First Nations: the District of West Vancouver, the District of North Vancouver and the City of North Vancouver, Squamish and Tsleil Waututh First Nations.

Figure 1: Landsat image of North Shore Communities

3.1 Scope, Objectives and Policy Context

The objective of the study is to determine the feasibility of recovering resources from liquid and organic solid waste using an integrated systems approach. The scope of work is presented in the Technical Appendix. Specifically, Metro Vancouver had the following objectives for the study:

- Identify and quantify resource flows (water, energy and nutrients from liquid and solid waste);
- Identify and quantify potential uses and users of resources;
- Identify possible locations and scenarios for resource recovery facilities;
- Produce a conceptual design of the waste treatment and resource recovery facilities;

- Produce a preliminary business case for IRR on the North Shore, assessing incremental costs and revenues associated with resource recovery;
- Identify the broader policy and governance implications of the IRR approach.

In terms of policy context, Metro Vancouver has recognized the value of integrated resource recovery in its draft solid and liquid waste management plans (Draft Integrated Liquid Waste and Resource Management Plan, May 2010; Draft Integrated Solid Waste and Resource Management Plan, July, 2010) and in its Drinking Water Management Plan. IRR is consistent with Metro Vancouver's Sustainable Regional Initiative decision-making principles:

- Protect and enhance the natural environment;
- Provide for ongoing prosperity; and
- Build community capacity and social cohesion.

IRR can also contribute to the following BC Climate Action Plan policies and initiatives:

- Reduction in greenhouse gas (GHG) emissions of 33% by 2020 based on 2006 levels and 80% below this level by 2050;
- The Climate Action Charter engaging signatory local governments to develop strategies and take actions to be neutral in respect of their operations by 2012;
- All public sector organizations--schools, hospitals, post secondary institutions, etc. are required to be carbon neutral by 2010.

Metro Vancouver has also adopted a Sustainability Framework and Action Plan, of which the relevant policies are:

- Protect and enhance natural ecosystems, notably watersheds and wetlands;
- Increase biofuel use;
- Reduce water consumption;
- Divert 70% of solid waste from landfills by 2015;
- Become a net energy producer by 2015;
- Reduce GHG emissions by 15% by 2015 and 33% by 2020 from levels in 2007; and
- Metro Vancouver operations will be carbon neutral (excluding solid waste operations) by 2012.

4 Base Case and Planning Approach

Integrated Resource Recovery will be assessed in accordance with Metro Vancouver's draft solid and liquid waste management plans.

The base case for wastewater treatment for this study is a proposed secondary level treatment plant at the McKeen site (see Figure 2). Resource recovery would include anaerobic digestion of treated biosolids with cogeneration of electricity to contribute electricity to the treatment plant. The timeframe for operating the new plant is 2020.

The base case for solid waste management for 2010 for comparison purposes is an average diversion of 55% of all wastes achieved through recycling, product responsibility programs for specific waste streams (such as batteries or tires) and yard waste collection/disposal for composting. The balance of the waste stream is either disposed at landfills or at the Metro Vancouver Waste-To-Energy incinerator located in Burnaby.

The planning basis for solid waste management as proposed in the draft Integrated Solid Waste and Resource Management Plan (ISWRMP) is for a minimum of 70% diversion of all solid wastes by 2015 with an aspirational target of 80% diversion by 2020. In terms of wet organic waste – yard and food waste – the ISWRMP proposes a ban on disposal, other than by anaerobic digestion, for all wet organics available in the collection systems by 2015. Disposal of wood waste (dry organics) will also be banned from landfills by 2015. Wood waste will be managed according to the following hierarchy: reuse and recycling; composting and biofuel production; energy generation.

Some organic solid waste is currently being diverted by North Shore municipalities, with co-mingled food and yard waste being composted, and construction wood waste handled for generation of biofuels, mulch and compost. Metro Vancouver has recently issued a Request for Qualifications for proponents to provide a biofuel facility to process up to 80,000 tonnes of wet organic wastes.

For the longer term, Metro Vancouver has adopted a zero waste philosophy which provides guidance in support of goals one and two of the Integrated Solid Waste and Resource Management Plan: Minimize Waste Generation and Maximize Reuse, Recycling and Material Recovery. These goals will be achieved by reducing the amount of material consumed at source, increasing product responsibility by producers, and closed-cycle recycling and recovery of resources for materials and energy.

It was agreed that the quantities of solid waste used in this study would be based on estimates prepared by Metro Vancouver for the three North Shore municipalities. The ISWRMP proposes to increase all solid waste diversion to a minimum of 70% by 2015. This will increase food waste diversion from 9% currently to 55%, wood waste diversion from 31% currently to about 72%, and yard waste from 80% currently to about 90%. Scenario 3 presents a scenario where food and wood waste diversion would be increased to 90%. Detailed estimates of the organic waste totals for the North Shore Municipalities will be presented in Table 3.

IRR Scenarios

The original Scope of Work proposed the evaluation of two IRR scenarios and comparison of these with the planning base case outlined above. These two scenarios consisted of IRR in conjunction with a distributed configuration of treatment plants, and IRR in conjunction with a centralized treatment plant located at McKeen Avenue. These two scenarios are presented in the following figures.

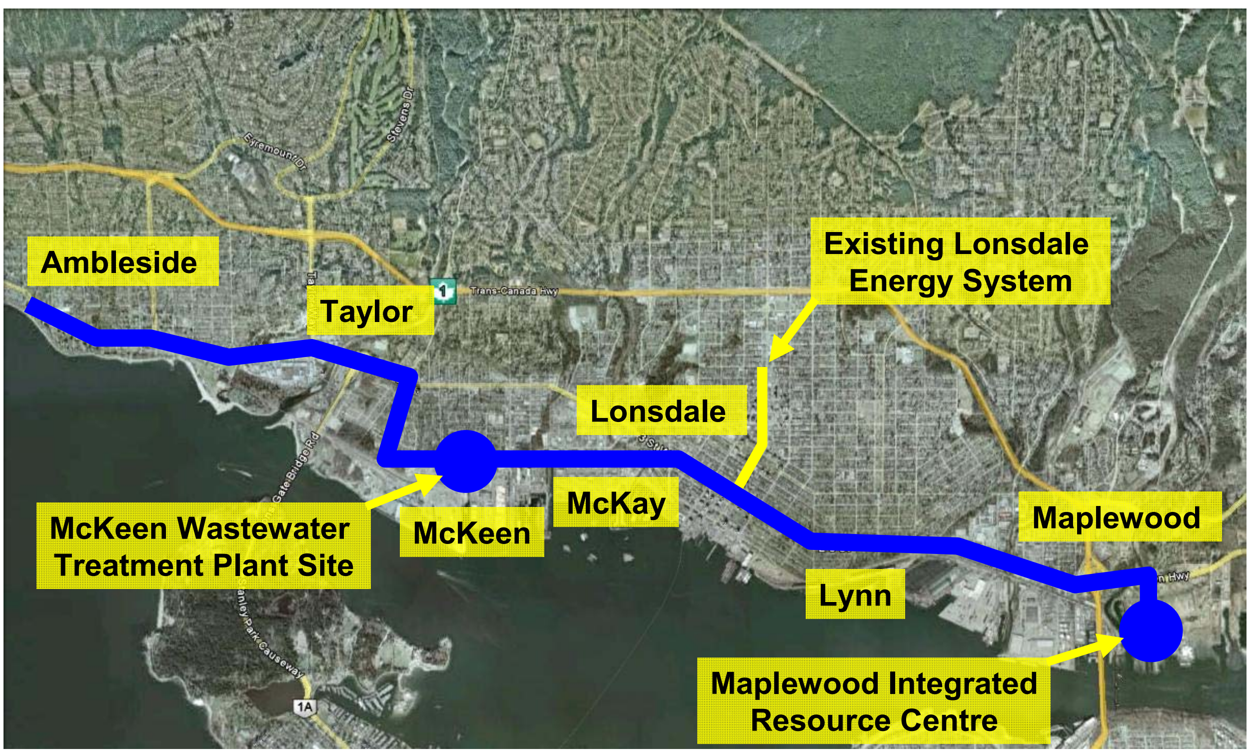

Figure 2: Potential Route for District Water & Energy System (DEWS)

Figure 3: Potential Water and Energy Recovery Centre (WERC) Locations Studied

In response to the interim report filed in April, 2010, it was agreed that six scenarios would be evaluated:

- Scenario 1: Integrated Resource Recovery based on seven distributed wastewater treatment plants together with an energy centre at Maplewood to process an average diversion of 70% solid organic waste (See Figure 3).

- Scenario 2: Integrated Resource Recovery based on a centralized liquid waste treatment plant located at McKeen Avenue and an energy centre at Maplewood to process an average diversion of 70% solid organic waste. Biosolids from treated wastewater would be processed at Maplewood, industrial heat sources included, and sensitivity analysis on resource values incorporated.

- Scenario 3: Integrated Resource Recovery as designed in Scenario 2, but based on an average diversion of solid organic waste of 90%.

- Scenario 4: Integrated Resource Recovery as designed in Scenario 2 but based on recovering resources from 90% of organic waste received at the North Shore Transfer Station.

- Scenario 5: Integrated Resource Recovery based on centralized wastewater treatment located at McKeen Avenue and an energy centre at Maplewood to process an average diversion of 70% of solid organic wastes. Sensitivity analyses were applied to a number of factors such as recovering energy from biosolids from treated wastewater at McKeen Avenue rather than Maplewood; not including industrial heat sources and changing assumptions on resource values.

- Scenario 6: Resource recovery based on a centralized liquid waste treatment plant located at McKeen Avenue without any processing of solid organic waste on the North Shore.

Scenario 6 should not be compared directly with the other five scenarios as it does not include the costs or benefits associated with resource recovery from solid waste on the North Shore. It is assumed that solid waste recovery would take place elsewhere in Metro Vancouver in accordance with the Integrated Solid Waste Management Plan. It is included in this report to determine whether additional costs for recovering resources from liquid waste alone are supported by potential revenues.

The key items considered in the scenarios are as follows:

- Evaluation of the pros and cons of processing biosolids from the wastewater treatment plant at McKeen or at Maplewood. There are important financial and energy management factors as well as social issues of transporting unstabilized biosolids from McKeen to Maplewood.
- Evaluation of the potential added value associated with capturing waste heat from industries located in the Maplewood area.
- Evaluation of the values associated with producing biomethane from the Maplewood Integrated Resource Centre compared with directly providing heat to the Lonsdale Energy Corporation system.
- Evaluation of buying chipped wood already processed from waste, or receiving and processing wood waste to produce chipped wood for the gasifier.

We evaluated components for resource recovery to provide a range of information that could be applied elsewhere in the Region. For example, while wastewater treatment must be implemented on the North Shore, recovery of organic solid wastes could be undertaken elsewhere in the region. Accordingly, we evaluated resource recovery options for liquid wastes on the North Shore that do not include integration with solid waste streams such as:

- Extracting heat from sewers without pre-treatment as occurred for the Southeast False Creek Neighbourhood Energy Utility;
- Extracting heat from treated wastewater using heat pumps at the treatment site and distributing heat by district energy systems; and
- Providing treated wastewater to buildings by district energy systems and extracting heat at each building.

Where liquid and solid waste recovery infrastructure is integrated, a number of recovery Scenarios for solid organic waste diversion were analyzed:

- 70% and 90% diversion of all organic solid wastes;
- Recovery of all organic solid wastes that are processed at the North Shore Transfer Station. This includes some material brought over from elsewhere in Metro Vancouver; and

- Implications for organic solid waste recovery infrastructure if a mixed waste incinerator was to be located on the North Shore.

These resource recovery options are evaluated according to a decision tree approach which logically arranged the options in sequence. This decision tree is presented in the Evaluation section of this report and analyzed in detail in the Technical Appendix (Conversion Technology Options).

4.1 Evaluation Criteria—Triple Bottom Line Analysis

The business case for evaluating the scenarios and options was based primarily on financial criteria, but a number of non-monetary environmental and social criteria were also included in the triple bottom line analysis. All of these evaluations were analyzed at the concept level.

1. Financial. Capital, operating, maintenance and replacement costs were evaluated over the project's full life span to assess best value for the taxpayer. Net revenues were similarly assessed for all components of the IRR system. This analysis was undertaken for all six IRR scenarios to facilitate comparison.

2. Greenhouse gas reductions. A net balance in GHG emissions was calculated.

3. Reduced water consumption. Opportunities to reduce potable water consumption and replace it with treated water were assessed.

4. Meet all applicable environmental standards. IRR scenarios were tested to meet all environmental requirements at the federal, provincial and municipal levels which can realistically be in place by 2015. Differences between current regulations and those required to support IRR implementation are discussed in the section on governance.

5. Properly functioning ecological systems. The health of major watersheds was identified and the potential to improve the health of these ecological systems through the application of IRR principles was assessed.

6. Social and community values. Location of resource recovery facilities, potential for odour and noise, and compatibility with land use zoning were considered. Likewise, compatibility of land use planning and zoning for the three municipalities were considered in projecting energy use for recovered resources.

7. Adaptation to a changing climate. Increases in sea level, higher risk of extreme weather events, and droughts were all anticipated with a changing climate over the 50-year planning horizon of this study. Location of facilities and ways to improve the resilience of ecosystems to these changing conditions were assessed.

8. Practicality and procurement. The report provides an assessment of the risk associated with IRR as well as comments on its procurement.

5 Investigation Approach, Methodology and Assumptions

5.1 IRR Principles

IRR scenarios were based on the following principles as developed by the consulting team. These principles are also consistent with those included in the Provincial Government's 'Guide to Integrated Resource Recovery' (Ministry of Community Development, 2009):

- **Integrate land use and planning decisions**. Design new infrastructure to make joint use of water and energy services. The terms of reference for this study encourages integrated energy and water design for new developments to reduce the need for large additional infrastructure systems.

- **Use resources more than once**. Resources can provide multiple benefits. At Dockside Green in Victoria, reclaimed, disinfected water is used to create a new stream that enhances property values; potable water once used is then treated and reused for non-potable uses. Once energy is extracted from organic waste, the nutrient rich residue can be used as a soil conditioner or compost to replace petrochemical-based fertilizer.

- **Use each resource to its highest and best value**. Different forms of waste command different values: biomethane extracted and used as fuel for vehicles is more intrinsically valuable than when used as fuel to generate electricity, which, in turn, is more valuable than biomethane locked in compost. IRR seeks to find the highest value suited to the site and local demands.

- **Design with nature**. Integrated design restores ecosystems rather than degrading them. For example, treated water could potentially be discharged to riparian areas where the nutrients could be reused by terrestrial ecosystems before entering watercourses and marine systems.

- **Optimize system boundaries**. The scale of the waste and water system considered for IRR is a critical element in the analysis. If the system is too small, there may not be sufficient resources to be recovered economically. IRR also considers all sources of resource recovery including industries which generate energy as potential inputs.

- **Consider markets and energy first, treatment sites and technology second**. Markets for energy and opportunities to regenerate ecological systems were considered in conjunction with sources of recovered resources. Then IRR design and technologies that resulted in the highest and best use of balancing supplies with demands were identified and evaluated according to a triple bottom line analysis.

This approach is illustrated in Figure 4.

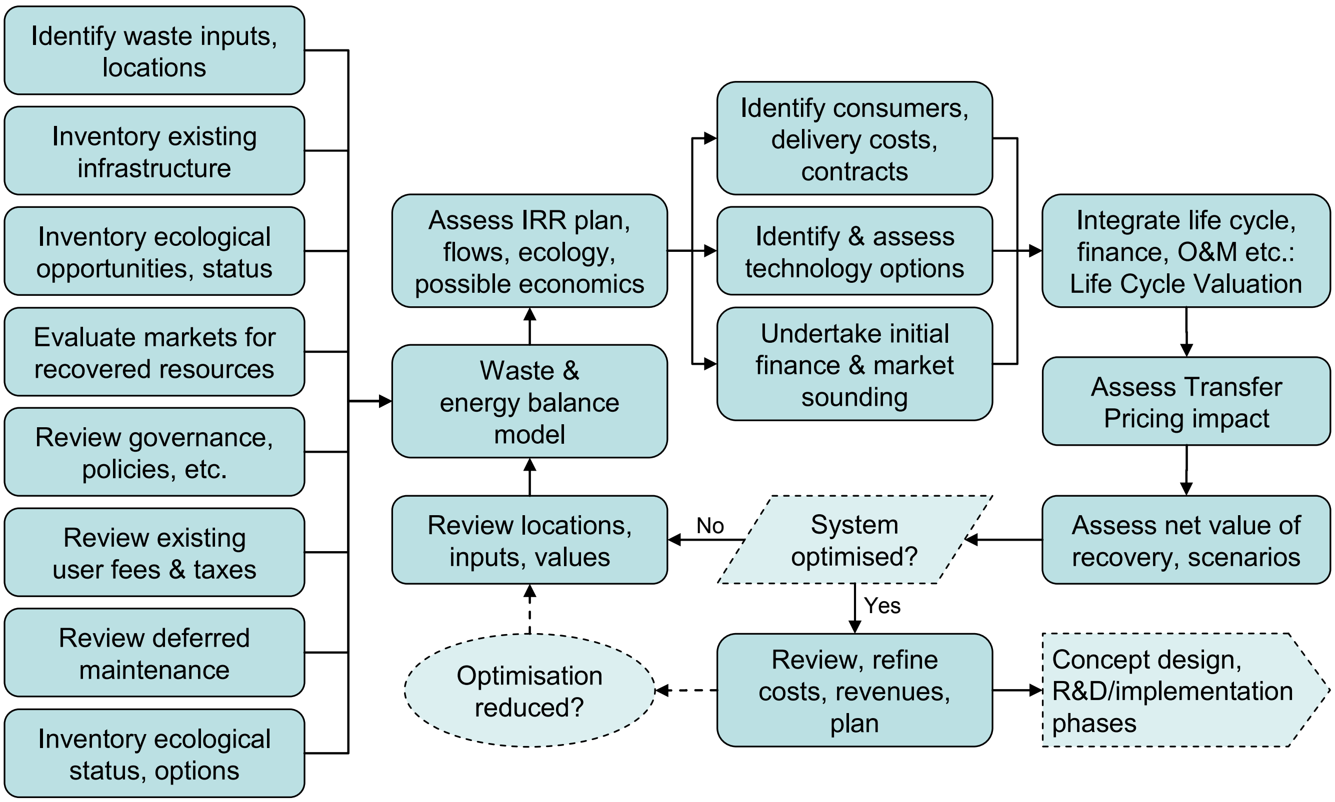

Figure 4: IRR Assessment Process

The IRR assessment process started with an inventory of resources and existing finances and then undertook an interactive analysis using an energy balance, ecological balance and financial models until the system was optimized, within the current scope. Specific technological solutions were determined only through the interactive analysis and not pre-determined at the start of the assessment.

Identification of resource recovery options required a holistic examination of energy, water, ecology, greenhouse gas emissions, community planning, land use, governance, and valuation. These principles were applied to identify Integrated Resource Recovery options for the North Shore Communities. Details of the tasks and supporting activities are outlined in the Technical Appendix.

A number of iterations were carried out to optimize the match between recovered resources and identified demand. The potential revenues, capital and operating costs, and greenhouse gas reductions were then fed into a business model to evaluate the financial aspects of each selected scenario. This provided full life cycle valuation (costs and revenues) over 50 years, financially adjusted.

All technologies proposed in this analysis are established in facilities operating around the world. The waste streams available for recovery in 2015 were quantified within the boundaries of the North Shore Communities. In the case of liquid waste, all data were directly available for the North Shore Municipalities. In the case of wet and dry organic waste, recovery information for the North Shore Municipalities was available for 2008. For estimates in 2015, data across Metro Vancouver were prorated for the North Shore. The Technical Appendix (Technical Methodology- Data Collection Methods) provides a more detailed explanation of the data collection process used in the study .

5.2 Business Case Method

General Approach

Governments are generally oriented to minimize costs since most taxpayer services have minimal revenue potential. In the case of IRR, there are substantial revenues so a revenue – orientated business approach has been used:

- A focus on value leads to maximizing profit, net of costs, in this case maximizing value to the taxpayer;
- The taxpayer is in essence the lender. Any business case should thus consider the taxpayer as though they are a lender, *i.e.* considering the loan, exit strategy, procurement, returns, timescale, risk, and other factors affecting a lending decision. This is consistent with market investment and development approaches and standards;
- Market investment decisions assess the full life cycle of an investment so a true net picture of financial performance can be estimated; and
- Sustainable investments typically have a larger initial capital investment, with resultant longer life cycle of the equipment and benefits, which means the value may be received only over a period of years. Traditional discounting techniques applied to long-term projects are now being questioned by the international financial community so both discounted and undiscounted values are included in the analysis[1].

[1] See Technical Appendix for more detailed discussion. Also: "The Stern Review on the Economics of Climate Change" including various comments on the impact of long term discount rates in the popular media; UK Treasury Board "The Green Book - Appraisal and Evaluation in Central Government" Annex 6, Discount rate; and "Methodology for Risk-free Discount Rates … for Accounting Valuation Purposes".

A Valuation for Financial Reporting model was thus adopted as being a standards-based approach that has the requisite neutrality and transparency to address a revenue-centric process, which IRR represents. In addition we considered the following factors:

- The provincial Capital Asset Management Framework ("CAMF") sets out guidelines for business cases where public projects will require funding. The method used for analysis is most closely consistent with a CAMF Strategic Options Analysis level of assessment;

- Metro Vancouver uses business cases for capital approvals, with similarities to CAMF in having an initial "Strategic Options Analysis" and subsequent more detailed analysis;

- International and national standards that govern valuation and appraisal are approved by 60 countries (including Canada) and apply in British Columbia. Real estate appraisals use simplified versions of this approach for lending institutions;

- In the event that this business case were to be advanced for external lending, this document – with allowance for audit and confirmation – would contribute to securing financial support;

- A 50-year cycle was adopted, to better align with, and account for, the longer life cycle of plant and equipment. The model was adjusted to allow for life cycle capital replacement and financing, including associated soft costs, contingencies etc., since this has an appreciable impact on net value;

- Valuation approaches adopt a "highest and best use and value" concept, *i.e.* they attempt to identify how value might be optimized. Throughout this study the concept of highest and best use and value has been adhered to, since this is in turn consistent with securing best value for the taxpayer;

- In terms of reporting, a variety of standard metrics were reviewed and, due to the impact of life cycle and the sustainable nature of the project, a variety of non-standard (i.e. non-financial) metrics were also reported;

- The economic model was also used to model resources recovered from each scenario. Not all aspects were taken through to detailed modelling due to the constraints of scope, time and budget, however an adequate sampling of key items has been provided.

Further detail on the model and adaptations are provided in the Technical Appendix.

5.3 Ecological Methods and Water Reuse

Low summer flows are known to be a problem for North Shore streams, so it seemed logical that several streams might be candidates for stream flow augmentation with reclaimed, disinfected, and dechlorinated water. Twenty percent of Mean Annual Discharge (MAD) is considered the base flow required to maintain healthy riffle habitat for most salmonid-bearing streams in BC (Ptolemy and Lewis, 2002).

Hydrometric data were reviewed to assess which streams fell below 20% MAD and identify during which months this occurred. The required “top up” volume was then calculated. This proved difficult due to overall lack of stream gauge data and the fact that most gauge data were reflective of conditions in the upper watersheds, whereas the reclaimed water would be available nearer the urbanized areas in the lower stream reaches.

Water Reuse

We identified a limited number of industries which might be interested in using treated wastewater at a lower price than potable water. We also considered use of treated water for irrigating golf courses and public spaces to replace potable sources. In most cases, the use was too seasonal and the location too far removed from the distributed treatment sites to be cost-effective.

5.4 Demand Projection Context

The market for recovered resources was estimated for the period of design and construction, namely 2013-2020 and for the length of the project—2046.

The population growth rate used for the North Shore municipalities is provided by Metro Vancouver’s Regional Growth Strategy (Metro Vancouver, 2009), and is derived from BC Stats' P.E.O.P.L.E. projection model. The underlying data are shown in Table 1.

Table 1: North Shore Population Growth

Year	Population
2006	179,900
2021	205,000
2031	223,000
2041	242,000

Population projection has a significant impact on the model because higher growth tends to increase revenues. Recent projections from BC Statistics indicate that the growth rate may be dropping, so this factor should be carefully assessed during the due diligence phase.

Commerce and industrial growth generally mirror population growth, though the North Shore is limited by availability of suitable commercial and industrial land.

The North Shore municipalities have identified commercial development potential in Lower Lynn, Marine Drive, Park Royal, Squamish Nation lands, and Ambleside, as shown in Figure 5 on page 27. These proposed projects were considered in the growth projections for using recovered resources.

Actual development of these and other areas on the North Shore will be dependent on financial and economic conditions that occur over the next ten years. The Technical Appendix includes a brief discussion of some of these factors as they represent a risk that must be considered when applying the principles included in *Valuation for Secured Lending.*

Energy

The future price of energy is a critical risk factor in evaluating IRR scenarios. Metro Vancouver has adopted a 6% nominal annual increase in electricity prices over the next 10 years. Rate increases for both Terasen and BC Hydro, which have been recently approved, have been considered in the model. However, we did not assume any increase in energy value above general inflation for reasons outlined in the evaluation section of this report.

Tipping Fees

We assumed a tipping fee of $50 per tonne for organic solid waste that would be received at the Maplewood Integrated Resource Centre. This was selected as there are increasing claims on biomass and we expect increasing competition in this area which is likely to drive down prices. There are current reports that indicate this is starting to happen for items such as wood waste.

6 Existing Wastewater and Solid Waste Infrastructure

Metro Vancouver operates the Lions Gate Wastewater Treatment Plant on the North Shore. The North Shore communities also host pump stations operated by Metro Vancouver and the municipalities, as well as municipal and Metro Vancouver sewer mains.

Wastewater flows to the Lions Gate Wastewater Treatment plant through an interceptor system that is also owned by Metro Vancouver. The interceptors extend from Lions Bay to the west and from Deep Cove to the east. Municipal planners and engineers have taken advantage of the North Shore's topography to arrange for flows of wastewater to reach the existing wastewater treatment plant by gravity as much as possible. Metro Vancouver reports that this system of pipes was installed in the 1960s. The capital cost to maintain this system is not included in any of the scenarios.

Metro Vancouver also operates the North Shore Transfer Station (NSTS) located within the Maplewood Industrial Park. The Transfer Station accepts solid waste from both the North Shore and other parts of Metro Vancouver for consolidation into shipments to landfills and incineration. A green waste collection operation is located adjacent to the Transfer Station.

AVAILABLE RESOURCE FLOWS

Metro Vancouver provided the wastewater treatment capacity data shown in Table 2.

Table 2: North Shore Wastewater Treatment Plant Design Criteria[2]

Parameter	Existing (2007)	2046 Design Case
Population	184,000	275,000
Flow (MLD)		
▪ Average Dry Weather Flows (ADWF)	96	111
▪ Average Annual Flow(AAF)	115	133
▪ Peak Wet Weather Flow (PWWF)	324	356
Max Month Load (tonnes/day)		
▪ BOD_5	19	28
▪ TSS	23	32

Metro Vancouver also provided estimates of generation of wet and dry organic waste for the North Shore based on data on current recovery rates and composition of disposed materials. Table 3 provide estimates of these flows for 2008 and 2015 based on three assumptions:

1. An overall diversion rate of 70% for all waste streams but applying differential rates for specific streams of organic waste.
2. An overall diversion rate of 90% for organic waste streams.
3. Volumes of organic waste currently and projected to be received at the NSTS.

Volumes of fish waste available on the North Shore (identified through survey work during this study) and estimated volumes of grease were added to the total amount of wet organic waste identified by Metro Vancouver. Finally, green wood from BC Hydro brush clearing activity on the North Shore (identified through survey work during this study) was added to the total of dry organic waste.

[2] Lions Gate Site Investigation Feasibility Report, Stantec, 2007

Table 3: Estimated Total Organic Waste Volumes, 2015

	70% Diversion	90% Diversion	NSTS
Wet Organic Waste	(t/yr)	(t/yr)	(t/yr)
Grass	8,891	8,891	13,386
Food Waste	17,523	27,930	42,051
Soiled Paper	4,295	6,874	10,350
Oil and Grease (Brown Grease)	712	915	915
Oil and Grease (Yellow Grease)	493	634	634
Industry (Fish Waste)	2,324	2,324	2,324
Total	**34,239**	**47,568**	**69,660**
Biosolids, Before Digestion (BDT/year)	11,951		
Dry Organic Waste			
DLC Lumber	23,519	26,024	39,181
Branches/Twigs/Stumps	20,745	20,745	31,234
BC Hydro Brush Clearing	1,175	1,175	1,175
Sub-total, Green Basis	**45,439**	**47,944**	**71,590**
Sub-total, Bone Dry Basis	29,776	31,779	47,549
Biosolids, After Digestion (BDT/year)	7,290	7,290	7,290
Total, Bone Dry Basis	**37,066**	**39,069**	**54,839**

In addition, there are significant sources of heat available from industrial facilities located in the Maplewood Industrial Park. The heat is available at temperatures between 30°C and 40°C and is much more efficiently converted to space heating than heat from wastewater with an average temperature of 15°C and 19°C (See Technical Appendix).

6.1 Potential Uses and Users of Resources

We identified potential consumers of recovered resources, and estimated the supplies of recovered resources each could require from 2015 to 2046. The value of these resources depends on both the quantity and seasonality of use. All-season demand is required for residential properties, hotels, hospitals and long-term care facilities, with more limited demands for schools and malls.

Users of reclaimed resources were identified by location, quantity of water or energy required, timing for their requirements (*e.g.* by season), and the quality of resource required. Initially these locations were obtained through field research and subsequently from the BC Safety Authority database on hot water boilers for the three North Shore municipalities. Only 45% of the boilers were considered to be suitable for conversion to district energy as some were high-pressure steam boilers and some were too small (loads less than 2,000 GJ /year) or were located too far from the proposed routing of district heating systems. More than 70% of the total demand came from existing multi-family buildings and 25% from public sector buildings. Total current demand for district heating is presented in Table 4 (See Technical Appendix– Data Collection Methods– Estimates for Current Demands for Heat).

Table 4: Current Demand for Heating

Neighbourhood	**Total Heating Demand** (TJ/Year)	**Number of Potential Client Connections**
Ambleside	329	53
Taylor	145	16
McKeen	36	3
MacKay	53	7
Lonsdale	771	164
Lynn	33	6
Maplewood	289	37
Totals	**1,657**	**286**

POTENTIAL USES

Reclaimed water: water reuse for toilet flushing, industrial cleaning and dust control, irrigation for aesthetic purposes, irrigation to produce cooling cells, and enhancement of flows in rivers, streams, and wetlands;

Heat energy: replacement of fossil fuels for space heating and domestic hot water, and replacement of fossil fuels for low-temperature industrial heating, including heating of industrial buildings;

Cold energy: replacement of conventional air conditioning and refrigeration systems, thus reducing consumption of electricity;

Biofuels produced from organic waste: synthesis gas to replace natural gas in large-scale industrial burners; biogas to produce electricity and heat through cogeneration; or when upgraded to biomethane, to replace fossil fuels in vehicles.

PROJECTED DEMAND FOR RESOURCES

In the base engineering model, the change in demand for resources that would occur by 2046 was estimated by applying a population growth factor of 0.87%. The population growth factor would increase demand by 30% (see Table 5). The proposed developments for the North Shore as supplied by the municipalities indicate a growth factor of 33%. As shown in the next section on resource supplies, there will be sufficient additional supplies of recovered resources to meet both existing and potential demands (For more details, see Technical Appendix– Data Collection Methods– Estimates of Future Demands for Heat).

Table 5: Future Demand for Heating

Neighbourhood	**Estimated Current Demand** (TJ/year)	**Potential Development**	**Potential Future Demand** (TJ/year)
Ambleside	329	Taylor Wood, Seniors on Marine	Unknown
Taylor Way	145	Squamish Nation[3]	Unknown
McKeen	36		
McKay	53	Marine Corridor[4]	49
Lonsdale	771	The Pier[5]	80
Lynn	33	Lower Lynn[4]	171
		Seylynn Village[4]	25
		Lynn Valley Town Centre[4]	144
Maplewood	289	Maplewood Village[4]	46
		Seymour Creek Village[6]	31
Totals	**1,657**		**546**
Percentage Increase, Based on Developments			33%
Percentage Increase, Based on Population Growth to 2045			30%

[3] Firm estimates of the size and type of demand for this development were not available at the time of the study. The development is anticipated to include approximately 600,000 m^2 of mixed-use space.

[4] District of North Vancouver. 2009. District Energy Assessment. 59pp.

[5] City of North Vancouver. Pier Development (http://www.cnv.org/server.aspx?c=2&i=111)

[6] www.squamish.net

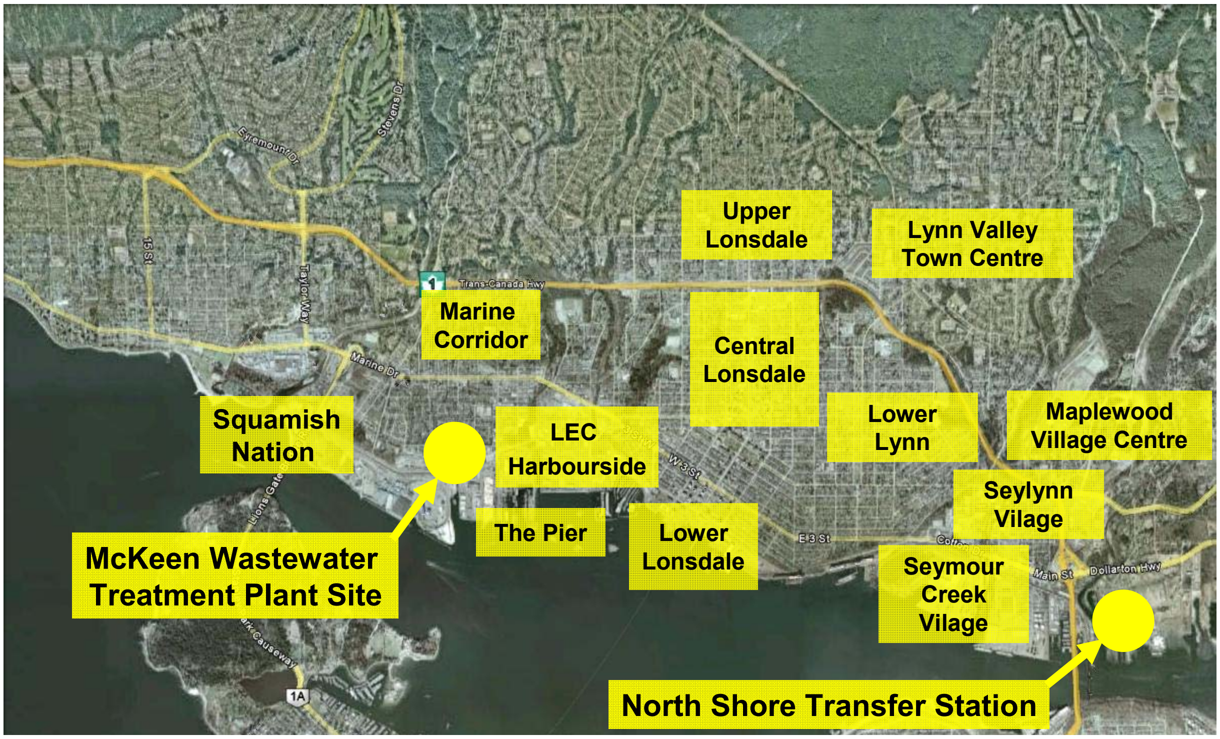

Figure 5: Areas of Future Development on the North Shore

7 Technical Evaluation

This section provides an initial technical evaluation of the scenarios based on energy, reclaimed water and nutrients. A more complete financial and triple bottom line analysis is provided in the following section.

7.1 Market Pricing for Recovered Resources

Pricing of energy is based on the amount of heat provided, not the price of fuel purchased. The average efficiency of boilers is considered to be 80% meaning that 1 GJ of natural gas will provide 0.8 GJ of useful energy. A consumer of recovered energy from the district heating systems proposed in this study would pay an average price of $18.46 per GJ which represents a 25% savings over current building owners' costs. The rationale for selecting this price is provided in the Technical Appendix (Market Pricing for Recovered Resources– Pricing of District Energy).

This cost is based on an analysis of both the building owners' costs of providing energy and a comparison with energy costs associated with two district heating systems—SE False Creek in Vancouver and Dockside Green in Victoria. The effective rates for district energy in the two examples are $24.94 per GJ for SE False Creek and $21.83 per GJ for Dockside. For the North Shore, a price of $18.46 has been selected for the average building. This price is approximately 26% lower than the average cost for providing the same amount of heat from natural gas estimated at $25.07/GJ. In the economic model, the district utility would incur all costs for connecting the client to the district energy system.

The lower price proposed in this study should be an attraction for clients to connect to the district energy system as there is also price certainty—prices are not subject to carbon taxes or to the fluctuating price of natural gas and the building owner does not have to be concerned with maintaining the equipment. For clarity, the economic model includes all capital and operating costs for providing heat to the building via the district energy system including connections to the client. The price of $18.46 /GJ is used to estimate revenues.

The Lonsdale Energy Corporation currently uses natural gas as a source of heat. Under the system envisioned in this study, the required heat would be provided through a heat exchanger that is capable of providing water supply temperatures of 82°C and return temperatures of 50°C, as is currently the case. The existing natural gas boilers would be used as back up.

Alternatively the heat could be generated directly by replacing natural gas with biomethane produced at the Maplewood Integrated Resource Centre and injected into the Terasen Gas distribution system. The comparative costs of these two options are analyzed later in the report.

The price of electricity produced from the cogeneration facility is based on BC Hydro's proposed price for green community-based projects. This price is currently under review. The utility has issued a Request for Proposals from the private sector for community-based biomass projects. The utility will set its price following analysis of the response. BC Hydro officials have indicated that the expected price will be in the range of $100-120/MWh. For the purposes of this study, the price of $110/MWh was selected. The price of compost created from the digestate produced in the anaerobic digestion process was calculated to be $20.26 per green tonne. This price was based on analysis of similar compost produced in the Comox Valley Regional District and adjusted for moisture content. More information is available in the Technical Appendix—Market Pricing for Recovered Resources. As noted previously, the valuation model does not assume the prices of heat, electricity or other revenues will grow above the level of inflation.

7.2 Configuration of IRR Architecture

The configuration of resource recovery infrastructure is modelled as follows:

1. Either a single central wastewater treatment plant located at McKeen Avenue or seven Water and Energy Recovery Centres (WERCs) located at Ambleside, Taylor Way, Mackay, Chesterfield, Lynn, and Maplewood in addition to the McKeen site.

2. Source separation of organic solid waste into the following streams:

    - Wet organic waste—food, green yard waste from residences, commercial and institutional sources including fish waste from industrial sources that can be processed in an anaerobic digestion facility; and

    - Dry organic waste—wood material (not including treated or painted wood), construction and demolition materials, woody material in yard waste and brush clearings from BC Hydro operations on the North Shore, and paper and paperboard products that can be gasified.

3. An integrated energy facility, located in the proximity of the Maplewood Industrial Park, will include an anaerobic digestion facility, a gasification facility and a cogeneration facility to produce electricity and high-temperature heat.

4. Biosolids produced at the wastewater treatment plant would be treated either at the McKeen site or at the Maplewood site.

5. A District Energy and Water System (DEWS) extending from Maplewood through McKeen to Ambleside.

6. Several neighbourhood energy systems to transfer heat from the DEWS line to the vicinity of individual buildings.

7. Connector pipes to transfer heat from the district energy system to individual buildings.

Wastewater treatment facilities would incorporate:

- Piping to convey untreated wastewater to the WERCs;
- Piping to convey treated wastewater from the WERCs to either local outfalls, or to the existing Lions Gate outfall;
- Treatment of wastewater to the secondary level;
- Further treatment of 10% of flows to the tertiary level, as well as disinfection, to meet Provincial standards allowing unlimited human contact for reused wastewater; and
- Heat pumps to recover both heat and cold from treated wastewater.

Maps illustrating these configurations are provided in the next section of the report.

In larger WERCs (Ambleside, McKeen, and Lonsdale), facilities would be included to dewater biosolids to 20% consistency (solids content) before trucking; biosolids at 5% consistency would be produced by the remaining WERCs. Biosolids from all facilities would be trucked to the single solid energy facility in the Maplewood Industrial Park in Scenario 1.

Co-location of the anaerobic digestion, gasification, and cogeneration facilities together with heat pumps can result in physical and economic synergies. If a heat pump is only required to deliver heat at 60°C instead of the district energy system temperature of 82°C, then its COP increases to 3, which significantly improves the efficiency of energy recovery. (In the case of heat pumps recovering heat from industrial cooling water at 35°C and delivering heat at 68°C, the COP increases to 4.) The remaining temperature increase from 60°C to district energy system temperatures can be provided from cogeneration. This arrangement means that energy recovered from cogeneration is leveraged by the lower-temperature energy provided by heat pumps. In other words, high temperatures can be obtained much more efficiently by heat pumps and co-generation acting in a series than by either system working on its own.

- The distribution of heat would be provided by integrated systems in the design of the centralized Scenarios 2, 3, 4 and 5. The District Energy and Water System (DEWS) would convey heating, cooling, and reclaimed water from points where it can most economically be produced to points where it can more economically be consumed. Local district heating systems would convey heat from the DEWS line to the proximity of client buildings. In this analysis, 286 buildings were identified as being capable of receiving this form of heat. Finally, connectors will be required to convey the heat into individual buildings.

The total amount of heat demand available by the time the recovery infrastructure systems would be in place, (2015 for solid waste and 2020 for the wastewater treatment) is estimated to be 1,657 TJ per year (see Table 5). As noted above, this heat would be distributed by the district heating systems from the treatment plant and from the cogeneration facility at the Maplewood Integrated Resource Centre. The amount of heat provided by each source would vary by scenario. These will be evaluated in accordance with the highest and best use principles used in IRR.

Based on this architecture, capital costs, ongoing costs, revenues, and greenhouse gas reductions were modelled and incorporated into the economic model.

Technical Evaluation of Resource Recovery Scenarios

The evaluation of the six scenarios was broken down into a series of questions to assist in understanding the components that lead to the highest and best use of recovered resources. The decision tree used in this approach is shown in Figure 6.

The questions are as follows:

- Should heat from wastewater be extracted prior to treatment or following treatment?
- Should wastewater treatment be undertaken at distributed sites or at a central site?
- Assuming architecture of a central wastewater treatment plant is supported by a solid waste energy centre at Maplewood, should heat from the treatment plant be distributed to buildings by a central heat pump at the plant or by distributed heat pumps at the demand locations?
- What are the highest and best use technologies for converting solid waste to useable energy?
- What are the implications of undertaking a sensitivity analysis on the following aspects of the IRR design:
    - Using biomethane to supply heat and electricity through cogeneration;
    - Processing biosolids at the McKeen site or at the Maplewood site;
    - Including or not including waste energy from industrial sources that are outside the direct control of Metro Vancouver;

- Buying wood chips on the market compared with processing them at Maplewood Integrated Resource Centre.

- What are the implications for resource recovery if heat is recovered from wastewater alone?

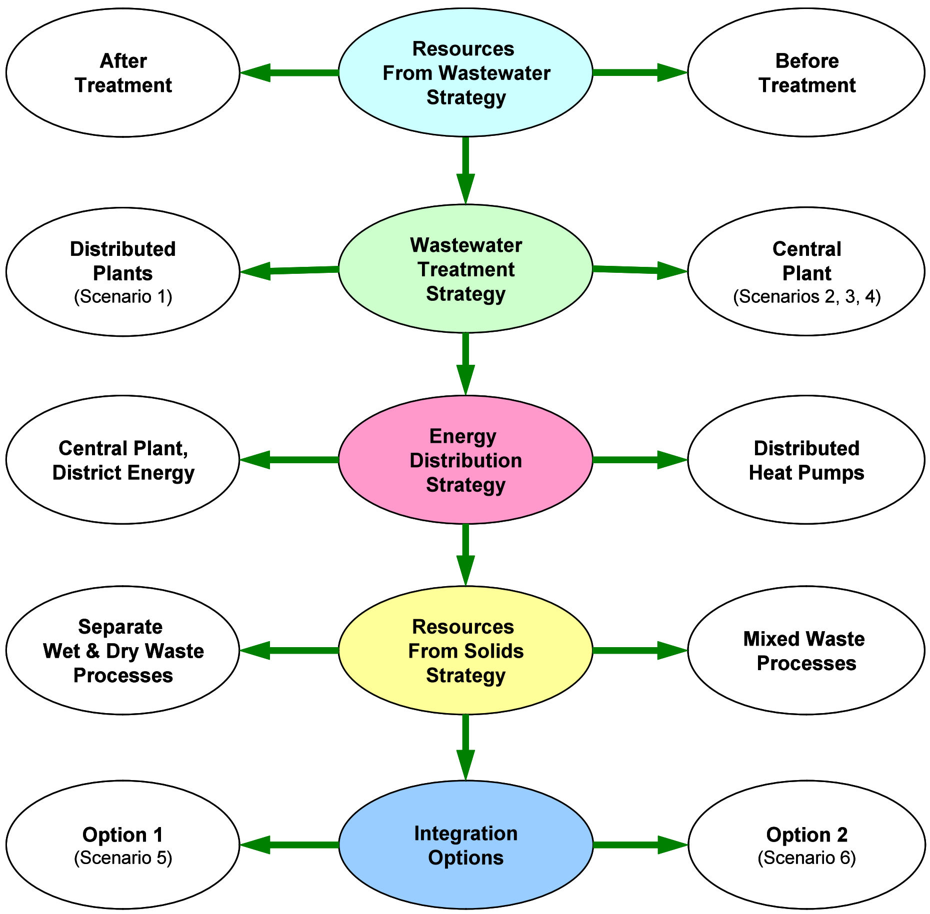

Figure 6: IRR Options Decision Tree

Each of these questions have to be considered in the context of net value for recovered resources. Each of these questions will now be considered in turn. Details for this evaluation are provided in the Technical Appendix (Conversion Technology Options).

Options for resource recovery from wastewater

Heat can be extracted from wastewater either before treatment or after treatment. The former option is used in the design of the district energy system for the Southeast False Creek development. An advantage of extracting heat from untreated wastewater is greater flexibility concerning the location of heat recovery and that treatment is not required. The disadvantages compared with extracting heat from treated wastewater are greater cost per unit of heat recovered, more limited amounts of heat available and timing of heat requirements which may be out of phase with wastewater flows.

On the North Shore, to serve a heat demand of 1,657TJ/year from between 115,000 and 133,000 m^3/day of wastewater would decrease the temperature of the wastewater by 8°C to 9°C. Because the average winter temperature of wastewater on the North Shore is 15°C, such a temperature decrease would compromise the effectiveness of the wastewater treatment process. In addition, when treatment occurs in an enclosed plant, there is potentially a small increase in temperature which improves the efficiency of heat recovery.

For the North Shore, extracting heat following treatment is a higher and better use of resources.

This conclusion may not be universally applied across Metro Vancouver. There are many locations such as Southeast False Creek where modest amounts of heat could be recovered from untreated wastewater.

Distributed VS Centralized Treatment

We compared the benefits and costs for seven distributed treatment plants shown on Figure 3 with a centralized treatment plant at McKeen Avenue shown in Figure 2. The seven sites were termed Water and Energy Recovery Centres (WERCs) as they were designed to recover energy and reclaim water.

The seven locations were based on: the availability of wastewater; potential demand centres for heat and cold from district energy systems; potential synergies for levering heat from the Maplewood Integrated Resource Centre; possibility of the need for a pump station retrofit in the near future; and availability of publicly owned lands. Land requirements would be a function of each WERC's treatment capacity and size.

In addition to the preliminary engineering assessment of possible locations for WERCs, individual sites were inspected at seven locations in terms of land value and availability. The analysis of potential locations for WERCs has been included in a separate memo provided to Metro Vancouver.

Table 6: Site Location Parameters

Site	Parameters
Location 1 - "Maplewood"	Area - 0.2 Ha for a WERC alone; 1 to 2 Ha for a solid waste facility In or within 1 km of the Maplewood Industrial Park
Location 2 - "Lynn"	Area - 0.15 Ha. Heywood to 3rd St. East to Gladstone (triangular)
Location 3 – "Chatterton"	Area - 0.15 Ha. Foreshore to Keith, Mahon to St. Andrews (Lonsdale area)
Location 4 - "Mackay"	Area - 0.3 Ha. Foreshore to 15th St., Pemberton to Fell
Location 5 - "Taylor Way"	Area - 0.2 Ha. Vicinity of Park Royal
Location 6 - "Ambleside"	Area - 0.2 Ha. Bellevue to Gordon Avenue, 23rd St. to 24th St.
Location 7 – "Gleneagles"	Area – 0.2 Ha. Vicinity of Gleneagles community centre

Individual sites were reviewed and their related finances included in the modelling. The locations were based on energy consumption and the potential to reuse treated water either for industrial non-potable uses, for irrigating golf courses and other green spaces, or for recharging nearby streams and wetlands.

Based on the criteria outlined above and on discussions with Metro Vancouver staff, the option of a WERC located at one of the five Gleneagles pump stations was also investigated. An analysis showed, however, that demand for reclaimed water and energy in the Gleneagles area was limited, as was the total energy demand. The site was eliminated from further review.

The size of each WERC was designed based on available flows in the interceptor wastewater pipes upstream of the plants, and the potential demands for heat and cold determined from a review of demand (Technical Appendix– Facility Description– Wastewater Treatment). Heat would be recovered and distributed to buildings following treatment as discussed above and transported by local district heating systems. In the distributed treatment Scenario 1, there would be no DEWS line connecting the Maplewood Integrated Resource Centre with Ambleside, but heat from the cogeneration plant would boost efficiency of heat pumps in the Maplewood area.

Biosolids from the smaller WERCs would be trucked to the larger plants, de-watered and then trucked to the digester at Maplewood.

In the centralized wastewater treatment scenarios—2, 3, 4, and 5, the treatment plant at McKeen Avenue would be connected to the Maplewood Integrated Resource Centre by the proposed DEWS line and heat would be distributed to local district energy systems and connectors to individual buildings. The configurations for the local district energy systems are shown in the following Figures.

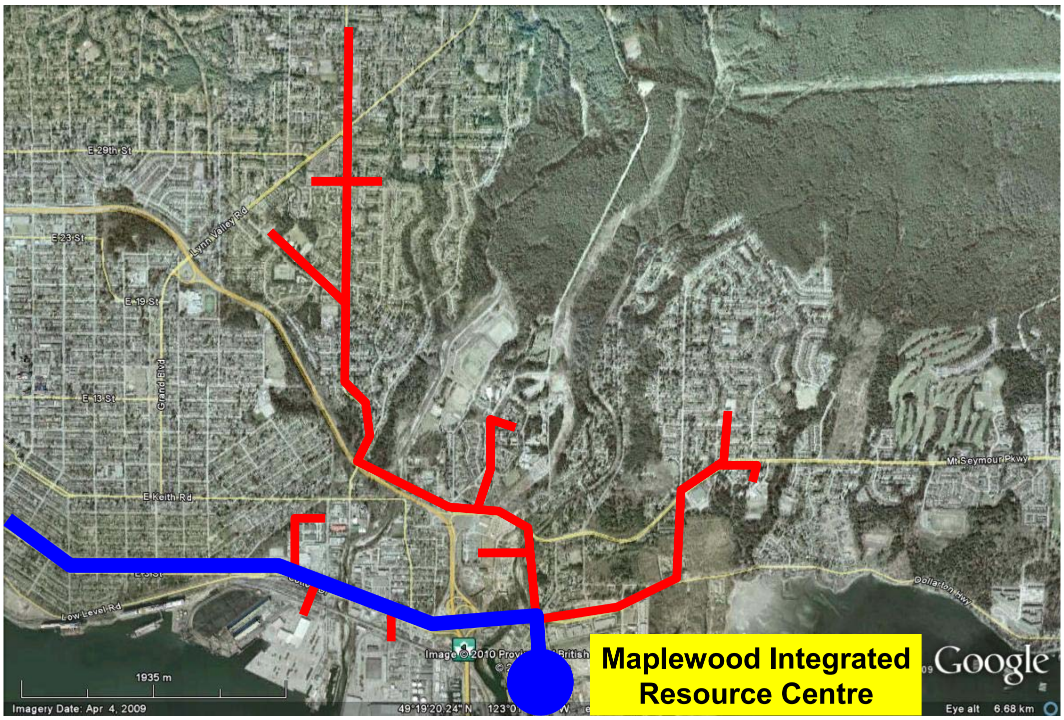

Figure 7: District Energy System at Maplewood

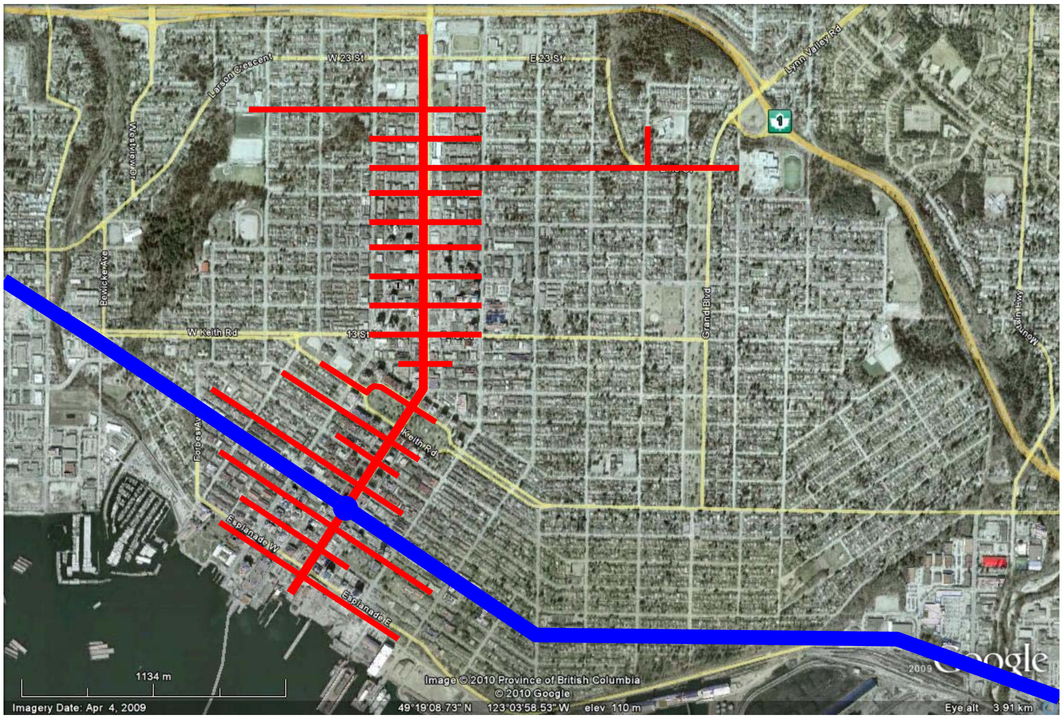

Figure 8: District Energy System at Lonsdale

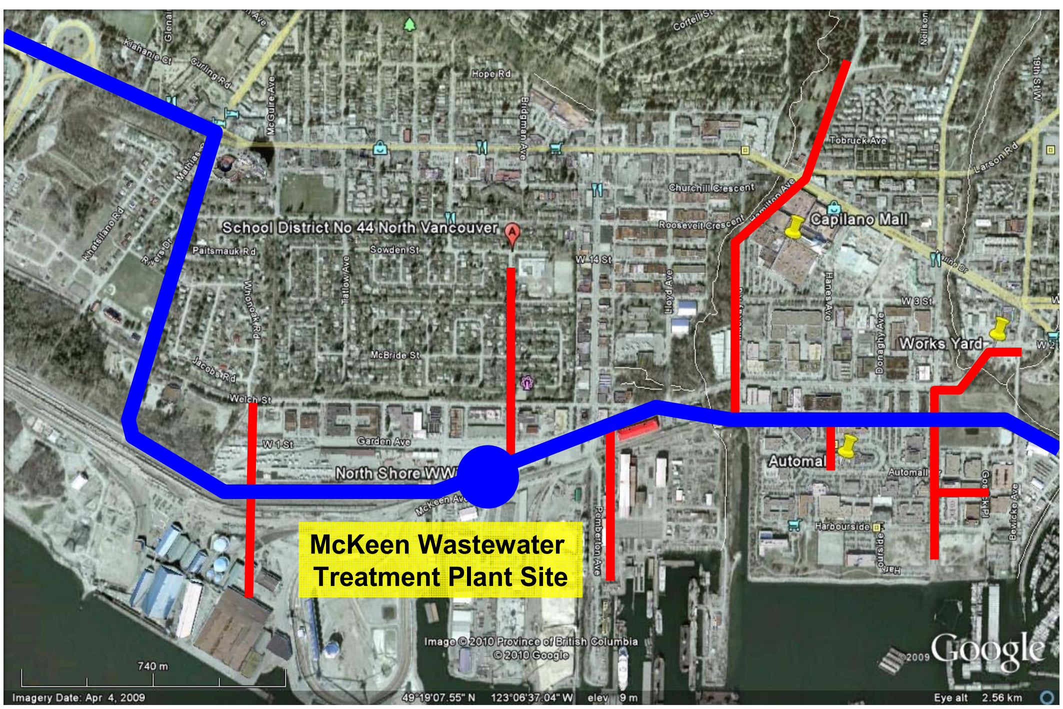

Figure 9: District Energy System at McKeen and McKay

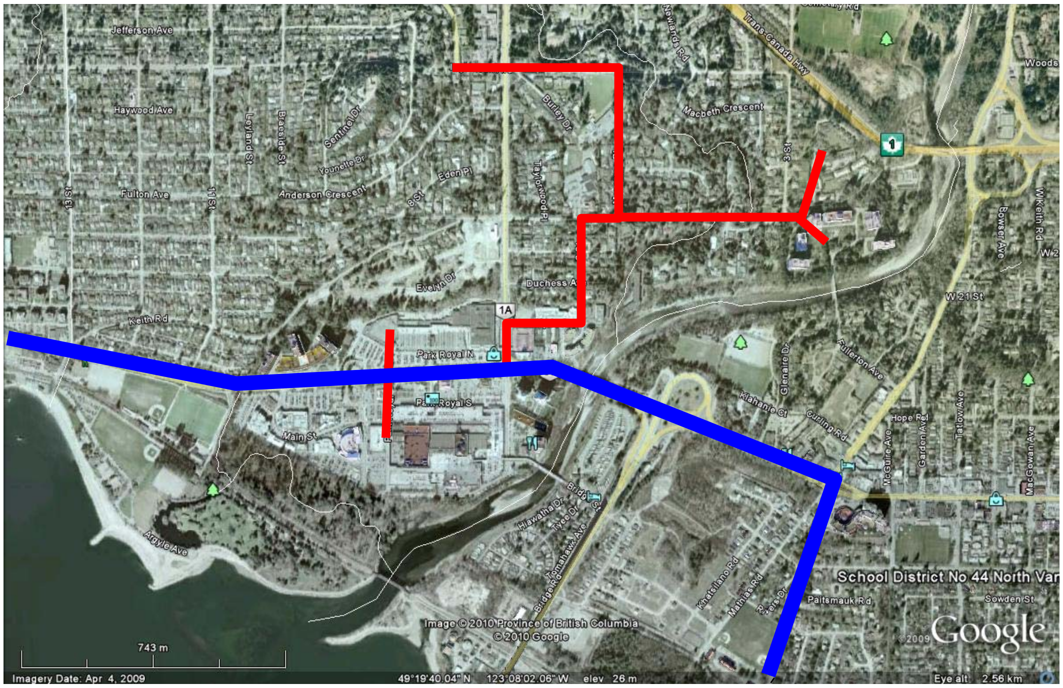

Figure 10: District Energy System at Taylor Way

Figure 11: District Energy System at Ambleside

The conceptual design of the WERCs and the centralized treatment plant are provided in the Technical Appendix (Facility Design– Wastewater Treatment).

The conceptual design of the Maplewood Integrated Resource Centre is also provided in the Technical Appendix (Resource Recovery from Solid Waste).

All facilities would meet all existing environmental regulations for discharged water quality and temperature, air emissions and noise levels. Details are provided in the Technical Appendix (Resource Recovery from Wastewater– Operation and Control).

Comparison of Energy from Distributed and Centralized Treatment Plants

Natural Resources Canada's RETScreen International program was used to calculate energy loads for the district energy systems adjusted for seasonality. The preference hierarchy for recovered resources in terms of highest and best use is:

- Cogeneration which produces revenues from tipping fees, electricity and compost as well as heat.
- Industrial waste heat from high-temperature sources, since electricity is not required to boost temperatures.
- Industrial cooling water which has a higher temperature than municipal wastewater.
- Municipal wastewater.
- Natural gas peaking boilers, due to high operating costs and release of GHGs.

Subject to running a full life cycle valuation, it follows that the highest and best use of recovered resources from a financial point of view is for infrastructure that maximizes use of cogeneration from organic waste processing and minimizes the use of natural gas peaking boilers. Industrial energy also adds value where it is available. The total energy provided by source under Scenario 1 and Scenario 2 is compared in Table 7 and Table 8.

Table 7: Energy Sources by Capacity, Scenario 1

Source	Capacity (MW)	Energy Provided (TJ/Year)			% of Total Annual Energy
		Summer	Winter	Annual	
Peaking Boilers	34.2	-	72	72	5%
Municipal Wastewater (Heat Pumps)	55.6	289	805	1,093	75%
Industrial Cooling Water (Heat Pumps)	2.1	-	33	33	2%
Industrial Waste Heat	-	-	-	-	-
Cogeneration	12.4	61	196	257	18%
Totals	**104.3**	**350**	**1105**	**1,455**	**100%**

Table 8: Energy Sources by Capacity, Scenario 2

Source	Capacity (MW)	Energy Provided (TJ/Year)			% of Total Annual Energy
		Summer	Winter	Annual	
Peaking Boilers[7]	40.2	-	65	65	4%
Municipal Wastewater (Heat Pumps)	38.9	-	614	614	37%
Industrial Cooling Water (Heat Pumps)	23.0	86	365	450	27%
Industrial Waste Heat	4.3	68	68	137	8%
Cogeneration	12.4	196	196	391	24%
Totals	**119.0**	**350**	**1,307**	**1,657**	**100%**

Because heat from cogeneration would be available only in the Maplewood neighbourhood under Scenario 1, this high-value heat would be less available to meet demands than under Scenario 2. Only 66% of heat required for the Lonsdale District Energy System would be available in Scenario 1. Heat recovered from wastewater in the Taylor Way and Ambleside neighbourhoods would just meet identified demands. Quantities and values associated with

[7] The RETScreen program suggests this value for peaking boilers, which has been used in the estimates of energy that will be provided by peaking boilers. The capital cost estimates in the Engineering Model however include capital for 80 MW of back-up/peaking boilers.

cooling were not included in this analysis because of the uncertainty of calculating location and quantity of demand. There is potential to access cooling by distributing cooled water in the district energy system via polymer pipes directly to customers. Alternatively, clients connected to district energy systems could replace their air conditioners with absorption chillers. More information is provided in the Technical Appendix (District Energy and Water System– District Cooling).

Energy balance diagrams for average winter and summer conditions as well as peak winter conditions are provided in the Technical Appendix. Subject to evaluation in the integrated financial model, we conclude:

On the North Shore, centralized treatment scenarios provide higher-value energy compared with decentralized treatment.

However there are a number of additional advantages to decentralized wastewater treatment that may apply in other parts of Metro Vancouver. Accordingly, a full triple bottom line evaluation of the two scenarios will be provided in the next section.

Centralized vs Distributed heat pumps

We evaluated whether heat could be transferred more efficiently through a central heat pump located at the central treatment plant or by distributed pumps located at demand centres.

For the North Shore, important synergies are possible by integrating heat recovery from liquid waste and industrial sources with heat recovery from cogeneration based on solid organic waste. However, there are some advantages to installing heat pumps in buildings – costs of district energy piping are lower as pipes do not have to be insulated and for some institutions such as hospitals, heat and cooling can be extracted from a single heat pumping system. The distributed design is applied to heating the Athletes' Village in Whistler and UBC's Okanagan Campus in Kelowna (See Technical Appendix– Conversion Technology Options– Options for Wastewater Treatment).

It is possible to design a hybrid system where treated water could be transferred at ambient temperatures and the pumps designed to serve a cluster of buildings. In this case the efficiencies gained by recovering energy from both solid and liquid waste would not be possible.

Generally, a centralized heat pump system provides higher and better use of recovered resources (financial returns) than decentralized pumps for the North Shore.

Higher Levels of solid waste diversion

As noted in the introduction, Metro Vancouver's ISWRMP recommends the diversion of all organic solid waste from disposal at landfills or mass burn incinerators. Accordingly, we undertook a Scenario analysis for diverting 90% of organic solid waste generated on the North Shore (Scenario 3) as well as diverting all the solid waste that will be handled by the NSTS at Maplewood (Scenario 4). In addition, we considered other options for recovering resources from solid organic waste streams to test that the conversion technologies applied at the Maplewood Integrated Resource Centre provided highest and best use.

For Scenario 3, where 90% of solid organic waste is diverted, the main difference from Scenario 2 is that food waste diversion is increased from an average of 56% to 90%. There is a small increase in wood waste collected, but no difference in yard waste because this is banned from landfills at present.

There is a 20% increase in the amount of waste diverted to resource recovery between Scenarios 2 and 3 and almost a doubling of the processed organic waste quantity between Scenarios 2 and 4. A full evaluation of these three options requires the full triple bottom line analysis presented in the next section. The implications between Scenarios are not fully apparent from either engineering or financial models alone.

Options for Resource Recovery from Solid Waste

The conversion technologies considered in this study include anaerobic digestion, gasification, cogeneration and composting. These technologies are evaluated in the Technical Appendix (Technical Methodology).

The main disadvantage of composting is its inability to recover energy. It also produces small quantities of greenhouse gases and potentially less fertilizer than anaerobic digestion, since volatile nitrogen compounds are lost during composting, but retained during anaerobic digestion.

Though landfilling organic material does not require source separation, decomposing organic waste in landfills produces methane, a potent greenhouse gas. It should be noted that landfill gas capture systems can only recover a portion of the total methane produced. Diversion of organic solid waste away from landfills will reduce their associated greenhouse gas emissions.

Scenario 5—Additional Options

We considered a number of options for resource recovery to understand better their advantages and disadvantages both for the North Shore and other parts of Metro Vancouver.

Note that the figures in the Tables comparing capital and operating costs in this section do not take into account the phasing over time of capital costs, replacement costs, operating costs, finance and revenues. These aspects are addressed in this study through the Valuation Model, the outputs of which are shown in the body of this report. Conclusions as to highest and best use and value were thus determined at an initial engineering level and do not have regard to the full life cycle valuation model, which was not undertaken for estimation purposes. More detailed analysis may change these conclusions.

Biomethane. The first of these questions concerned whether it was better to use biogas produced by the anaerobic digester directly for sale to Terasen Gas or to burn the biogas in a cogeneration facility to produce heat and electricity. Table 9 provides a comparison of inputs and outputs.

Table 9: Uses for Biogas

	Cogeneration	Biomethane	Difference
Annual Capex, Resource Recovery	$324,855,000	$319,843,000	-2%
Opex, Resource Recovery	$15,331,000	$15,756,000	3%
Heat Sold (GJ/year)	1,657,235	1,657,235	0%
Electricity Sold (GWh/year)	88,790	55,681	-37%
Electricity Used by Heat Pumps (GWh/year)	-106,135	-119,876	13%
Net Electricity Generation (Consumption)	-17,345	-64,195	270%
Biomethane Sold (GJ/year)	0	295,767	
Greenhouse Gas Reductions (CO_2e t/year)	208,900	222,500	7%
Annual Value of All Recovered Resources	$51,171,000	$50,393,905	-2%

There is a reduction in capital costs for cogeneration with the production of biomethane, as only the synthesis gas from the gasifier would be used for cogeneration. This is offset somewhat by the cost of equipment to upgrade the biogas and higher operating costs due to the need to purchase additional electricity to operate the heat pumps.

In the context of the North Shore, the highest and best use and value for biogas is therefore cogeneration. In the context of a farming community that is remote from concentrations of demand for heat, it could well prove that upgrading biogas to biomethane for sale to a gas utility would be its best use.

Industrial Heat Sources. Since Metro Vancouver does not have the same control over industrial heat sources as municipal waste streams, we calculated the incremental values of using excess industrial heat sources. These are low temperature heat from industrial cooling water and higher temperature heat from stack gases.

Table 10: Industrial Waste Heat

	With IWH	Without IWH	Difference
Capex, Resource Recovery	$324,855,000	$320,794,000	-1%
Annual Opex, Resource Recovery	$15,331,000	$16,898,000	10%
Heat Sold (GJ/year)	1,657,235	1,657,235	0%
Electricity Sold (GWh/year)	88,790	88,790	0%
Electricity Used by Heat Pumps (GWh/year)	-106,135	-148,807	40%
Net Electricity Generation (Consumption)	-17,345	-60,016	246%
Greenhouse Gas Reductions (CO_2e t/year)	208,900	207,700	-1%
Annual Value of All Recovered Resources	$51,171,000	$51,153,000	0%

Including industrial waste heat in an integrated resource recovery solution for the North Shore is modelled to result in a net reduction in operating expenses of approximately $2 million per year. In addition, reducing the temperature of industrial wastewater/cooling water before it enters the environment can be environmentally beneficial.

Wood Processing. Two options for processing wood for the gasifier were considered. One is to purchase wood chips from the market as there are firms in Metro Vancouver that provide this product now. The other option is to include a facility for chipping wood at the Maplewood site. We evaluated both options, as is shown in Table 11 for the 70% diversion rate.

The main difference between the two options is the access to tipping fees. In the wood purchase option, the processor would receive fees, whereas if wood is processed at Maplewood, the utility would receive the fees. The option of buying chipped wood from others would increase operating costs by approximately $620,000 per year, and would reduce revenues by approximately $2.2 million per year.

Table 11: Buying Wood Waste

	Chip on Site	Buy	Difference
Capex, Resource Recovery	$324,855,000	$323,686,000	-0.4%
Annual Opex, Resource Recovery	$15,331,000	$15,952,000	4%
Annual Cost of Purchased Wood Chips		$893,290	
Annual Cost of Processing On Site	$272,640		
Annual Value of All Recovered Resources	$51,171,000	$48,899,000	-4%

Processing Biosolids. As noted earlier**,** Metro Vancouver's current practice is to process biosolids at wastewater treatment facilities. There is a concern that transporting unstabilized biosolids across the North Shore will raise public concerns. We evaluated both options for processing biosolids at McKeen and at Maplewood. The results as applied to Scenario 2 are shown in Table 12.

Table 12: Processing Biosolids

	Maplewood	McKeen	Difference
Capex, Resource Recovery	$324,855,000	$306,051,000	-6%
Opex, Resource Recovery	$15,331,000	$13,906,000	-9%
Greenhouse Gas Reductions (CO_2e t/year)	208,900	203,200	-3%
Annual Value of All Recovered Resources	$51,171,000	$46,153,000	-10%

Note: The technical appendix also discusses the possibility of transporting biosolids through a pipeline.

More detailed analysis is suggested prior to making a decision on this item. There are advantages to processing biosolids at McKeen – reduced transportation costs; stabilized material on site. There are also advantages to processing biosolids at Maplewood such as the use of relatively inexpensive energy to dry biosolids and economies of scale in design of digesters and gasifiers. The costs that Metro Vancouver currently pays for processing digested biosolids into a soil amendment would be saved if the biosolids were processed at Maplewood. This has been factored into the revenue streams.

In the triple bottom line analysis presented in the next section, all of the sensitivity analyses in Scenario 5 will be compared with Scenario 2 based for the 70% diversion rate for solid waste.

Environmental Aspects

The main environmental criteria in the triple bottom line analysis include the reuse of water for improving steam ecological health and the reduction of greenhouse gas emissions.

Water Reuse

Streams on the North Shore have reduced ecological function due to historic development and the large extent of impervious surfaces. These impervious surfaces result in higher winter flows due to increased runoff and lower summer flows due to reduced groundwater recharge. As redevelopment occurs on the North Shore, opportunities should be taken to reduce impervious cover and increase rainwater infiltration into the ground. This could ultimately improve the base flows of all North Shore streams. Dual piping should be built into all new developments and retrofitted, wherever viable, into existing buildings such that reclaimed water and/or captured rainwater can be used to replace potable water for non-potable applications. This would permit more water to remain in the Capilano and Seymour Rivers for in-stream ecological purposes and provide a buffer against unpredictable changes in rainfall and snowpack. A comprehensive water model should be developed that considers:

- Demand management;
- Potential for reclaimed water use;
- Rainwater capture and groundwater infiltration; and
- Predicted hydrometric changes as a result of a changing climate.

These activities are consistent with Metro Vancouver's Drinking Water Management Plan.

Maplewood Flats is one of the best candidates for wetland improvement using reclaimed water. The current volume of pumped groundwater should be tracked during the summer of 2011 to determine the amount required for augmentation. Since Maplewood Flats is very close to the Maplewood Industrial Park, it is possible that some of the reclaimed water transported in the District Energy and Water System proposed in the Centralized IRR Scenario could replace groundwater as a source for wetland augmentation.

Capilano River requires additional water and nutrients to improve its health. The most effective way to increase flows would be to release water from the reservoir in the summer into the stream instead of into the water distribution system. In order to free up water to accomplish this goal, the water required by industry for non-potable purposes could be replaced with treated water from the wastewater treatment plant.

Brothers Creek, a tributary of the Capilano, is presently licensed for irrigation by the Capilano Golf and Country Club (9.5 Acre Feet for storage and 147.4 Acre Feet for irrigation annually). Since this water is accessed primarily in summer, displacing this water with reclaimed water would permit summer flows in Brothers Creek and the lower Capilano to be partially restored.

Mission Creek is the main tributary to Wagg Creek and though it has good fish habitat, summer base flows are too low to support fish. Groundwater has been identified as a significant contributor to in-stream flow during low flow periods for both Mission and Wagg Creek (Gartner Lee Ltd., 2004). Groundwater flows can be enhanced through land use planning and minimizing Effective Impervious Area (EIA) or through groundwater recharge with reclaimed water.

GREENHOUSE GAS REDUCTION

The Technical Appendix (Greenhouse Gas Analysis) provides a detailed assessment of the reduction of greenhouse gases associated with each of the six scenarios. The results are illustrated on Table 13, which indicates greenhouse gas emission reductions on the North Shore assuming implementation of Scenario 2. [8]

Table 13: Estimated GHG Reductions, North Shore

	GHG Emissions, 2007 (tonnes/year)
City of North Vancouver[9]	214,323
District of West Vancouver[10]	263,121
District of North Vancouver[11]	412,924
Total	**890,368**
Estimated Reduction in GHG Emissions (Scenario 2)	208,941
Estimated Reduction in GHG Emissions	**23.5%**

The reduction is estimated to total 208,941 tonnes CO_2e or 23% below emissions in 2007. About half of this amount is associated with reductions in methane release from landfills due to diverting most of the organic material to resource recovery facilities. The remaining reductions are due to replacing natural gas with heat from wastewater (25%) and from cogeneration and reuse of industrial waste heat (25%). Details of GHG reductions are presented in the Technical Appendix (Greenhouse Gas Analysis). GHG and other resource assessments are taken into the valuation model to assess total impacts over the projection period and are commented on in the *Financial and Triple Bottom Line Analysis*.

GHG reductions will vary with Scenario. The greater the diversion of organic solid waste, the larger the GHG reductions. This relationship is shown in Figure 12.

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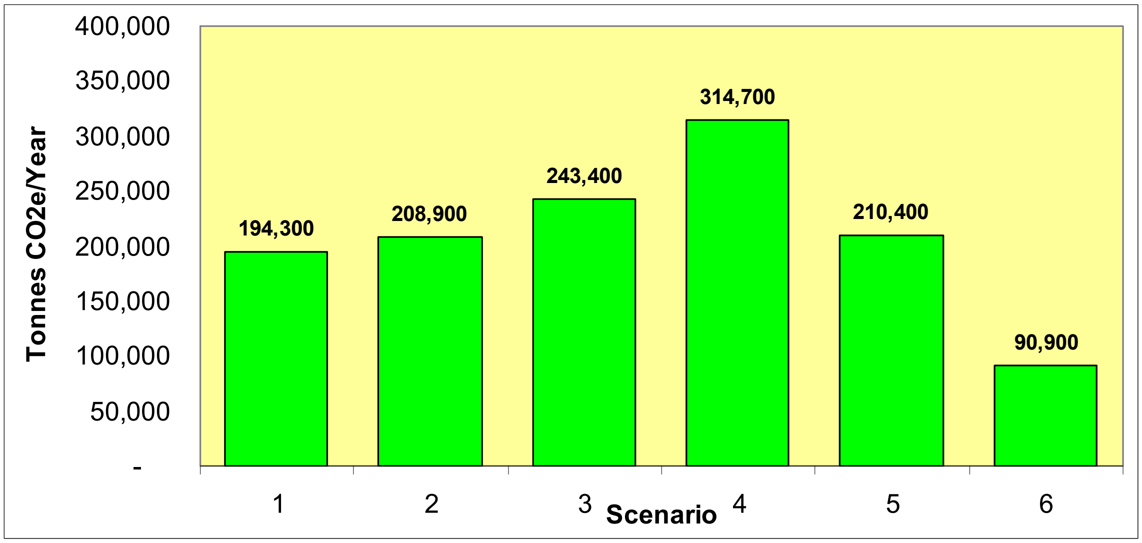
[8] It should be noted that Table 13 represents the initial "Base Year" GHG reductions. The valuation model projects how this will change over time.

[9] Province of British Columbia. 2010. North Vancouver City, Updated 2007 Community Energy and Emissions Inventory. 8pp.

[10] Province of British Columbia. 2010. West Vancouver District Municipality, Updated 2007 Community Energy and Emissions Inventory. 8pp.

[11] Province of British Columbia. 2010. North Vancouver District Municipality, Updated 2007 Community Energy and Emissions Inventory. 8pp.

Figure 12: Estimated GHG Emission Reductions by Scenario



Environmental Regulations

All the resource recovery facilities would meet existing and proposed environmental regulations for liquid waste treatment and for air emissions. The central and the distributed treatment plants would achieve the proposed new standard for secondary treatment required by both the federal and provincial governments. The use of treated wastewater for industrial purposes would meet higher treatment levels to be consistent with public health standards for potential human contact. The discharge of treated wastewater to aquifers proposed for Maplewood Flats and some of the smaller streams would meet the standard under review by the Ministry of Environment in the Municipal Sewage Regulation.

The modeling completed in this study indicates that source separation of solid organic waste can result in a greater degree of resource recovery, and a net highest and best use and value of these resources than would be the case for mixed-waste disposal options.

Social and Community Effects

Depending on the selected route, construction of the DEWS line and district energy systems for resource recovery in Scenarios 2 to 5 could result in construction disruption. Trucking unstabilized biosolids created at the central treatment plant to Maplewood would require significant public engagement prior to a decision being made. The Integrated Resource Centre at Maplewood may require zoning approval and any waste-to-energy facility will be subject to close public scrutiny.

There will have to be economic advice to building owners to help them understand the benefits associated with replacing existing gas-fired boilers with district energy. The financial success of the IRR Scenarios lies in connecting new developments and redevelopments to the new infrastructure.

Consistency with Metro Vancouver and Municipal Planning

Both Metro Vancouver and the North Shore municipalities have outlined ambitious policies for recovering resources and reducing greenhouse gases. These have been outlined in the opening section of the report. We conclude that the IRR scenarios outlined here appear to contribute materially to all of these goals, targets and policies; however, it will not be possible to achieve them without the scope of change outlined in this report. Transformative rather than incremental change will be required to achieve these sustainability goals and this report has outlined the nature of such a change.

The financial impacts, as well as the risks that attend such changes, are discussed in the following section where the triple bottom line analysis is presented.

8 Financial and Triple Bottom Line Analysis

This section summarizes the financial model constructed to assess each of the scenarios for resource recovery. Summary comments on the financial components are provided first, followed by an overall assessment of the results of the analysis. Details of assumptions and financial analyses are presented in the Technical Appendix.

8.1 Economic Summary

Standard valuation practice is to include an overview of aspects of the economy that might affect value. This section provides a brief summary of factors.

The economy is recovering from the 2008 global downturn, with different markets at varying stages of recovery, which continues to be both patchy and fluctuating. In the near term, this reduces pressure on energy prices but as the global economy strengthens there is likely to be increased upward pressure on energy prices and resources. This will tend to increase revenues for resource recovery.

Economic and/or population expansion would result in North Shore projects accelerating, bringing forward demand for waste processing and in consequence, increasing net revenues. It is currently difficult to predict how quickly this will happen, or where the precise demand will occur and in what phases. Components of the proposed solid waste infrastructure have been designed to adapt on a "just-in-time" basis to provide for this flexibility, but not for wastewater treatment, as set out in the Scope of Work.

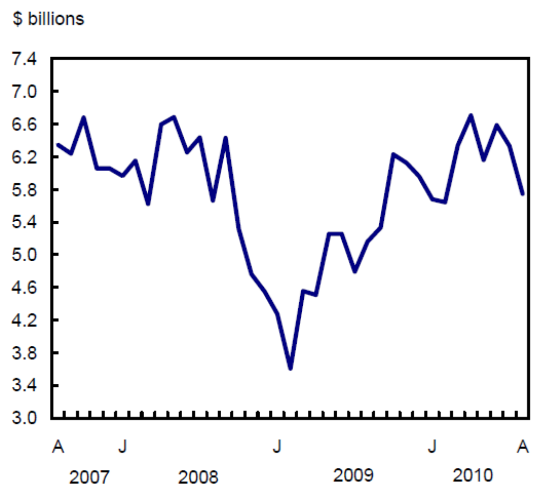


Figure 13: Building Permits, Canada (Stats Canada)

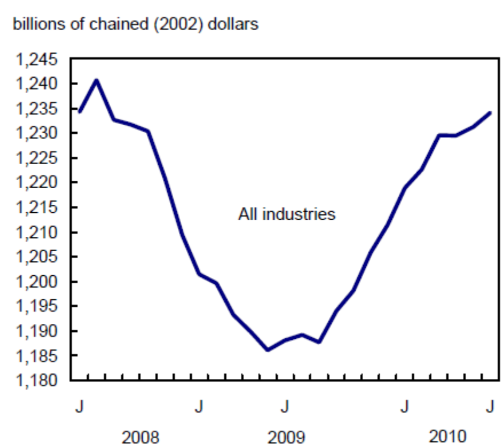


Figure 14: GDP Trend (Stats Canada)

8.2 Financial Analysis

The following provides a summary of the principal financial considerations and approaches. Further detail is provided in the Technical Appendix. We note that the analysis was commenced in late 2009 and completed in early 2011, so 2010 dollars and relative periods have been used for consistency.

Costs. The model provides life cycle cash flows for costs in all six scenarios. Costs include all capital costs, operational and maintenance costs and replacement cost over the life of each component. Related engineering and design (or "soft") costs are included. Costs were spread over appropriate periods having regard to pre-construction design, project management and construction periods. Capital cost and capital replacement was similarly applied, adjusted for item-specific inflation, net of background inflation (*i.e.* the model is "real" – in 2010 dollars).

Engineering cost estimates were based on estimates from equipment providers where available. Contingency was built into all cost estimates. Operating and other related costs were also included and phasing applied to each cost component.

Revenues. Revenues were based on prices dominantly for heat and electricity, as stated in the previous section of the report. Energy values were not assumed to grow above inflation during the project period. Carbon taxes and credits were also not assumed to increase over current legislated levels. Revenues were, however, increased in proportion to the growth in population, as more waste would be processed and create more saleable energy.

Inflation. The model uses 2010 values and does not include inflation. We chose a 1.2% background general inflation rate (per Stats Canada and BC Stats) as the base, but added inflation for specific components *e.g.* construction and staff costs where these were judged to be different from the background rate.

Energy prices have a significant influence on both inflation and the model and careful consideration was given to energy price trends. There appears to be little agreement on the future of energy price trends, except that they are usually expected to rise. However, the Principle of Substitution suggests that in a competitive market, consumption will, in the long-term, switch to alternative energy sources. This adjustment occurred following the 1970's oil crisis and again in 2008 when oil prices again peaked. The base assumption is considered conservative, but practical, given unpredictable and fluctuating trends. It is important to note therefore, that the model will tend to understate potential profit, especially for scenarios with high energy generation.

Absorption. Through discussions with selected private and public sector owners we tested the level of interest and acceptance of accessing the proposed district energy system. The model is adjusted for conservative absorption periods for energy contracts and revenues. Pre-completion sales will be important to addressing this risk, much as condominium pre-sales are handled in the residential development sector. We believe that contracts can be secured and this is a manageable risk but recognize that this factor will require more analysis in the next phase.

Absorption is also affected by population growth and development. Because development is driven by markets and is thus uncertain, we used population growth as a proxy for growth in waste resources. These projections assume that all the developments proposed for the North Shore and Squamish First Nation lands could be served by recovered resources from the IRR system.

Risk. Risks were continually assessed during modelling, with some solutions embedded in either system design or the financial model, or through sensitivity analysis. Sensitivity analysis was used to identify the importance of key assumptions and is included in the Technical Appendix.

Limitations of scope and budget meant that full assessment of risk and calculation of a risk-adjusted financial assessment was not possible. More work on this will be necessary if the project is to proceed. However major risks were identified and to the extent possible, mitigation strategies assessed and costed, and included in the model. This is explained in a later section of this report.

Financing. Various financing models were considered. Metro Vancouver generally uses 15-year amortization period, which will tend to increase annual payments but spread them over a short period, compared with life cycle financing which spreads financing over the life of the project. Life cycle financing increases the total loan cost, but reduces annual interest payments to the point where for certain scenarios, annual revenues exceed annual costs.

Both financing approaches were tested. A reasonably standard financing model was proposed as an alternative with debt being transferred to bond as expenditures occur. We used the Municipal Finance Authority rates. The two financing approaches are compared and discussed later in this section.

Discounting. Standard practice is to use Discounted Cash Flow ("DCF") models with associated standard financial metrics. However there is increasing concern internationally that sustainable projects may be disproportionately affected by discounting, because benefits are typically long-term and discounting depreciates this value. We have thus calculated undiscounted values in the model as well as discounted values for comparison.

A discount rate of 7.5% gross was selected (6.3% real, after deducting background inflation). Research was undertaken with international banks, checked with a number of experts, and several discount rates were run as a sensitivity analysis. Choice of discount rate proved one of the most sensitive aspects of the project.

Growth and Phasing. The analysis uses the population projection from the Metro Vancouver Regional Growth Strategy document which is based on provincial statistical projections (BC Stats' P.E.O.P.L.E model). This is a risk factor as growth projection over 50 years is difficult to predict. In accordance with the terms of reference, engineering designs for a wastewater plant assumed 2046 growth projections. Given the rapid improvement in treatment technology, some components in the solid waste recovery infrastructure were phased to take advantage of such changes. This incremental approach did not apply to the district heating system and other major infrastructure that would be difficult to phase.

Shadow Price of Carbon. The 2006 Stern Review elevated concerns regarding pricing carbon.[12] Lord Stern noted that the cost of carbon to society is not fully reflected in the market. Subsequently the UK government mandated the use of a "Shadow Price of Carbon" [or "SPC"] for government projects[13] to address this possible market failure.

The true cost of carbon is an impact on society as a whole, therefore including it in business cases reflects the latent risk and cost of decisions. The premise behind the SPC in the UK is that government should not knowingly commit pollution, and that the cost must thus be considered. This is why the cost to society is assessed in the UK.

BC has introduced carbon tax and carbon credits, but the combined effect is less than the UK's analysis of the true cost of carbon. We have thus included the SPC in reporting, using the UK government's mandated calculation table and method[14], as being representative of international evidence-based best practices. The impact of SPC is considerable.

Incrementalism. The prospect of an incremental approach for some components of the resource recovery infrastructure provides an opportunity to charge the cost for additional infrastructure as and when needed. This is a policy implication of IRR that is considered in the governance section of the report.

Capacity for liquid waste treatment is included to 2046. An alternate incremental approach would be possible and benefit financials by significant cost reduction for certain plant. Solid waste phasing was assessed and included in modelling.

Life Cycle Evaluation. The model provides a projection of likely costs and revenues for resource recovery projects over 50 years. This is termed "full life cycle valuation". The importance of this is shown by the financial conclusions and in the Technical Appendix. The model simulates how more sophisticated commercial investments are modelled and will be familiar to business and the financial community. A 50-year projection was chosen to most closely approximate the life cycle of some of the major capital plant. Residual life cycle and capital replacement, with associated soft costs, were included in the method and assessment.

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[12] Lord Stern's comments build on the work in the Millennium Ecosystem Assessment, see explanation of work by Satharithai and Barbier, reviewed in World Resources Institute " banking on nature's assets", http://pdf.wri.org/banking_on_natures_assets.pdf

[13] See UK government's analysis with technical responses, or the explanation of how to use SPC in public sector valuations.

[14] The calculation table increments the SPC annually to take account of increasing GHGs and their indicated compound effect. This is not a single figure, since the amounts vary over time. The calculation has been adjusted based on each Scenario's projected GHGs in the year they happen. The reader is referred to the UK government's DEFRA web site for more information on SPC, and the Technical Appendix.

8.3 Financial Results

Table 14 summarizes the key financial and non-financial results for the six IRR scenarios. Column 7 provides comparative financial information for replacing the Lions Gate Treatment plant without heat recovery.

Table 14: Scenario Summary

Key financial indicators	1	2	3	4	5	6	7
1: Initial CapEx (inc. softs, contingency) - PV	-$376m	-$360m	-$368m	-$396m	-$341m	-$298m	-$148m
2: Net total value - PV (pre-finance)	-$228m	-$106m	-$83m	-$24m	-$206m	-$258m	-$249m
3: Net total value after finance - 2010$$	-$766m	-$64m	$44m	$336m	-$542m	-$797m	-$1,101m
4: Estimated average subsidy per taxpayer	-$70/yr	-$19/yr	-$16/yr	-$28/yr	-$48/yr	-$69/yr	-$93/yr
5: Estimated average subsidy/home	-$177/yr	-$48/yr	-$41/yr	-$70/yr	-$120/yr	-$174/yr	-$234/yr
6: Estimated duration of taxpayer subsidy	48yrs	31yrs	23yrs	6yrs	50yrs	50yrs	50yrs
7: Taxpayer ROI (contributed tax as equity)	-97%	-52%	57%	1,041%	-100%	-100%	-100%
8: Estimated IRR before tax & finance	Not calculable	Not calculable	Not calculable	Not calculable	Not calculable	Not calculable	Not calculable
Key resource recovery indicators	**1**	**2**	**3**	**4**	**5**	**6**	**7**
9: Total projected energy generated	5,132 GWh	5,132 GWh	5,774 GWh	7,935 GWh	2,743 GWh		
10: Total tonnage processed/generated	112,000 tonnes	112,000 tonnes	136,000 tonnes	200,000 tonnes	60,000 tonnes		
11: Total water recovered	2,560 Mm3	2,560 Mm3	2,560 Mm3	2,560 Mm3	2,560 Mm3	2,560 Mm3	
12: Total CO2e reduction	11.1 mtCO2e	11.9 mtCO2e	13.9 mtCO2e	17.9 mtCO2e	12.0 mtCO2e	5.2 mtCO2e	
13: Relative total Shadow price of carbon (benefit)	-$616m	-$432m	$0m	$893m	-$413m	-$1,910m	

Scenarios
1. Distributed WW Treatment, Maplewood Energy Plant, 70% Diversion
2. McKeen WW Treatment, Maplewood Energy Plant, 70% Diversion
3. McKeen WW Treatment, Maplewood Energy Plant, 90% Diversion
4. McKeen WW Treatment, Maplewood Energy Plant, Current Transfer Station Volume
5. McKeen WW Treatment, Maplewood Energy Plant, 70% Diversion, Revenue Modified
6. McKeen WW Treatment, Heat Recovery from Wastewater Only
7. McKeen WW Treatment Only

Greater detail on each Scenario is provided in the Scenario Dashboard Appendix starting on page 82. Table 14 is interpreted as follows:

- Line 1 notes the initial capital costs and associated soft costs, excluding life cycle costs and revenues, expressed as a present value. This is a common method of evaluation. Under this metric Scenario 6 provides the least-cost IRR solution. On a least-cost present value basis, none of the other resource recovery models would be chosen due to higher capital and operating costs associated with full resource recovery. The approximate proportions are shown in Figure 15.

- Line 2 includes life cycle costs and revenues and shows the present value for each Scenario, before finance. This suggests that Scenario 4 is best and Scenario 3 is also marginally positive. Scenario 2 while a net loss is still superior to scenario 6. The revenues are illustrated in Figure 16.

- Line 3 assesses full life cycle valuation after finance in 2010 constant dollars. On this metric, Scenarios 1 and 6 are least preferred, with Scenarios 3 and 4 indicating a positive net value to the taxpayer (*i.e.* a net dividend). All Scenarios are superior to replacing Lions Gate plant alone, since the full capital and operating costs would have to be taxpayer-supported for the life cycle (separately estimated to exceed $1.1bn, after finance).

- Line 3 also demonstrates that integration of solid and liquid wastes provides significantly more net value than IRR from liquid waste alone.

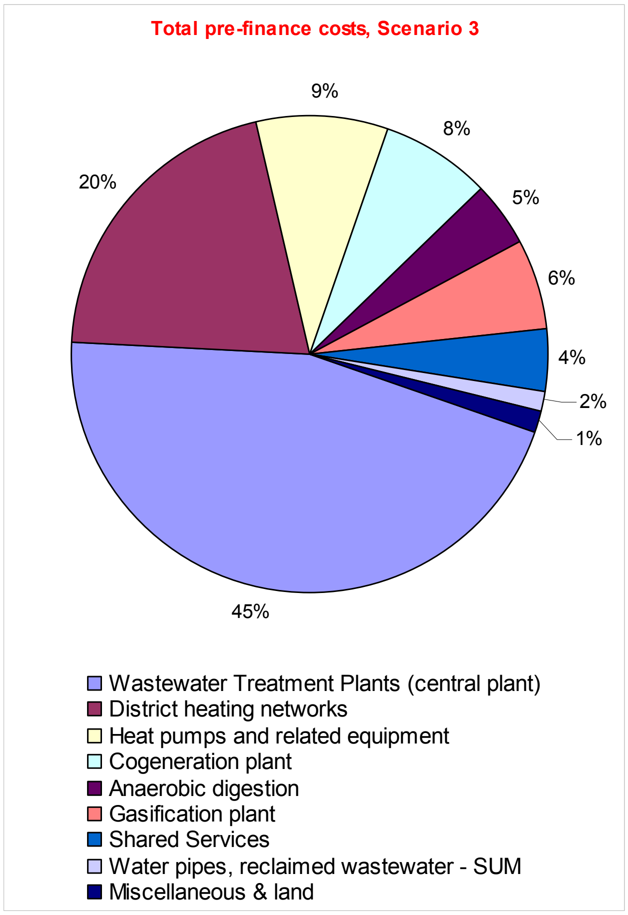


Figure 15: Scenario 3 Cost Sources

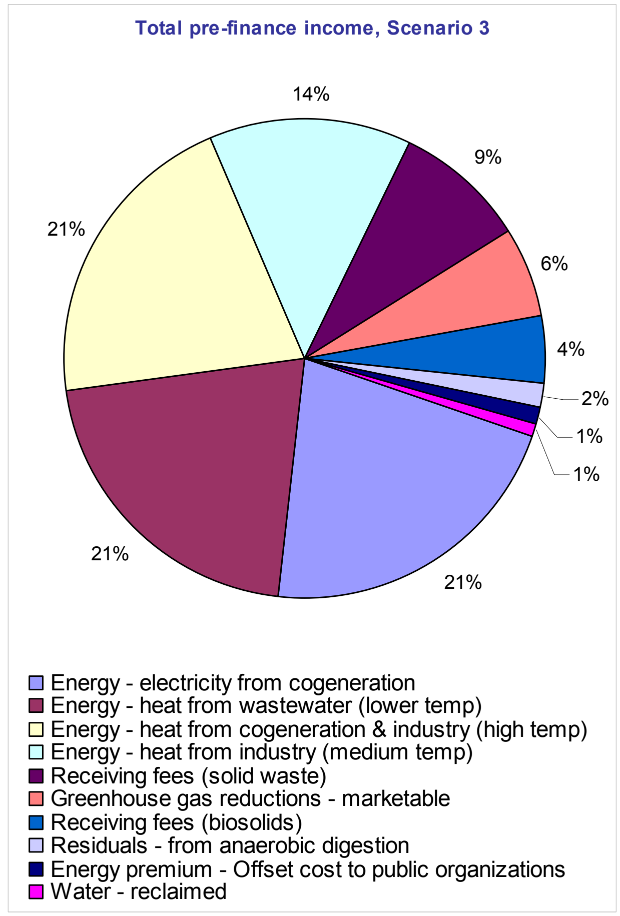


Figure 16: Scenario 3 Revenue Sources

- Lines 4 and 5 are included to provide an initial indication of how long term financing can affect the cost per residence. This should be considered an indicative average only. More detailed analysis is provided in the Technical Appendix. Generally speaking, Scenarios 2, 3, and 4 are similar and all are preferable to Scenarios 1, 5, and 6;

- Line 6 summarizes the duration of estimated taxpayer subsidy, because each scenario requires different durations of taxpayer funding, until revenues can support costs. An example of this is provided in Figure 17, which shows a short term peak subsidy in the order of $175/home. Scenarios 2, 3, and 4 are similar in needing shorter durations of taxpayer support;

- Lines 7 and 8 show financial results. More detailed interpretation follows on these conclusions;
- Lines 9 through 13 show present key resource recovery indicator totals for the entire life of the projection. This more completely shows the potential quantity of resources recovered from a decision to pursue a specific scenario. It shows that Scenario 4 is superior, followed by Scenarios 3, 2 and 1.
- Line 13 shows the Shadow Price of Carbon ["SPC"], based on the UK's mandated calculation relative to Scenario 3. This indicates that some scenarios could substantially increase the cost to the public, if carbon impact from waste processing is not properly taken into account. [15]
- Traditional financial indicators are difficult to calculate since the cash flow produces revenues that swing between positive and negative, making an Internal Rate of Return impossible to calculate. The varying cash flow is illustrated by Figure 17 and is shown in greater detail for each scenario in the Scenario Dashboard Appendix starting on page 82;
- Scenario 4 is financially superior across many indices; however, it relies on wastes from Burnaby and Vancouver. This is discussed further in the Triple Bottom Line analysis.
- A cash-on-cash return could be calculated for revenue-positive Scenarios (3 and 4), and shows 57% and 1,041% returns for Scenario 3 and 4 respectively, in 2010 dollars, relative to taxpayer equity contribution, after debt. These levels of return on equity would likely only be of interest to the private sector if the public risks can be fully managed.
- Because the business being valued is normally considered a cost-oriented government activity (waste treatment), it is unusual for it to be profitable in a traditional sense. For consistency a life cycle valuation model was run to compare against Lions Gate replacement. Scenario 3 is estimated to be $1.14bn better than replacement of Lions Gate without resource recovery, with Lions Gate replacement being reliant on taxpayer funding.
- Figure 15 shows that the dominant share of revenues are from products dependent on the district energy system, comprising approximately 60% of the revenues. Thus while the DEWS line is a significant portion of total costs, it is necessary to maximize potential revenue. This also means that it is difficult to phase the system since the main infrastructure is needed from inception.
- The distributed waste water treatment option (Scenario 1) is financially less attractive than centralized treatment (Scenario 2) and also results in less greenhouse gas reductions.

[15] The SPC is explained in brief on page 52 and in the Technical Appendix. To re-state, the calculation is a non-market evaluation in effect similar to the cost to the economy from the results of climate change for each Scenario. For further information please refer to the UK Government's explanation.

However on a triple bottom line analysis, it has advantages in flexibility in location, taking advantage of newer technologies in the future to phase its development.

- All scenarios assume separation of waste materials and diversion, with differing levels of diversion. This is a risk item but also an externality, since it excludes the cost of managing the greater waste volumes.

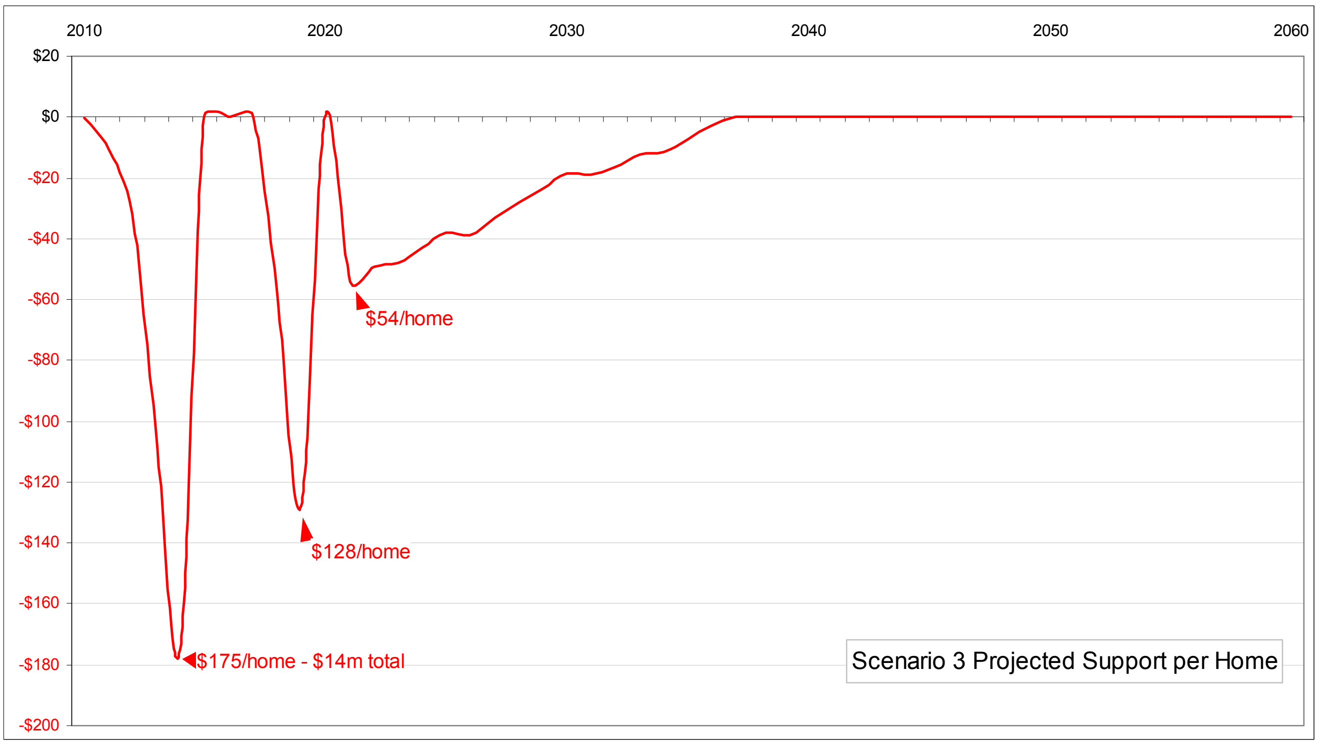


Figure 17: Scenario 3 Estimated Taxpayer Cash Flow

- Table 14 illustrates that a discounted analysis produces appreciably different results than an undiscounted analysis, *i.e.* consistent with international analysis on problems with discounting. Using Scenario 3 as an example, the discounted conclusion shows a loss of $368m, a loss of $183m once revenues are considered. An undiscounted analysis shows a small profit, of $44m.

An analysis of the impact on the taxpayer for each scenario is shown in Table 15. We caution that the cost per taxpayer or residence is an estimate only, since more detailed balancing of how tax would be charged are outside the scope of work. We note:

- Line 1 shows the total subsidy required from taxpayers and as noted previously, this varies because of (a) the cost of the scenario, and (b) the speed at which revenues pay for project costs. Line 2 shows that with the exception of Scenario 6, positive revenues are generated that contribute to a sinking fund, with Scenarios 5 and 6 generating the least value. Line 3 shows the net benefit or subsidy to the taxpayer. Line 4 is an indicator of the total returns as a percentage of taxpayer subsidy. As before, Scenarios 2, 3, and 4 are superior.

- Lines 5 through 7 provide present values based on an all risk discount rate which again show Scenarios 2, 3, and 4 as being best.
- Line 8 shows the peak year's subsidy with Scenarios 2 through 4 being similar, largely due to having similarly priced plant. Lines 9 through 12 show an estimated equivalence per taxpayer and per residence.
- As previously noted, the duration of required taxpayer support varies, as shown by Line 13.

Table 15: Post-Finance Taxpayer Summary

Post-finance summary		1	2	3	4	5	6
1	Total of all tax subsidies	-$792m	-$123m	-$77m	-$32m	-$544m	-$797m
2	Sinking fund surplus at term	$95m	$110m	$211m	$664m	$9m	
3	Net taxpayer dividend (subsidy), 2010$$	-$766m	-$64m	$44m	$336m	-$542m	-$797m
4	Taxpayer return on investment (cash on cash)	-97%	-52%	57%	1,041%	-100%	-100%
5	Total taxpayer dividend (subsidy), PV @ 6.3%	-$156m	-$42m	-$18m	$44m	-$145m	-$203m
6	PV, sinking fund @ 6.3%	$4m	$5m	$10m	$31m	$0m	
7	Net taxpayer dividend (subsidy), PV @ 6.3%	-$151m	-$37m	-$8m	$76m	-$144m	-$203m
8	Maximum taxpayer subsidy required	-$23m	-$13m	-$13m	-$16m	-$22m	-$28m
9	Maximum subsidy per taxpayer/yr	-$111	-$67	-$70	-$81	-$107	-$140
10	Average subsidy per taxpayer/yr	-$70	-$19	-$16	-$28	-$48	-$69
11	Maximum subsidy per home	-$280	-$168	-$175	-$203	-$269	-$353
12	Average subsidy per home	-$177	-$48	-$41	-$70	-$120	-$174
13	Subsidy duration (yrs)	48yrs	31yrs	23yrs	6yrs	50yrs	50yrs

- For taxpayers, the reason to improve garbage separation is shown by comparing Line 5 for Scenarios 2 and 3 in Table 15. Line 11 in Table 15 shows a maximum of approximately $7/residence in extra taxes will be needed to obtain an appreciable increase in waste reduction and move towards achieving a dividend.

  We should note that Scenario 2 does not include the full costs of managing the 30% of waste not covered by Scenario 2, which we expect would further reduce the $7/residence margin. The Triple Bottom Line analysis (Table 17) redresses this by ranking the scenarios and having regard to the external cost of landfill or other disposal model.

8.4 Recovered Resources

The recovered resources used to generate revenues were counted both as an average and as totals. The inclusion of totals makes the decision to move towards resource recovery more accountable as the total benefits are inadequately reflected by annualised averages. Some of these relate to sustainability framework metrics being tracked by Metro Vancouver:

- Total renewable electricity generated in MWh;
- Total solid waste diverted in tonnes;
- Total water recovered in cubic metres; and
- Total greenhouse gas reductions in tonnes of CO_2 equivalent.

Summarized results are included in Table 14. The detailed resources recovered are noted in Table 16.

Table 16: Recovered Resources

Resource recovery summary - total volume	1	2	3	4	5	6
Solid waste wet tonnes (input charge)	4,353,157 tonnes	4,353,157 tonnes	5,252,540 tonnes	7,908,200 tonnes	1,714,821 tonnes	
Biosolid dry tonnes (input charge)	384,431 tonnes	384,431 tonnes	384,431 tonnes	384,431 tonnes		
Electricity from cogeneration	5,131,702 MWh	5,131,702 MWh	5,773,799 MWh	7,934,878 MWh	2,742,667 MWh	
Heat from cogeneration & industry (high temp)	16,803,318 GJ	30,679,071 GJ	33,818,046 GJ	42,505,115 GJ	13,407,881 GJ	
Heat from wastewater (lower temp)	61,449,851 GJ	35,778,227 GJ	34,352,805 GJ	29,555,322 GJ	75,213,368 GJ	87,390,522 GJ
Heat from industry (medium temp)		23,749,297 GJ	22,323,875 GJ	19,231,686 GJ		
Energy sold to public organizations - 25.0% of supply	19,754,967 GJ	23,037,898 GJ	23,114,207 GJ	23,324,559 GJ	22,372,383 GJ	22,061,686 GJ
Energy - biofuels					10,901,504 GJ	
Reclaimed water (total)	2,559,910,505 m3	2,559,910,505 m3	2,559,910,505 m3	2,559,910,505 m3	2,559,910,505 m3	2,559,910,505 m3
Reclaimed water (identified saleable)	105,703,554 m3	105,703,554 m3	105,703,554 m3	105,703,554 m3	105,703,554 m3	105,703,554 m3
Residuals from anaerobic digestion	1,717,301 tonnes	1,717,301 tonnes	2,218,904 tonnes	3,253,464 tonnes	1,782,579 tonnes	
GHG reductions - total	11,071,928 tCO2e	11,908,884 tCO2e	13,873,935 tCO2e	17,938,953 tCO2e	11,993,652 tCO2e	5,181,617 tCO2e
GHG reductions - marketable	9,872,329 tCO2e	10,709,286 tCO2e	12,674,336 tCO2e	16,739,354 tCO2e	10,794,053 tCO2e	3,982,018 tCO2e
Relative shadow price of carbon (benefit/savings)	-$616m	-$432m	$0m	$893m	-$413m	-$1,910m

8.5 Triple Bottom Line Analysis

Triple Bottom Line assessment has developed to become a practice of assessing a range of items under three "accounts" – economic; ecological/environmental; and societal.[16] The Scope of Work required a Triple Bottom Line analysis but it is only a preliminary assessment given the scope's emphasis on engineering and financial analysis. Table 17 assesses 36 criteria across all three accounts, some being based on quantitative assessment but most being qualitative.

Scenario 2 was selected as the base planning case for comparison purposes as it most closely represents Metro Vancouver's integrated waste management plans. Other scenarios were then ranked against this base planning case, with equal weighting applied to economic, environmental and social aspects. Risk items were also included and all items were ranked from -5 to +5. Evaluation was undertaken "blind" by Fidelis team members (without reference to the results during ranking), having regard to comments received from Metro and municipal staff.

The Triple Bottom Line evaluation indicates that Scenario 3 ranks first, followed by Scenario 4 and 2. The main differences arise from contract and projection risk, where Scenario 4's dependency on external volumes, contracts and transport were considered susceptible,

[16] The original author of Triple Bottom Line, John Elkington, now recognises there are considerably more than three accounts. This document refers to common practice as there are no recognised standards on Triple Bottom Line evaluation.

following discussion with City of Vancouver staff and others. Scenario 4's reliance on other municipalities' waste and growth trend projections is considered to be at risk; and if agreement were reached to secure these volumes, it would no doubt result in payments to Burnaby and Vancouver to compensate for committing to deliver the waste, thus negating the financial benefit.

Scenario 3 represents a higher diversion rate variant of Scenario 2, but is essentially the same model. The ranking thus indicates the appreciable financial and non-financial advantages of trying to achieve high waste diversion.

Table 17: Triple Bottom Line Evaluation

Net totals:		Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
Economic		17▼	—	5▲	7▲	5▼	13▼
	Rank	#6	#3	#2	#1	#4	#5
Environmental		7▼	—	3▲	2▲	3▼	21▼
	Rank	#5	#3	#1	#2	#4	#6
Social		13▼	—	—	4▼	1▲	—
	Rank	#6	#2	#2	#5	#1	#2
	▼	45▼	—	11▼	29▼	13▼	52▼
	▲	8▲	—	19▲	34▲	6▲	18▲
	Net total	37▼	—	8▲	5▲	7▼	34▼
	Rank	**#6**	**#3**	**#1**	**#2**	**#4**	**#5**

As at: 1 Mar 2001

	Evaluation item	***Primary account***	1	2	3	4	5	6
1	Change management	Economic	▼▼	—	▼	▼▼▼	▲	▲▲
2	Complexity	Economic	▼▼▼	—	▼	▼▼	▲▲	▲▲
3	Energy independence	Economic	▼▼	—	▲	▲▲▲▲	▼	▼▼▼▼
4	Capital cost	Economic	▼▼▼	—	▲▲	▲▲▲▲	▼▼	▼▼▼▼
5	Net value	Economic	▼▼	—	▲	▲▲▲	▼	▼▼▼▼
6	Jobs	Economic	▲	—	▲	▲▲	▼	▼▼
7	Tax burden	Economic	▼▼	—	▲▲▲	▲▲▲▲	▼▼	▼▼▼▼
8	Supplier & competitive readiness	Economic	—	—	—	—	—	▲
9	Earthquake risk	Economic	—	—	—	—	—	▼▼
10	Contract risk	Economic	▼	—	▼	▼▼▼▼	▼	▲
11	Projection risk	Economic	▲	—	▼	▼▼▼	—	▲
12	Finance risk	Economic	▼▼	—	▲	▲▲	—	▼▼
13	System risk	Economic	▼▼	—	—	—	—	▲▲
14	Change management	Environmental	▼▼▼	—	—	—	—	▼▼
15	Airshed	Environmental	▼	—	▲	▲▲	▼	▼▼
16	Creeks & streams	Environmental	▲▲	—	—	—	—	—
17	Groundwater	Environmental	—	—	—	—	—	▼
18	GHG reduction	Environmental	▼	—	▲	▲▲▲	—	▼▼▼▼
19	Reduced water consumption	Environmental	—	—	—	—	—	—
20	Renewable fuel use	Environmental	▼	—	—	—	—	—
21	Waste diversion	Environmental	—	—	▲	▲▲▲	▼▼	▼▼▼▼▼
22	Adaptability & resilience	Environmental	▲	—	▲	▼▼	—	▼▼
23	Contamination & ecological risk	Environmental	▼▼	—	—	▼	—	▼▼
24	Environmental management risk	Environmental	▼▼	—	▼	▼▼▼	—	▼▼▼
25	Change management	Social	▼▼	—	▼▼	▼	▲	▲▲
26	Community planning	Social	▲▲	—	—	▼	—	—
27	Jobs	Social	▲	—	—	—	—	▼▼
28	Odour	Social	▼▼	—	—	▼	—	▼
29	Disturbance	Social	▼▼▼	—	▼	▼▼	▲	▲▲▲▲
30	Municipal policy alignment	Social	▼	—	▲	▼▼	—	—
31	Metro policy alignment	Social	—	—	▲▲	▼	▼	—
32	Provincial policy alignment	Social	—	—	▲	▲▲▲	—	▼▼▼
33	Statutory compliance	Social	—	—	—	—	—	—
34	Taxpayer financial capacity	Social	▼▼	—	▲▲	▲▲▲▲	▼	▼▼▼
35	Community acceptance risk	Social	▼▼▼	—	▼	—	—	▲
36	Government capacity risk	Social	▼▼▼	—	▼▼	▼▼▼	▲	▲▲

Details of the line items in the matrix are presented in the Technical Appendix. Generally, Scenario 4 would be considered best from an economic view, but when environmental and social factors are considered, Scenario 3 is preferred. This is because in Scenario 4 there are significant equity issues associated with importing solid organic waste to the North Shore from elsewhere in Metro Vancouver requiring more complex governance negotiations.

8.6 Finance

Depending on selected scenario, revenues may offset the initial and ongoing cost of operations, including capital replacement. However current models all indicate that some form of taxpayer subsidy will be required. Analysis indicates it may be possible to improve net impact on the taxpayer through review and adjustment of how financing is undertaken, illustrated in Table 18.

Table 18: Finance Sensitivity Analysis - Scenario 3

	Finance sensitivity					
	10yrs	15yrs	20yrs	25yrs	30yrs	Life cycle
1: Total taxpayer benefit (subsidy), undiscounted	$714m	$626m	$536m	$434m	$320m	$44m
2: Total taxpayer benefit (subsidy), PV	-$69m	-$57m	-$47m	-$38m	-$30m	-$18m
3: Maximum taxpayer subsidy required	-$50m	-$31m	-$22m	-$17m	-$15m	-$13m
4: Maximum subsidy per taxpayer/yr	-$247	-$155	-$110	-$85	-$77	-$70
5: Average subsidy per taxpayer/yr	-$106	-$85	-$63	-$45	-$29	-$16
6: Maximum subsidy per door	-$621	-$390	-$278	-$213	-$194	-$175
7: Average subsidy per door	-$268	-$214	-$159	-$114	-$73	-$41
8: Subsidy duration (yrs)	19yrs	20yrs	23yrs	26yrs	31yrs	23yrs

Table 18 looks at the impact on financing for Scenario 3, and shows varying fixed finance terms between 10 and 30 years, plus a "life cycle finance" option where plant is financed for the duration of its projected life cycle. This is interpreted as follows:

- Line 1 shows the projected taxpayer benefit or subsidy, undiscounted, adjusted for long term finance. This contrasts with Line 2, which provides the same metric but present valued, before finance;
- Lines 3 through 7 provide estimations of taxpayer impact;
- Line 8 indicates the duration of required subsidization by taxpayers;
- While lines 1 and 2 show that shorter finance terms increase overall total value, this comes at the cost of increased taxpayer support. If the goal is to maximize overall profit then the taxpayer will need to accept "short term pain for long term gain";
- Lines 6 and 8 appear contrary to lines 1 and 2: essentially, longer amortization reduces overall profit, but also reduce the number of years where taxpayer support is needed, as well as the amount needing to be paid.

These results were reasonably predictable. Financing over the life cycle lengthens the amortization and results in greater total interest payments, thus reducing the overall profit. However it also reduces annual interest payments below the level of projected revenues, making it more affordable.

Thus in line 1, the total taxpayer benefit or subsidy reduces as the amortization period lengthens. However lines 5 through 7 show that as amortization lengthens, the amount of taxpayer support reduces. This is a result of the revenues exceeding the annual payments on loans.

Currently Metro Vancouver uses a 15-year amortization period and the model indicates that moving to life cycle financing has the possibility of reducing taxpayer funding to about one fifth (20%) of the amounts required for 15-year amortization.

The analysis raises some key questions. If minimizing the cost to the taxpayer is paramount, longer amortization periods increases the total interest being paid and reduces the dividend to the taxpayer, but is more affordable. Conversely, current practices should increase the profit to the taxpayer, provided the taxpayer supports paying significantly higher taxes in order to gain later profits. This is an affordability issue.

The choice is therefore whether minimizing immediate cost to the taxpayer is the key objective, or maximizing revenues. Clearly Metro Vancouver will wish to consider this further. The decision has large implications when considered across the whole region.

8.7 Risk

The Technical Appendix provides greater detail on risk. Risk analysis is required given that IRR has not been implemented in BC. The following points summarize salient risk aspects that have been considered:

- Contract risk associated with converting gas boilers to heat pumps by owners of existing buildings was identified by Metro Vancouver and municipal staff as the main concern.

  We assessed which properties would buy energy and interviewed selected private sector owners to confirm demand. We also priced energy so that it would be attractive for existing buildings to voluntarily sign up. To provide further security we discussed with experienced energy vendors what lending requirements would be applied, and then reviewed and confirmed that alternate energy consumers existed in case the target loads could not be secured. We also considered possible statutory options, similarly to those already in use by the City of North Vancouver. We thus concluded that there are reasonable opportunities to mitigate this risk, but that a more detailed analysis should be included in the work plan recommended as the next step.

  Risk associated with the rate of future development is also a factor. We assume that municipalities would consider mandating that future development would be required to access the IRR infrastructure.

- There is appreciable knowledge and educational risk, associated with unfamiliarity of implementing a whole system model for IRR by either the public or private sectors. This risk also applies to the unfamiliarity in the public sector for managing large revenue flows. The consulting community is equally challenged, since few have integrated engineering, economic and ecological understanding and models, required to maximize IRR.

We believe it is necessary to address the risk and have included it in the recommended work plan. More comment is thus provided in the Procurement section and Technical Appendix.

- There is risk associated with the level of diversion of solid wastes. Metro Vancouver has indicated that the 70% overall diversion rate by 2015 is manageable, but that achievement of an overall 90% diversion for organic material will be more of a challenge. Not all agree that this risk is high for the North Shore however, and we found evidence that the issue should be manageable.

- There is risk associated with securing rights-of-way and plant locations, however these are considered limited. We reviewed sites and identified several sites owned or controlled by Metro or other governments, and most DEWS routes are controlled by municipalities, so permission is assumed. Alternatively, rights-of-way exist through Port Metro lands and we met with members of their executive staff to ascertain whether collaboration could be secured. Given that Port Metro may benefit from IRR, we concluded this was an option. Lastly, land issues may exist in accessing buildings hooking into the DEWS line, but owners will have an incentive to agree and provisional sums were included in all models for land and access costs.

- Since government controls waste streams, source supply is considered low risk, lowering energy supply risk impacts. We have noted the increased risk for obtaining industrial heat sources but we conclude that for the North Shore, these heat sources have substantial value and are worth pursuing in the work plan.

- Public Private Partnerships are mostly "Administrative P3s" where the private sector provides contracted services in return for payment. These are rarely true profitable ventures. It is likely that current P3s models would result in increased risk for viability and operational integrity of the scenarios evaluated in this report. Current procurement models are not well aligned for IRR if it is to be optimized, which is commented on further in the Work Plan section starting on page 66.

  Current procurement practices are also considered a potential impediment because they assume a competitive market, which does not yet exist to any depth for IRR in BC. Whether hiring consultants, equipment providers or full system operators, care will be required to pre-qualify providers. Mandated models exist in Europe to address this problem and are starting to be used in Canada, but remain a risk.

- Cost risk exists but is considered manageable largely during concept design, design and pre-contract stages. Contingency factors have been included in the model across both soft costs (engineering and similar costs) and capital costs. It should be noted that additional research on costs was undertaken, including estimates from equipment suppliers and some concept sketches, creating a higher level of certainty with the cost estimates than is normal for this class of analysis.

- Revenue risk exists, with multiple dimensions, however the model has been structured to start to mitigate this risk, through financing and discount factors.
- Timing is a risk, but it is considered manageable and has been priced into the model in several ways (absorption, critical path, just-in-time and related aspects). The main risk in this regard relates to community participation and both cost and time has been allowed in the model to address this through discussions with potential energy clients.
- Statutory risk exists, but is small. The model is designed to comply with current and anticipated regulatory changes.
- Tipping fees were reduced to $50, approximately 40% below current tipping fees. This is considered adequate to reduce the risk of waste being diverted to other uses where there tipping fees are higher.

The reader is referred to the Technical Appendix for extended comment on risk.

Risk will be central to Councils and the Metro Board taking the decision whether to proceed with IRR. Some of this is addressed in the Procurement section, but we believe risk can be managed provided a careful implementation plan is adopted early, with competent input and oversight. Since we recommend further analysis, the risks can be identified and their resolution be tied to satisfactory milestones as the analysis and work plan proceeds.

Some risks can be easily addressed at low cost, early in the process. Others will require appreciable additional research and/or only be resolved or managed towards the end of procurement. Operations and related risks will require continual management, but can be mitigated much as they are today by engineering departments for existing waste systems.

We did not identify any specific risk that would cause IRR to fail with catastrophic loss. In addition, the evidence from Scandinavia is that the risks are manageable, which provides a level of comfort that the risk is manageable through a work plan.

8.8 PROCUREMENT & IMPLEMENTATION

Current approaches to waste management are generally dominated by government control, resulting from provincial statute and mandate, the requirement to manage efficiency and risk, and the need to address political and operational concerns. While components are often owned, managed and/or delivered by government itself, many aspects are outsourced and/or provided entirely by the private sector. In other words, choices vary as to whether components or whole systems are managed by private sector contracts. There are few known true partnerships in the sector where costs and rewards are shared and governed through a partnership agreement where the parties have aligned objectives.

Procurement, the approach to procurement and operations can significantly affect the highest and best use and value and the net impact on the taxpayer, therefore procurement was reviewed to a basic level, consistent with the scope and limitations of the study. The analysis, background research and methodology are discussed in the Technical Appendix.

We interviewed selected CEOs and executives in the private sector to confirm basic parameters and satisfy ourselves that with appropriate due diligence, the IRR system could be undertaken either as a fully outsourced P3, or as a government-owned and managed operation, or a hybrid of some form, subject to the following considerations:

- **Private sector**. With regard to private sector capacity, IRR components do not rely on a specific supplier as the components are generally of well-established technologies available from multiple suppliers. Quality and competition are thus not considered significant impediments at this time;

  We identified several service providers capable of operating comprehensive systems, as well as operators of component portions of systems;

  We undertook basic due diligence with both operators and international financial sources to provide initial assurance that private finance could be available. This was cross-checked with former provincial Treasury Board staff to satisfy us that procurement mechanisms could be structured to engage private sector interest. We concluded that the underlying risk pre-requisites of financiers could increase costs for external financing, but that mechanisms exist and are in successful use by federal and provincial governments to mitigate possible private financing impact;

  Initial research was undertaken to indicate that the operating choice need not trigger or affect labour issues. Almost all providers already have multiple union contracts, and labour law and contract continuity appears satisfactory;

  Because providers exist and it appears financial and labour options can be configured to address external costs, we concluded that, at least for concept level analysis, the highest and best use can use finance rates based on the Municipal Finance Authority's lending platform. Upwards adjustment was applied to allow for margin, risk and lending terms, appropriate to an IRR system;

- **Public sector**. With regard to public sector capacity, we identified the need for municipal, regional and provincial levels of government to address their capacities to evaluate public sector roles in procurement of IRR infrastructure. This will require detailed assessment of a variety of municipal utility designs and is a key component in the recommended work plan.

- **Impact of incremental planning**. Governments at all levels are starting to consider sustainable energy systems such as energy loops fuelled by more efficient and/or non-fossil fuel systems. Municipal analyses show these have various internal paybacks, but indicate that such systems may be more marginal than IRR systems.

  By advancing such systems without an overall plan that contemplates IRR, future application of IRR in other parts of Metro Vancouver may become sub-optimal. For the private sector, this increases risk and reduces the potential for viability. For the public sector, it will increase costs. Consequently, local government should consider opportunities for IRR before embarking on localized energy systems to retain flexibility to reduce costs to taxpayers.

WORK PLAN

Following a combined Metro/Municipal staff workshop, we were requested to comment on how IRR could be procured in a staged manner, *i.e.* to suggest a work plan for implementing IRR, to reduce risk exposure and cost, thereby providing a level of Council/Board comfort. While this must be the subject of more detailed analysis, we conclude that a work plan should be considered as follows:

- We suggest running additional scenarios to see how adjustments to timing, phasing, capacity management, financing and revenue improve the model.
- The system has to be planned as a whole but it is possible to phase in portions, provided these are fully consistent with an overall planned design. To achieve this we suggest quickly assessing options and sensitivities, to determine how the model can be improved (*i.e.* costs reduced and revenues accelerated, risk managed etc.).
- Solid organic waste phasing is a somewhat smaller investment but generates revenues and could be advanced. This would have to be combined with implementing the DEWS loop so revenues are secured, and must be sized and phased to be compatible with long term plans.
- Phasing of liquid waste is recommended, as noted previously, with system expansion deferred to meet demand. This would appreciably reduce costs and defer some expenditures. A similar approach has already been included in the solid waste model, improving financials by approximately 15%.
- Existing plans for water, waste and resource recovery in Metro Vancouver should be evaluated in accordance with the principles for IRR set out at the beginning of this report.
- Documented experience elsewhere is that establishing a work plan and then implementing and managing within the plan is the best approach.

- Contract risks can to some extent be risk-mitigated through early assessment of demand. This was priced into the model to secure revenue commitments ahead of time, similar to pre-leasing a commercial building.

- Reviewing the finance model may open the potential for either government implementation or for implementation as a P3. This should be an early discussion because if it can be resolved and an early market sounding confirms the potential, the cost and risks could, in large part, be absorbed by the private sector.

- Infrastructure maintenance and existing asset life cycle planning must be reviewed to include these in an overall IRR work plan and reduce manageable risk. The system will require adjustment if value is to be optimized and properly phased.

- Especially if private sector involvement is a possible option, agreement on vision is needed between Metro and the municipalities. We believe this is achievable, but it is a pre-requisite. The provincial and federal governments may play a supportive role to this and we suggest the project is used to pilot IRR.

- Consensus on IRR long-term operating model and structure will be a key concern because if the system can be optimized and government risks resolved, private sector equity interest is possible. This could reduce risk (for example using a DBOOT[17] or other suitable model). Packaged and structured properly, we believe the opportunity could be attractive because it opens the potential for increased revenues, but resolving government risk and clarifying the operating model is a fundamental pre-requisite.

- Because each community is different, equity will need to be considered and resolved as part of governance discussions. Each municipality has its own topography, waste generation, population and population growth profile, energy consumption, building locations and efficiencies, and these will vary over time. A mechanism will have to be structured to reflect the resultant nature of inputs and outputs, which are unequal, as a population-based mechanism will, in the long run, change who pays and who profits.

  The operating structure will thus have to resolve ownership, shareholdership and voting rights, and how profits and costs, risks and rewards are apportioned. We have reviewed models and believe it can be resolved, but it will require the municipalities to drive the direction since the resultant equity issue needs resolving at the municipal level. We anticipate that resolving this at the regional level will be increasingly inequitable, as it includes both efficient and inefficient, as well as non-contributing parties (i.e. non-North Shore communities). We urge that First Nations be included in the discussion as they will be both energy consumers and waste contributors, with significant development plans.

[17] Design, Build, Own, Operate, Transfer. Variations include private financing and none need preclude carefully defined public control.

- We have identified a mechanism to safeguard public oversight and control while benefitting from risk transfer, should private sector involvement be selected. Mandated European processes offer a possible contributive solution to this and should be considered.

Providing the above and other related steps are undertaken we conclude that IRR could be implemented at reduced cost to the taxpayer, *i.e.* consistent with implementation being affordable.

8.9 Other Aspects

Governance Issues

The study terms of reference required that we 'identify the major policy and planning implication of implementing IRR on the North Shore'.

Integrated Resource Recovery is not for the faint of heart. It is a transformative policy in managing solid and liquid wastes. As such, it requires considerable changes for existing governance structures and policies. This section outlines some of these implications and leads to recommendations in the final section of this report.

Incrementalism & Phasing

The potential to move to an incremental approach to resource recovery is consistent with modern business models, where this is widely known as "Just-in-Time". Recent improvements in technology for waste management are reducing plant sizes and moving more towards "off-the-shelf" equipment. This has the following advantages:

- An incremental approach means that future plant does not have to be built until closer to the time it is needed. For the North Shore this makes it possible to reduce some plant sizes by about 35%. This would reduce initial capital expenditures and avoid having to plan and build plant for 2046;

- Reduced initial capital expenditures lower the immediate burden on today's taxpayer with commensurate reduction in debt carry;

- Technology is improving rapidly in waste handling and processing, with improved quality of product and lower cost as plants move from being specially designed to being off the shelf. This replaces "large plant" economies of scale that may be questionable, with economies of volume and mass production. This also has potential risk benefits because engineered machinery can more easily be replaced if it fails and more competitive markets can be leveraged through bid processes;

- Because populations rarely grow as projected, an incremental approach provides flexibility to manage actual waste issues as, when and how they occur, for the nature of community needs in the future. This reduces design and projection risk;
- The effect of conservation will also change the total consumption of water and energy and the generation of waste over time. Projection based on today's society is thus risky;
- Offsetting these possible benefits, an incremental approach puts greater emphasis on planning for expansion and flexibility. This is likely to be cheaper than an investment in large plant that may be obsolete by the time it is first needed.

The above has impacts included in the model and consequences for how payments may in future be apportioned.

We designed the liquid waste system for 2046 based on the population growth projections adopted by Metro Vancouver, derived from BC Stats. This is standard practice for most major infrastructure projects. We note:

- The resultant increased plant capacity is estimated at 33% by volume, and 35-40% by population. Because cost savings from reducing plant size are not linear it is difficult to estimate the possible benefit. The cost saving may be sufficient to eliminate the requirement for substantive taxpayer subsidy;
- Our analysis suggests that incremental approaches are possible and the added initial capacity and cost can be deferred until revenues can pay for the extra cost (in Scenarios 2, 3, and 4).

Charging for System Expansion

Most municipalities have adopted Development Cost Charges and Local Area Levies as a response to charging development for increased demand for community infrastructure. A move to an incremental approach for IRR opens the potential to charge development for the infrastructure expansion cost as it is discrete and identifiable.

This has been assessed as the scope included post-finance assessment and this is considered a viable finance option. It is also included because Metro Vancouver required the liquid waste treatment system to be planned to 2046, with resultant +/-35% increase in cost and capacity. This raises initial taxpayer cost by an estimate $5.6m/year, which could either be deferred or charged to new development as it happens (consistent with work by the City of Vancouver and most municipal bylaws). It could be charged as a DCC or local Special Area Levy.

Table 19: Charging for Incremental Infrastructure

	DCC/Special Levy sensitivity								Scenario 3
New home portion:	**0%**	**5%**	**10%**	**15%**	**20%**	**25%**	**50%**	**75%**	**100%**
Overall revenue impact									
1: Undiscounted net benefit	$254m	$267m	$281m	$295m	$309m	$323m	$392m	$465m	$548m
2: PV, net benefit	$44m	$50m	$55m	$61m	$67m	$72m	$100m	$130m	$162m
New homeowner cost/benefit									
3: DCC levy per new door, avg.	-$1,733	-$2,115	-$2,497	-$2,878	-$3,260	-$3,641	-$5,550	-$7,592	-$9,861
4: DCC levy per new door, avg., amortised	-$168	-$205	-$242	-$280	-$317	-$354	-$539	-$737	-$958
General taxpayer cost/benefit									
5: Maximum subsidy required	-$13m	-$13m	-$13m	-$12m	-$12m	-$12m	-$10m	-$8m	-$6m
6: Maximum subsidy per taxpayer/yr	-$70	-$68	-$66	-$64	-$62	-$60	-$51	-$42	-$33
7: Average subsidy per taxpayer/yr	-$21	-$22	-$20	-$25	-$24	-$22	-$24	-$17	-$10
8: Maximum subsidy per door	-$175	-$171	-$166	-$162	-$157	-$152	-$129	-$106	-$83
9: Average subsidy per door	-$52	-$54	-$50	-$63	-$60	-$56	-$60	-$43	-$26
10: Subsidy duration (yrs)	9yrs	8yrs	8yrs	6yrs	6yrs	6yrs	4yrs	4yrs	4yrs

Scenario 3 has been used as a representative scenario, by, for illustrative purposes, reducing major liquid treatment plant costs by 20% and assessing the impact on using levies to charge new development for system expansion, in the proportions noted in the table. The results are interpreted as follows:

- Lines 1 and 2 show the amount that would be received through potential levies. A 100% pass through to new development is estimated to increase revenues to roughly $548m over the 50-year projection period;

- Line 3 shows the estimated DCC charge to developers and/or new home owners. In a sellers' market it is likely that this would be passed through rather than being absorbed by developers (*i.e.* in the near-term affecting developer profits, delaying some projects until profit is restored or land can be acquired more cheaply, but then filtering through to the cost of new housing).

- Line 4 shows the same sum as an annualized amount in the event that it is charged as a local area improvement charge or similar levy, *i.e.* amortized. These lines represent averages, but are apportioned in scale to population increase, throughout the projection period. Higher rates of pass-through can substantially increase development and homeowner cost, which has affordability and other implications;

- Lines 5 through 10 show the impact on the general taxpayer from the pass-through. Higher rates of pass-through are estimated to sufficiently improve the net financials to such a degree that it may be possible to eliminate the need for taxpayer subsidy, given that further optimization is possible.

We conclude that the highest and best use and value will however be supported by considering use of Special Area Levies in some form.

Liquid and Solid Waste Planning

Currently the Ministry of Environment requires separate plans for liquid and solid waste management prepared by local governments under the Environment Management Act. Stormwater management is implemented under a section of the liquid waste management plans but is not integrated with waste treatment. To maximize net values under TBL principles, liquid and solid waste plans together with stormwater management should be integrated in their next revision by Metro Vancouver, once it has completed an overview of IRR for all Sewerage and Drainage Districts.

Ownership of resources

When waste is considered to be a resource with value rather than a liability, it focuses more attention on the ownership of the waste stream between levels of local government. It is generally recognized that solid organic waste is owned by municipalities up to the point that it is transferred to regional government jurisdiction for disposal to a landfill. Similarly, liquid waste in local distribution lines, prior to entering a trunk sewer, is owned by municipalities, but thereafter becomes the responsibility, and thus the ownership, of regional governments. The overall interest of local government is to generate a public service at lowest net cost to the taxpayer. There is potential to generate considerable revenues from IRR provided it is based on highest and best use of resources, so there needs to be a healthy dialogue on how these revenues should be allocated between municipal and regional levels of government.

Water Reuse

The BC Water Plan, "Living Water Smart", released in May 2008 also makes specific reference to water conservation and watershed stewardship. Accordingly, the Water Act and the Municipal Sewage Regulation (MSR) are being revised to reflect this change in policy. The IRR scenarios presented in this report are consistent with the direction of *Living Water Smart* and will require the amendments proposed in both legislation and regulation to achieve its outcomes.

Treated water can potentially be reused for non-potable uses by industry and residences. The provincial government has set targets for reducing water demands by 33%, and 50% of all additional water supplies for communities will come from conservation by 2020. If treated water can be reused for non-potable purposes by industry, residences and irrigation of public spaces, it would significantly reduce the increased need for water supplies in North Shore reservoirs. At the same time, reuse potentially allows more water to be released into Seymour and Capilano rivers to increase their environmental health during the year. Such measures may become more valuable over the next 35 years if the predicted trend towards drier summers and variable snowpack materializes under a changing climate.

Rainwater Management

The terms of reference for this study include a reference to stormwater management. We have already noted that there is a significant level of infiltration and inflow (I & I) to the sewers on the North Shore. This high rate of I & I both increases the cost of pumping water to the treatment plants and the costs of treatment at the plants. In addition, it lowers the temperature of the wastewater and thus reduces the heat values for potential use. The scope of the study precluded an assessment of integrating rainwater management with wastewater management.

The Province has initiated policy with respect to rainwater management included in its Water Sustainability Action Plan (Ministry of Environment, 2009). This plan has been supported by a Stormwater Planning Guidebook in collaboration with non-government organizations to create a website, based on the water balance model, called The Water Bucket (www.waterbucket.ca). It emphasizes Low Impact Development for urban areas where rainwater is managed to keep it on the land as long as possible rather than funnelled into pipes and discharged directly from storm drains to creeks or to Burrard Inlet.

Energy Recovery Centres

The centralized option calls for an energy centre to be built in the Maplewood industrial area. Although components of this energy centre exist in BC (for example Dockside Green, Southeast False Creek, Revelstoke District Energy System, Lonsdale Energy Corporation) such a fully integrated complex has not been built in British Columbia. There may be public concerns over location and design of this proposed energy complex as any facility that produces emissions in the Lower Mainland air shed, no matter how small, is controversial. The fact is, such an integrated centre would reduce greenhouse gas emissions by 23-35% below 2007 levels and will also reduce NOx emissions by replacing natural gas boilers at individual buildings with district heat cogeneration equipment that includes state-of-the-art NOx emissions controls. It will likely be subject to an environmental assessment process under provincial legislation which will provide an opportunity to describe the economic, social and environmental benefits associated with these types of energy centres based on source separated materials. Both provincial and local levels of government need to coordinate assessment and zoning policies to expedite approvals for such energy complexes.

District Energy and Water System (DEWS)

Metro Vancouver and the North Shore municipalities have indicated an interest in encouraging new developments proposed for the North Shore (see Figure 5) to access the resource recovery infrastructure. Bylaws associated with development cost charges should be reviewed to ensure that future developments access this infrastructure. The City of North Vancouver has experience through its Lonsdale Energy Corporation in this regard.

The DEWS line opens possible additional revenue opportunities for building owners. By adding technologies such as solar thermal systems to existing buildings, owners can sell the energy into the DEWS system (who then re-sell this energy to other consumers). This could not occur without the DEWS line and this is known to occur in other countries. This possible benefit has not been taken into account in the model and is anticipated would improve the model's viability; is consistent BC's Energy Plan; and supports community sustainable energy adaptation.

SOCIAL FACTORS AND LAND USE IMPLICATIONS

Metro Vancouver has embraced the principles of IRR. The key principles are reflected in a shift in strategy to optimize net revenues from treating waste, and to apply a whole systems design to urban infrastructure. To a large extent, the success of the IRR approach will depend on an informed and engaged citizenry to make the changes in life style and urban design needed to accommodate the tenets of IRR. This transformation will require education programs to inform the public on source separation of waste streams and the potential to use treated wastewater for non-potable uses. Metro Vancouver has identified some of these initiatives in its ISWRMP. It will be a challenge to increase solid organic waste diversion from 70% to 90% without considerable investment in public education. A budget has been allowed for this in the analysis.

9 Conclusions and Recommendations

In the Scope of Work, Fidelis Resource Group was asked to evaluate scenarios for Integrated Resource Recovery (IRR) of liquid and solid waste streams on the North Shore, consistent with Metro Vancouver's integrated solid and liquid waste and resource management plans.

Over the past few years, both the provincial government and Metro Vancouver have developed a suite of policies to reduce greenhouse gas emissions, encourage development of renewable energy, and improve the health of watersheds and wetlands. These policies are outlined at the beginning of this report.

IRR contributes directly to the achievement of these policies by integrating economic, ecological, and social values associated with recovering energy from water heated by treated wastewater and organic solid wastes, and distributed by a district energy system serving the main population centres of the North Shore. Carbon neutral electricity would also be generated from a gasifier and supplied through BC Hydro's grid; treated wastewater would be reused and contribute to improving the ecological health of some streams and wetlands; nutrients would be reused. IRR would result in a decrease in greenhouse gas emissions by between 23 and 27% below 2007 levels when fully implemented.

Implementation of IRR requires a new approach to designing urban infrastructure, its governance, and its procurement. The report outlines the triple bottom line values associated with this new infrastructure.

Six scenarios were evaluated and are referred to throughout the report using the following scenario numbers;

1. Integrated Resource Recovery based on seven distributed wastewater treatment plants together with an energy centre at Maplewood to process an average diversion of 70% solid organic waste.

2. Integrated Resource Recovery based on a centralized liquid waste treatment plant located at McKeen Avenue and an energy centre at Maplewood to process an average diversion of 70% solid organic waste. A major district energy system would extend between Maplewood and Ambleside and connect the two locations. Biosolids from treated wastewater would be processed at Maplewood and industrial heat sources included.

3. Integrated Resource Recovery as designed in Scenario 2 but based on an average diversion of solid organic waste of 90%.

4. Integrated Resource Recovery as designed in Scenario 2 but based on an average diversion of 90% of all the solid organic waste received at the North Shore Transfer Station including about 53,100 tonnes imported from other parts of Metro Vancouver.

5. Integrated Resource Recovery based on centralized wastewater treatment located at McKeen Avenue and an energy centre at Maplewood to process an average diversion of 70% solid organic wastes. Biosolids from treated wastewater would be processed at McKeen Avenue and industrial heat sources would not be included. Sensitivity analyses on specific resource values were incorporated.

6. Resource recovery based on a centralized liquid waste treatment plant located at McKeen Avenue without any processing of solid organic waste on the North Shore.

Scenario 6 should not be compared directly with the other five scenarios as it does not include the costs or benefits associated with resource recovery from solid waste on the North Shore. It is assumed that solid waste recovery would take place elsewhere in Metro Vancouver in accordance with the Integrated Solid Waste Management Plan. It is included in this report to determine whether additional costs for recovering resources from liquid waste alone are supported by potential revenues.

Scenario 1 includes neighbourhood district energy systems to distribute heat recovered from wastewater to customers. Scenarios 2, 3, 4, and 5 include a major District Energy and Water System (DEWS) to distribute recovered heat and water connected with neighbourhood district energy systems totalling an estimated 54 km.

The North Shore offers natural advantages that favour integrated resource recovery that may distinguish it from other parts of Metro Vancouver:

- Concentrations of multi-family residential buildings exist close to the waterfront and in the Lonsdale neighbourhood;

- Concentrations of industry exist in Maplewood that can provide low-cost heat and uses for treated wastewater;

- Streams, rivers and wetlands that can benefit from receiving recharging flows of treated water during dry periods;

- The Lonsdale Energy Corporation with its established district energy infrastructure and administration;

- Public properties suitable for locating new resource recovery infrastructure; and

- A site for a new wastewater treatment plant that is located between three areas with energy demands.

Accordingly, the principal findings and recommendations outlined below may not necessarily be applied to the rest of Metro Vancouver.

Our analysis and report follows a modified "Valuation for Secured Lending" standard which is in common use by industry and is considered appropriate to the task. Evaluation is thus primarily focused on financial metrics, but has been combined with Triple Bottom Line analysis to reflect the public interest and for consistency with Metro Vancouver's standard practice. The combined approach is considered consistent with international best practices.

A draft of the final report was shared with Metro Vancouver and municipal staff in a facilitated workshop. The main conclusions from this workshop were as follows:

- There was general agreement that IRR for the North Shore should be approved in principle, subject to more detailed analyses. It was felt that the general public would support IRR if it led to reduced taxes and greenhouse gas emissions and increased use of renewable energy as these were goals espoused in OCPs.

- There was concern over the complexity of the infrastructure design and an interest in seeing if this could be phased in a way that was more adaptive to community needs.

- There was recognition that existing governance models and procurement practices were not suited to IRR implementation and that new options should be explored.

9.1 Principal Findings

In view of this feedback and our analysis contained in the report, our principal findings are:

- All six scenarios result in higher net revenues than purely treating wastewater at McKeen with on-site cogeneration of energy from biosolids.

- Distributed wastewater treatment plants are financially unattractive on the North Shore, but may have merit elsewhere in Metro Vancouver.

- Combining solid and liquid waste produces synergies in energy recovery that results in higher and better use of resources than separating the two waste streams (Scenarios 2, 3, 4, and 5).

- A 50-year life cycle valuation was used. The preferred scenarios are projected to generate between $2.8 and $3.2 billion in new revenues.

- These revenues may exceed additional costs for IRR infrastructure resulting in tax payer dividends if financing models are optimized.

- The dividend from the preferred Scenario 3, after finance over 50 years, is estimated to be $44 million(2010 constant dollars, after finance). As it takes time for the initial revenues to be generated, initial tax payer support is estimated at about $177 per residence per year with an annual average of around $41 per residence per year. This is a considerable reduction from the projected tax payer costs for replacing Lions Gate treatment plant.
- Increasing solid organic waste diversion from 70% to 90% on average can increase net revenues by approximately $108 million (2010 constant dollars, after finance)(Scenario 3). The additional costs of collecting source-separated organic waste to achieve these levels of diversion have not been included, but are thought to be relatively small, based on analyses of other jurisdictions.
- Phasing-in capacity for IRR to meet future growth in both liquid and solid waste can reduce up-front capital costs and help synchronize revenue and cost streams, thus improving financial feasibility.
- All IRR Scenarios will distribute recovered water and energy to gain revenues from selling the recovered resources. The preferred system loop would be approximately 54km in total, which is smaller than many European systems.
- Annual energy available from the preferred IRR scenarios is equivalent to heating 40,000 homes (Note: the North Shore's 2006 census population was 171,186). About 25% of this energy could be used by public sector buildings to contribute to provincial carbon reduction targets.
- The financing model and possible duration of taxpayer support can potentially change given IRR revenue potential. We estimate this could reduce taxpayer support requirements in the range of 6 to 50 years. Further benefit could potentially be secured through alternate financing mechanisms, in combination with phasing and procurement options.
- All the scenarios provide non-monetary ecological benefits by reusing up to 10 % of the treated water for non-potable industrial purposes. This quantity totals 13,000 m^3/day, or 11–18 billion cubic metres over the projection period for most scenarios. This offsets water consumption in the Capilano and Seymour Rivers and can be used to improve ecological health in the summer months.
- Governance and funding models should be reviewed with particular attention being given to establishing a municipal utility across all three North Shore municipalities. Review of tax and funding models, operations, and management will also be desirable.
- Current business case methods are being challenged internationally. We found that current traditional discounting model indicators can be misleading, with consequent impact on Board decisions. Alternate approaches should be considered and both traditional and alternate models have been used in this report.

- Other key factors affecting the financial analysis include:
    - Changes in the real price of renewable energy have not been assumed. This is considered a conservative assumption which will disproportionately benefit the higher energy generation scenarios and may yield windfall benefits if energy prices rise appreciably;
    - Rates of economic and population growth affect project viability and phasing. Careful assessment of population growth forecasts by BC Statistics is recommended;
    - Integration of the model with detailed knowledge of deferred maintenance may change conclusions over the most viable approach. Data provided by Metro Vancouver was not sufficient for including this aspect, but assessment is improving and the issue may benefit from later review.
- The analysis is specifically adapted for the North Shore. The combination of recovering heat and electricity close to major industry at Maplewood and creation of a utility corridor improves the business case for the taxpayer. IRR would have to be individually assessed for other communities, but we conclude that it has wide application beyond the North Shore.
- The main risk factors are the willingness of existing apartment owners and the Lonsdale Energy Corporation to switch from natural gas-fired boilers to hot water systems; the magnitude and complexity of the IRR system proposed; assured access to industrial waste energy sources; the ability to procure the system; the focus on optimizing returns; a requirement to connect to IRR infrastructure; and the preparedness of government and the community to make this change. These are significant factors which should be included in the recommended work plan.
- A number of provincial and Metro Vancouver policies are supported by all scenarios. Greenhouse gas reduction ranges between 23-27% below 2007 levels and thus will significantly contribute to local governments' climate action goals.
- Because the conversion technologies modelled in this study would be served by NO_X reduction equipment, the total NO_X emissions would be approximately 83% lower than the current emissions from natural gas boilers on the North Shore.
- Costs of treatment can be reduced significantly though managing inflow and infiltration, in combination with water conservation strategies. Details of such a strategy lay outside the terms of reference of this study, but if resource recovery is to be implemented, managing inflows should be investigated.
- We do not recommend the need for a mixed waste incinerator for the North Shore. However, should Metro Vancouver decide to locate such an incinerator on the North Shore based on an IRR assessment for its entire Region, such an incinerator would eliminate the need for a separate gasifier for processing dry organic waste. Subject to the IRR

principles set out at the beginning of this report, other aspects of the proposed IRR infrastructure should be integrated with energy recovery from the incinerator.

In summary, implementation of IRR is not for the faint of heart. It involves significant investments in infrastructure – more than 50 Km of underground utilities, a new integrated energy complex, new initiatives to collect and source separate all organic wastes and new governance arrangements to procure a public/private utility that will undertake the planning, design, construction and financing of the IRR infrastructure with revenue sharing at both levels of local government.

The study has been designed to give Metro Vancouver the capability to understand components of IRR architecture and analyse how IRR might be applied to the rest of the Region. We caution that optimization cannot be achieved by a disintegrated approach. Piecemeal implementation will increase taxpayer costs and diligence is needed to ensure optimization.

Time is of the essence. The longer the delay in making a final decision on IRR, the longer the time until new revenues are generated, the greater the tax payer burden and the more opportunities that are lost by continuing with existing practices.

9.2 Recommendations

1. This analysis indicates there are sufficient net benefits associated with the centralized treatment IRR Scenarios to support approval-in-principle. In view of the size of the investment, the complexity of the infrastructure, and the need to develop a new procurement and governance model, a series of steps leading to a final decision is recommended:

    - North Shore municipalities in conjunction with the two First Nation Bands, Metro Vancouver and the Province should develop and implement a work plan to assess the key risk factors in the study—phasing of infrastructure; cost and revenue projections; conversion of existing heating systems; access to industrial heat sources; treatment of biosolids; alignment of district heating infrastructure; financing arrangements and energy balance; and capacity of local government to implement IRR.

    - The four levels of government should evaluate various municipal utility options suited to procure IRR infrastructure and to procure and manage the overall project. These options should include a mix of public and private interests to attract innovation, but also represent the public interest.

- The report should be reviewed by the proposed Integrated Utility Management Advisory Committee to be established to advise Metro Vancouver on integrated resource recovery planning.

2. Following this review, the three levels of government should commission a detailed engineering and financial analysis to prepare documentation of the procurement process.

3. The IRR proposal for the North Shore should be considered as a pilot for the rest of Metro Vancouver.

4. Metro Vancouver should switch to an approach to maximizing net revenues in solid and liquid waste management plans rather than minimizing costs, and will benefit from reporting metrics that include resource recovery indicators.

5. Metro Vancouver and other government agencies will benefit from moving to full life cycle valuation approaches that emulate business practices, consistent with existing international policies and practices and the provincial Capital Asset Management Framework.

6. Further effort should be given to optimizing IRR system costs and revenues. Special attention is drawn to infrastructure phasing and development; financing arrangements; development cost charges applied to future developments; and dependence on population growth forecasts.

7. Metro Vancouver, in conjunction with the North Shore municipalities, should undertake a comprehensive assessment of changes in financing, DCC policies, zoning, revenue sharing and design of municipal utilities to minimize costs to the taxpayer.

8. A comprehensive water model should be developed that considers demand management, potential for reclaimed water use, rainwater capture and groundwater infiltration, and predicted hydrometric changes as a result of a changing climate.

9. At the regional level, Metro Vancouver should identify strategic locations in the Region where synergies from combining solid and liquid waste exist. Scenario 4 included processing additional solid organic waste from outside the North Shore resulting in significant added value. A new governance model might explore opportunities for revenue sharing across municipalities in Metro Vancouver where such synergies optimize net values.

10. There may be value in consolidating wet organic waste recovery in one of two locations and dry organic waste recovery in other locations in the Region to increase efficiencies of transportation and reduce energy conversion costs. However, significant care needs to be taken to correctly and fully evaluate the implications and compare this to using more localized systems.

11. It is clear that conversion technologies (anaerobic digestion, gasification) produce higher revenues than current composting operations for organic wastes. Metro Vancouver should assess how all organic solid waste across the Region might be recovered through these technologies over the next ten years. The proposed analysis for an anaerobic digester at Surrey is a positive step in this direction.

In closing we note that the study scope required a concept level of analysis. This report provides a more detailed assessment and the results are consequently considered more robust.

10 Scenario Dashboard Appendix

The Scenario "dashboards" summarize performance for each Scenario and assist in identifying how to optimize returns. The following pages comprise dashboards for each Scenario.

Key financial indicators	1	2	3	4	5	6
1: Initial CapEx (inc. softs, contingency) - PV	-$376m	-$360m	-$368m	-$396m	-$341m	-$298m
2: Net total value - PV	-$228m	-$106m	-$83m	-$24m	-$206m	-$258m
3: Net total value after finance - undiscounted	-$766m	-$64m	$44m	$336m	-$542m	-$797m
4: Estimated average subsidy per taxpayer	-$70/yr	-$19/yr	-$16/yr	-$28/yr	-$48/yr	-$69/yr
5: Estimated average subsidy/home	-$177/yr	-$48/yr	-$41/yr	-$70/yr	-$120/yr	-$174/yr
6: Estimated duration of taxpayer subsidy	48yrs	31yrs	23yrs	6yrs	50yrs	50yrs
7: Taxpayer ROI (contributed tax as equity)	-97%	-52%	57%	1,041%	-100%	-100%
8: Estimated IRR before tax & finance	Not calculable	Not calculable	Not calculable	Not calculable	Not calculable	Not calculable

Key resource recovery indicators	1	2	3	4	5	6
9: Total projected energy generated	5,132 GWh	5,132 GWh	5,774 GWh	7,935 GWh	2,743 GWh	
10: Total tonnage processed/generated	112,000 tonnes	112,000 tonnes	136,000 tonnes	200,000 tonnes	60,000 tonnes	
11: Total water recovered	2,560 Mm3	2,560 Mm3	2,560 Mm3	2,560 Mm3	2,560 Mm3	2,560 Mm3
12: Total CO2e reduction	11.1 mtCO2e	11.9 mtCO2e	13.9 mtCO2e	17.9 mtCO2e	12.0 mtCO2e	5.2 mtCO2e
13: Relative total Shadow price of carbon (benefit)	-$616m	-$432m	$0m	$893m	-$413m	-$1,910m

Financial summary - PV	1	2	3	4	5	6
Initial cost summary						
1: Initial hard costs (exc. softs, contingency)	-$376.0m	-$360.2m	-$367.7m	-$395.9m	-$341.4m	-$298.5m
2: Initial soft costs	-$67.9m	-$60.1m	-$61.2m	-$65.1m	-$57.5m	-$51.5m
3: Initial CapEx (inc. softs, contingency)	-$443.9m	-$420.3m	-$428.9m	-$461.1m	-$399.0m	-$350.0m
Overall (pre-finance) cash flow summary						
4: Total life cycle revenues, PV	$514.5m	$567.7m	$604.7m	$712.9m	$458.7m	$310.7m
5: Total life cycle costs (inc. replacement etc), PV	-$742.6m	-$673.5m	-$687.7m	-$736.6m	-$665.0m	-$568.9m
6: Net benefit (cost), PV	**-$228m**	**-$106m**	**-$83m**	**-$24m**	**-$206m**	**-$258m**
7: Benefit/revenue (subsidy/cost) per capita/yr	-$118/yr	-$55/yr	-$43/yr	-$12/yr	-$107/yr	-$134/yr
8: Benefit/revenue (subsidy/cost) per door/yr	-$298/yr	-$138/yr	-$109/yr	-$31/yr	-$270/yr	-$338/yr
9: Estimated IRR before tax & finance	Not calculable	Not calculable	Not calculable	Not calculable	Not calculable	Not calculable
Finance adjusted cash flow summary						
10: Long term finance rate	5.07%	5.07%	5.07%	5.07%	5.07%	5.07%
11: Profit (loss) after LT finance & subsidy	**-$151m**	**-$37m**	**-$8m**	**$76m**	**-$144m**	**-$203m**

Financial summary - undiscounted	1	2	3	4	5	6
Initial cost summary						
1: Initial hard costs (exc. softs, contingency)	-$649.4m	-$561.9m	-$571.9m	-$609.1m	-$538.1m	-$481.1m
2: Initial soft costs	-$106.9m	-$86.9m	-$88.1m	-$92.8m	-$83.9m	-$76.8m
3: Initial CapEx (inc. softs, contingency)	-$756.3m	-$648.8m	-$660.0m	-$701.9m	-$622.0m	-$557.9m
Overall (pre-finance) cash flow summary						
4: Total life cycle revenues	$2,563.6m	$2,797.1m	$2,956.3m	$3,422.2m	$2,332.5m	$1,699.2m
5: Total life cycle costs (inc. replacement etc)	-$2,814.1m	-$2,287.5m	-$2,325.9m	-$2,452.5m	-$2,336.9m	-$2,037.1m
6: Net benefit (cost)	**-$251m**	**$510m**	**$630m**	**$970m**	**-$4m**	**-$338m**
7: Benefit/revenue (subsidy/cost) per capita/yr	-$27/yr	$55/yr	$68/yr	$104/yr	-$0/yr	-$36/yr
8: Benefit/revenue (subsidy/cost) per door/yr	-$68/yr	$138/yr	$170/yr	$262/yr	-$1/yr	-$91/yr
Finance adjusted cash flow summary						
9: Long term finance rate	5.07%	5.07%	5.07%	5.07%	5.07%	5.07%
10: Profit (loss) after LT finance	**-$766m**	**-$64m**	**$44m**	**$336m**	**-$542m**	**-$797m**
11: Estimated required total subsidy	-$792m	-$123m	-$77m	-$32m	-$544m	-$797m

Tax equivalent estimate	1	2	3	4	5	6
Average						
1: Subsidy per capita/yr	-$70/yr	-$19/yr	-$16/yr	-$28/yr	-$48/yr	-$69/yr
2: Subsidy per door/yr	-$177/yr	-$48/yr	-$41/yr	-$70/yr	-$120/yr	-$174/yr
Maximum						
3: Subsidy per capita/yr	-$111/yr	-$67/yr	-$70/yr	-$81/yr	-$107/yr	-$140/yr
4: Subsidy per door/yr	-$280/yr	-$168/yr	-$175/yr	-$203/yr	-$269/yr	-$353/yr
5: Duration of taxpayer subsidy	48yrs	31yrs	23yrs	6yrs	50yrs	50yrs

Resource recovery summary - annual volume	1	2	3	4	5	6
Solid waste wet tonnes/year (input charge)	74,974 tonnes	74,974 tonnes	90,464 tonnes	136,202 tonnes	29,534 tonnes	
Biosolid dry tonnes/year (input charge)	7,290 tonnes	7,290 tonnes	7,290 tonnes	7,290 tonnes		
Electricity from cogeneration	88,790 MWh	88,790 MWh	99,900 MWh	137,291 MWh	47,454 MWh	
Heat from cogeneration & industry (high temp)	289,401 GJ	528,381 GJ	582,444 GJ	732,060 GJ	230,922 GJ	
Heat from wastewater (lower temp)	1,165,308 GJ	678,482 GJ	651,451 GJ	560,474 GJ	1,426,313 GJ	1,657,235 GJ
Heat from industry (medium temp)		450,371 GJ	423,340 GJ	364,701 GJ		
Energy sold to public organizations - 25.0% of supply	367,240 GJ	418,368 GJ	418,368 GJ	418,368 GJ	418,368 GJ	418,368 GJ
Energy - biofuels					187,755 GJ	
Reclaimed water (total)	48,545,000 m3	48,545,000 m3	48,545,000 m3	48,545,000 m3	48,545,000 m3	48,545,000 m3
Reclaimed water (identified saleable)	2,004,515 m3	2,004,515 m3	2,004,515 m3	2,004,515 m3	2,004,515 m3	2,004,515 m3
Residuals from anaerobic digestion	29,577 tonnes	29,577 tonnes	38,216 tonnes	56,034 tonnes	30,701 tonnes	
GHG reductions - total	194,257 tCO2e	208,941 tCO2e	243,418 tCO2e	314,738 tCO2e	210,428 tCO2e	90,911 tCO2e
GHG reductions - marketable	173,210 tCO2e	187,894 tCO2e	222,371 tCO2e	293,691 tCO2e	189,381 tCO2e	69,864 tCO2e
Relative shadow price of carbon (benefit/savings)	-$12m	-$8m	$0m	$18m	-$8m	-$37m

Resource recovery summary - total volume	1	2	3	4	5	6
Solid waste wet tonnes (input charge)	4,353,157 tonnes	4,353,157 tonnes	5,252,540 tonnes	7,908,200 tonnes	1,714,821 tonnes	
Biosolid dry tonnes (input charge)	384,431 tonnes	384,431 tonnes	384,431 tonnes	384,431 tonnes		
Electricity from cogeneration	5,131,702 MWh	5,131,702 MWh	5,773,799 MWh	7,934,878 MWh	2,742,667 MWh	
Heat from cogeneration & industry (high temp)	16,803,318 GJ	30,679,071 GJ	33,818,046 GJ	42,505,115 GJ	13,407,881 GJ	
Heat from wastewater (lower temp)	61,449,851 GJ	35,778,227 GJ	34,352,805 GJ	29,555,322 GJ	75,213,368 GJ	87,390,522 GJ
Heat from industry (medium temp)		23,749,297 GJ	22,323,875 GJ	19,231,686 GJ		
Energy sold to public organizations - 25.0% of supply	19,754,967 GJ	23,037,898 GJ	23,114,207 GJ	23,324,559 GJ	22,372,383 GJ	22,061,686 GJ
Energy - biofuels					10,901,504 GJ	
Reclaimed water (total)	2,559,910,505 m3	2,559,910,505 m3	2,559,910,505 m3	2,559,910,505 m3	2,559,910,505 m3	2,559,910,505 m3
Reclaimed water (identified saleable)	105,703,554 m3	105,703,554 m3	105,703,554 m3	105,703,554 m3	105,703,554 m3	105,703,554 m3
Residuals from anaerobic digestion	1,717,301 tonnes	1,717,301 tonnes	2,218,904 tonnes	3,253,464 tonnes	1,782,579 tonnes	
GHG reductions - total	11,071,928 tCO2e	11,908,884 tCO2e	13,873,935 tCO2e	17,938,953 tCO2e	11,993,652 tCO2e	5,181,617 tCO2e
GHG reductions - marketable	9,872,329 tCO2e	10,709,286 tCO2e	12,674,336 tCO2e	16,739,354 tCO2e	10,794,053 tCO2e	3,982,018 tCO2e
Relative shadow price of carbon (benefit/savings)	-$616m	-$432m	$0m	$893m	-$413m	-$1,910m

Scenarios

For further information see report.

1. Distributed WW Treatment, Maplewood Energy Plant, 70% Diversion
2. McKeen WW Treatment, Maplewood Energy Plant, 70% Diversion
3. McKeen WW Treatment, Maplewood Energy Plant, 90% Diversion
4. McKeen WW Treatment, Maplewood Energy Plant, Current Transfer Station Volume
5. McKeen WW Treatment, Maplewood Energy Plant, 70% Diversion, Revenue Modified
6. McKeen WW Treatment, Heat Recovery from Wastewater Only

Scenario: 1. Distributed WW Treatment, Maplewood Energy Plant, 70% Diversion

	Today	Undiscounted life cycle costs					PV life cycle costs					Analysis		
Cost	CapEx	CapEx	O&M	Total @ yr	$Liquid	$Solid	CapEx	O&M	Total, PV	$Liquid PV	$Solid PV	Cost as %	%Liquid	%Solid
1: Wastewater Treatment Plants (distributed plants)	-$435.3m	-$881.1m	-$434.3m	-$1,315.4m	-$1,315.4m	$0.0m	-$274.7m	-$77.7m	-$352.4m	-$352.4m	$0.0m	47.5%	100.0%	0.0%
2: Wastewater Treatment Plants (central plant)	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	0.0%	100.0%	0.0%
3: Water pipes, reclaimed wastewater - SUM	-$7.3m	-$17.4m	-$9.1m	-$26.5m	-$26.5m	$0.0m	-$5.9m	-$2.0m	-$7.9m	-$7.9m	$0.0m	1.1%	100.0%	0.0%
4: Heat pumps and related equipment	-$50.8m	-$125.9m	-$423.7m	-$549.6m	-$549.6m	$0.0m	-$36.9m	-$75.8m	-$112.7m	-$112.7m	$0.0m	15.2%	100.0%	0.0%
5: District heating networks	-$135.7m	-$285.4m	-$115.7m	-$401.1m	-$317.4m	-$83.7m	-$82.6m	-$20.7m	-$103.3m	-$81.8m	-$21.6m	13.9%	79.1%	20.9%
6: District cooling networks	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	0.0%	0.0%	100.0%
7: Anaerobic digestion	-$20.6m	-$48.9m	-$60.0m	-$108.9m	$0.0m	-$108.9m	-$18.7m	-$13.2m	-$31.8m	$0.0m	-$31.8m	4.3%	0.0%	100.0%
8: Nutrient recovery plant	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	0.0%	100.0%	0.0%
9: Biomethane Upgrading Plant	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	0.0%	0.0%	100.0%
10: Gasification plant	-$20.6m	-$68.6m	-$65.3m	-$134.0m	-$6.7m	-$127.3m	-$26.3m	-$14.3m	-$40.6m	-$2.0m	-$38.6m	5.5%	5.0%	95.0%
11: Cogeneration plant	-$17.9m	-$85.4m	-$88.4m	-$173.8m	-$8.7m	-$165.1m	-$23.8m	-$19.4m	-$43.2m	-$2.2m	-$41.1m	5.8%	5.0%	95.0%
12: Shared Services	-$32.6m	-$48.3m	-$40.1m	-$88.4m	$0.0m	-$88.4m	-$28.0m	-$8.8m	-$36.9m	$0.0m	-$36.9m	5.0%	0.0%	100.0%
13: Miscellaneous & land	-$15.7m	-$16.4m	$0.0m	-$16.4m	$0.0m	-$16.4m	-$13.7m	$0.0m	-$13.7m	$0.0m	-$13.7m	1.8%	0.0%	100.0%
	-$737m	-$1,577m	-$1,237m	-$2,814m	-$2,224.4m	-$589.7m	-$511m	-$232m	-$743m	-$559.0m	-$183.6m	100%		
		56.1%	43.9%				68.8%	31.2%						

	Today	Undiscounted life cycle revenues			PV life cycle revenues			Analysis		
Revenue	Total	Total @ yr	$Liquid	$Solid	Total	$Liquid	$Solid	Revenue as %	%Liquid	%Solid
A: Receiving fees (solid waste)	$3.7m/yr.	$217.7m	$0.0m	$217.7m	$48.2m	$0.0m	$48.2m	9%	0%	100%
B: Receiving fees (biosolids)	$2.4m/yr.	$128.1m	$128.1m	$0.0m	$23.3m	$23.3m	$0.0m	5%	100%	0%
C: Energy - electricity from cogeneration	$9.8m/yr.	$564.5m	$25.8m	$538.7m	$124.0m	$6.2m	$117.8m	24%	5%	95%
D: Energy - heat from cogeneration & industry (high temp)	$5.2m/yr.	$304.0m	$0.0m	$304.0m	$67.3m	$0.0m	$67.3m	13%	0%	100%
E: Energy - heat from wastewater (lower temp)	$21.1m/yr.	$1,111.7m	$1,111.7m	$0.0m	$202.0m	$202.0m	$0.0m	39%	100%	0%
F: Energy - heat from industry (medium temp)	$0.0m/yr.	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	0%	100%	0%
G: Energy premium - Offset cost to public organizations	$0.6m/yr.	$30.2m	$23.8m	$6.5m	$5.8m	$4.6m	$1.1m	1%	80%	20%
H: Energy - cold from wastewater	$0.0m/yr.	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	0%	100%	0%
I: Energy - microhydro from wastewater	$0.0m/yr.	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	0%	0%	100%
J: Energy - biofuels	$0.0m/yr.	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	0%	0%	100%
K: Water - reclaimed	$0.5m/yr.	$25.9m	$25.9m	$0.0m	$4.7m	$4.7m	$0.0m	1%	100%	0%
L: Nutrients - struvite from wastewater treatment	$0.0m/yr.	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	0%	100%	0%
M: Residuals - from anaerobic digestion	$0.6m/yr.	$36.4m	$0.0m	$36.4m	$8.1m	$0.0m	$8.1m	2%	0%	100%
N: Residuals, from gasification	$0.0m/yr.	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	0%	0%	100%
O: Greenhouse gas reductions - marketable	$2.5m/yr.	$145.1m	$26.9m	$118.3m	$31.1m	$31.1m	$0.0m	6%	100%	0%
P: DCC transfer pricing	$0.0m/yr.	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	0%	45%	55%
Q: Taxpayer subsidy	$0.0m/yr.	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	0%	45%	55%
	$46.5m/yr.	$2,564m	$1,342m	$1,221m	$515m	$272m	$243m	100.0%		
			52.4%	47.6%		52.9%	47.1%			

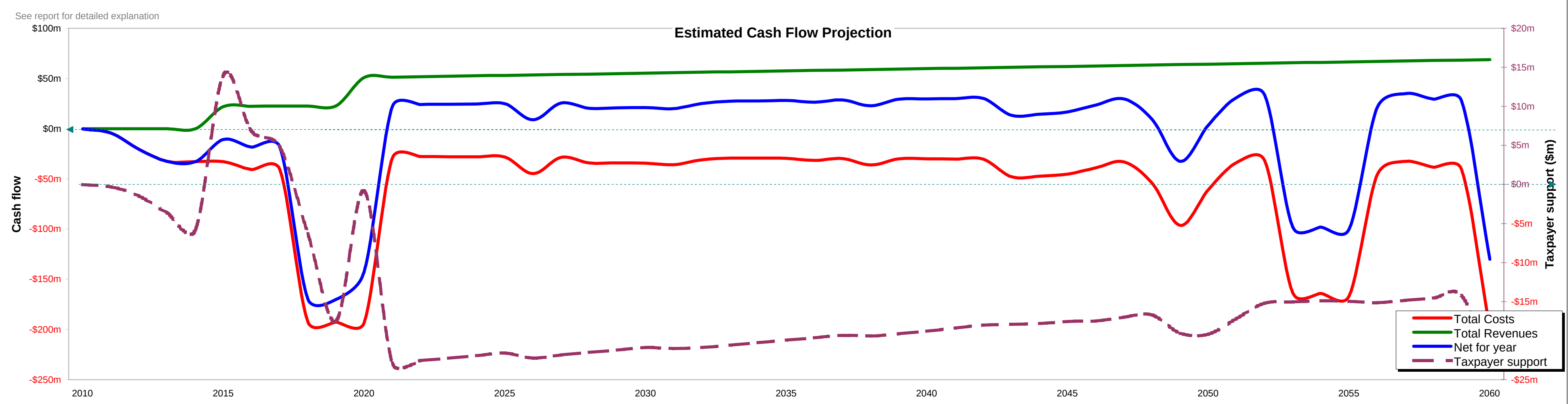
See report for explanation of model & assumptions.

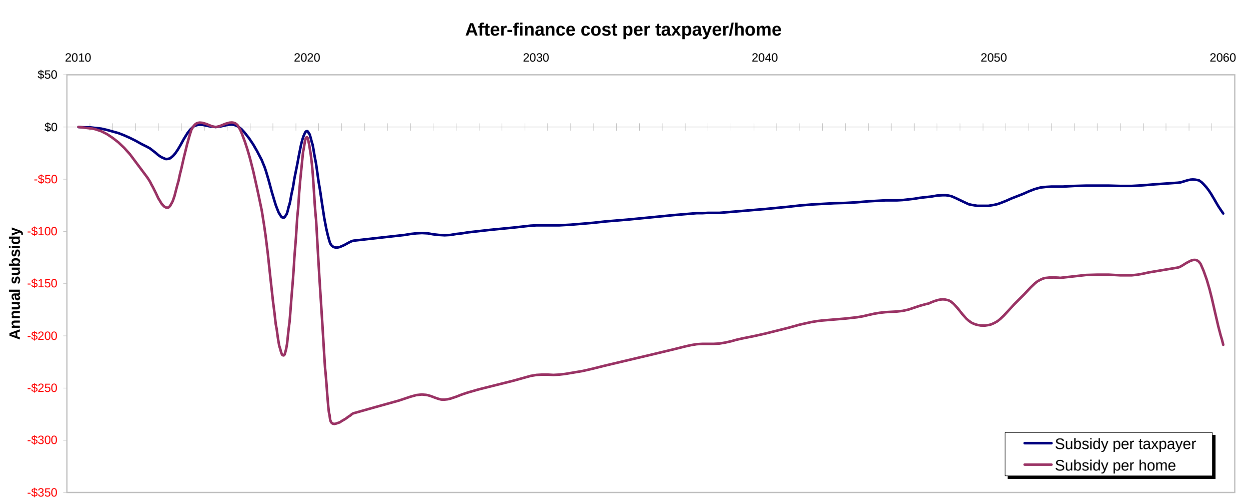
Financial summary		
Initial cost summary	Undiscounted	PV
1: Initial hard costs (exc. softs, contingency)	-$649.4m	-$376.0m
2: Initial soft costs	-$106.9m	-$67.9m
3: Initial CapEx (inc. softs, contingency)	-$756.3m	-$443.9m
Overall (pre-finance) cash flow summary		
4: Total life cycle revenues	$2,563.6m	$514.5m
5: Total life cycle costs (inc. replacement etc)	-$2,814.1m	-$742.6m
6: Net benefit (cost) *before finance*	**-$251m**	**-$228m**
7: Benefit/revenue (subsidy/cost) per capita/yr	-$27/yr	-$118/yr
8: Benefit/revenue (subsidy/cost) per home/yr	-$68/yr	-$298/yr
9: Real discount rate (general inflation adjusted @ 1.2%pa)		6.3%
11: Estimated IRR before tax & finance		Not calculable
Finance adjusted cash flow summary		
12: Long term finance rate		5.07%
13: Profit (loss) after LT finance	**-$766m**	**-$151m**
14: Estimated required total dividend (subsidy)	-$792m	N/A

Resource recovery summary	Volume pa	Total volume
Solid waste wet tonnes/year (input charge)	74,974 tonnes	4,353,157 tonnes
Biosolid dry tonnes/year (input charge)	7,290 tonnes	384,431 tonnes
Electricity from cogeneration	88,790 MWh	5,131,702 MWh
Heat from cogeneration & industry (high temp)	289,401 GJ	16,803,318 GJ
Heat from wastewater (lower temp)	1,165,308 GJ	61,449,851 GJ
Heat from industry (medium temp)	0 GJ	0 GJ
Energy sold to public organizations - 25.0% of supply	367,240 GJ	19,754,967 GJ
Cold from wastewater	0 GJ	0 GJ
Microhydro from waste water	0 tonnes	0 tonnes
Energy - biofuels	0 GJ	0 GJ
Reclaimed water (total)	48,545,000 m3	2,559,910,505 m3
Reclaimed water (identified saleable)	2,004,515 m3	105,703,554 m3
Struvite from waste water treatment	0 tonnes	0 tonnes
Residuals from anaerobic digestion	29,577 tonnes	1,717,301 tonnes
Residuals from gassification	0 tonnes	0 tonnes
GHG reductions - total	194,257 tCO2e	11,071,928 tCO2e
GHG reductions - marketable	173,210 tCO2e	9,872,329 tCO2e
Relative shadow price of carbon (unmarketed)	-$12m	-$616m

Input Stream Summary (pre-finance)			
2010 dollars	Liquid	Solid	Total
Total revenues	$1,342m	$1,221m	$2,564m
Total costs	-$2,224m	-$590m	-$2,814m
Profit (loss)	-$882m	$632m	-$251m
Present Value	Liquid	Solid	Total
Total revenues	$272m	$243m	$515m
Total costs	-$559m	-$184m	-$743m
Profit (loss)	-$287m	$59m	-$228m

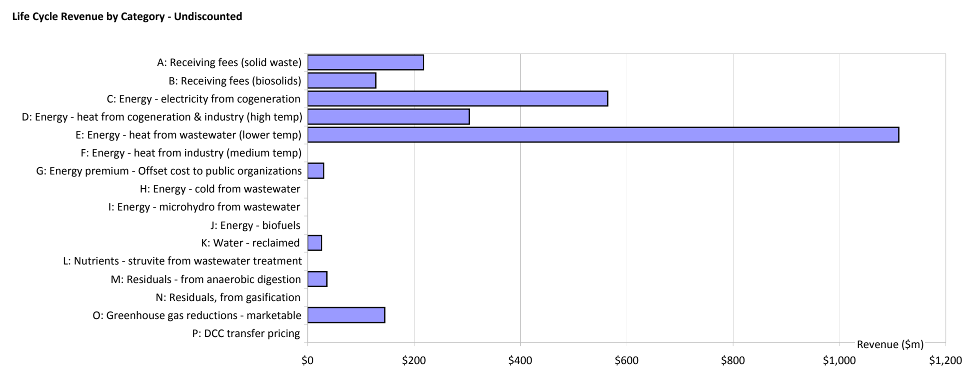
Taxpayer Summary	Maximum	Average
15: Subsidy per capita/yr	-$111/yr	-$70/yr
16: Subsidy per home/yr	-$280/yr	-$177/yr
17: Duration of taxpayer subsidy	48yrs	N/A
18: Total subsidy per taxpayer	-$3,378	N/A
19: Total subsidy per home	-$8,515	N/A
20: Taxpayer ROI	-97%	N/A

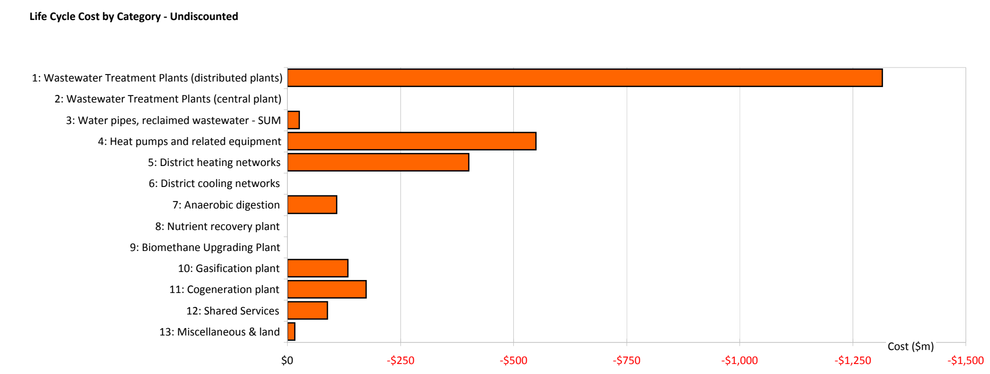




Summary of major input assumptions to the model

Analysis starts: 2010. Analysis ends: 2060. Duration: 50yrs.
Metro population growth model active
North Shore 2010 population : 186,000
North Shore 2010 homes : 74,000
Long term finance (Life cycle) @ 5.07%
Soft costs apportioned pre-/during construction: 75%/25%
Soft costs for CapEx replacement & incremental plant @ 33% of base
General inflation: 1.20%. Constrn inflation @ 1.40%. O&M inflation @ 2.10%
All risks discount rate @ 6.30%, reversionary/term cap. rate @ 9.00%
Positive balances accrue at 3%
DCC/Levy: Off
Cost items 6, 8 & 9 omitted from reporting (not used for current scenarios)





Scenario: 2. McKeen WW Treatment, Maplewood Energy Plant, 70% Diversion

	Today	Undiscounted life cycle costs					PV life cycle costs					Analysis		
Cost	**CapEx**	**CapEx**	**O&M**	**Total @ yr**	**$Liquid**	**$Solid**	**CapEx**	**O&M**	**Total, PV**	**$Liquid PV**	**$Solid PV**	**Cost as %**	**%Liquid**	**%Solid**
1: Wastewater Treatment Plants (distributed plants)	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	0.0%	100.0%	0.0%
2: Wastewater Treatment Plants (central plant)	-$292.2m	-$565.9m	-$325.3m	-$891.2m	-$891.2m	$0.0m	-$177.6m	-$58.2m	-$235.8m	-$235.8m	$0.0m	35.0%	100.0%	0.0%
3: Water pipes, reclaimed wastewater - SUM	-$7.9m	-$18.9m	-$9.8m	-$28.7m	-$28.7m	$0.0m	-$6.4m	-$2.2m	-$8.6m	-$8.6m	$0.0m	1.3%	100.0%	0.0%
4: Heat pumps and related equipment	-$43.7m	-$112.0m	-$344.2m	-$456.1m	-$456.1m	$0.0m	-$31.3m	-$61.6m	-$92.9m	-$92.9m	$0.0m	13.8%	100.0%	0.0%
5: District heating networks	-$181.6m	-$253.1m	-$137.0m	-$390.0m	-$206.7m	-$183.3m	-$139.9m	-$30.1m	-$170.0m	-$90.1m	-$79.9m	25.2%	53.0%	47.0%
6: District cooling networks	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	0.0%	0.0%	100.0%
7: Anaerobic digestion	-$20.6m	-$48.9m	-$60.0m	-$108.9m	$0.0m	-$108.9m	-$18.7m	-$13.2m	-$31.8m	$0.0m	-$31.8m	4.7%	0.0%	100.0%
8: Nutrient recovery plant	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	0.0%	100.0%	0.0%
9: Biomethane Upgrading Plant	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	0.0%	0.0%	100.0%
10: Gasification plant	-$20.6m	-$68.6m	-$65.3m	-$134.0m	$0.0m	-$134.0m	-$26.3m	-$14.3m	-$40.6m	$0.0m	-$40.6m	6.0%	0.0%	100.0%
11: Cogeneration plant	-$17.9m	-$85.4m	-$88.4m	-$173.8m	$0.0m	-$173.8m	-$23.8m	-$19.4m	-$43.2m	$0.0m	-$43.2m	6.4%	0.0%	100.0%
12: Shared Services	-$32.6m	-$48.3m	-$40.1m	-$88.4m	$0.0m	-$88.4m	-$28.0m	-$8.8m	-$36.9m	$0.0m	-$36.9m	5.5%	0.0%	100.0%
13: Miscellaneous & land	-$15.7m	-$16.4m	$0.0m	-$16.4m	$0.0m	-$16.4m	-$13.7m	$0.0m	-$13.7m	$0.0m	-$13.7m	2.0%	0.0%	100.0%
	-$633m	-$1,217m	-$1,070m	-$2,288m	-$1,582.8m	-$704.8m	-$466m	-$208m	-$673m	-$427.4m	-$246.1m	100%		
		53.2%	46.8%				69.2%	30.8%						

	Today	Undiscounted life cycle revenues			PV life cycle revenues			Analysis		
Revenue	**Total**	**Total @ yr**	**$Liquid**	**$Solid**	**Total**	**$Liquid**	**$Solid**	**Revenue as %**	**%Liquid**	**%Solid**
A: Receiving fees (solid waste)	$3.7m/yr.	$217.7m	$0.0m	$217.7m	$48.2m	$0.0m	$48.2m	8%	0%	100%
B: Receiving fees (biosolids)	$2.4m/yr.	$128.1m	$128.1m	$0.0m	$23.3m	$23.3m	$0.0m	4%	100%	0%
C: Energy - electricity from cogeneration	$9.8m/yr.	$564.5m	$25.8m	$538.7m	$124.0m	$6.2m	$117.8m	22%	5%	95%
D: Energy - heat from cogeneration & industry (high temp)	$9.6m/yr.	$555.0m	$0.0m	$555.0m	$122.9m	$0.0m	$122.9m	22%	0%	100%
E: Energy - heat from wastewater (lower temp)	$12.3m/yr.	$647.3m	$647.3m	$0.0m	$117.6m	$117.6m	$0.0m	21%	100%	0%
F: Energy - heat from industry (medium temp)	$8.1m/yr.	$429.6m	$429.6m	$0.0m	$78.1m	$78.1m	$0.0m	14%	100%	0%
G: Energy premium - Offset cost to public organizations	$0.6m/yr.	$35.3m	$19.0m	$16.3m	$7.1m	$4.0m	$3.1m	1%	56%	44%
H: Energy - cold from wastewater	$0.0m/yr.	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	0%	100%	0%
I: Energy - microhydro from wastewater	$0.0m/yr.	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	0%	0%	100%
J: Energy - biofuels	$0.0m/yr.	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	0%	0%	100%
K: Water - reclaimed	$0.5m/yr.	$25.9m	$25.9m	$0.0m	$4.7m	$4.7m	$0.0m	1%	100%	0%
L: Nutrients - struvite from wastewater treatment	$0.0m/yr.	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	0%	100%	0%
M: Residuals - from anaerobic digestion	$0.6m/yr.	$36.4m	$0.0m	$36.4m	$8.1m	$0.0m	$8.1m	1%	0%	100%
N: Residuals, from gasification	$0.0m/yr.	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	0%	0%	100%
O: Greenhouse gas reductions - marketable	$2.8m/yr.	$157.4m	$29.1m	$128.3m	$33.7m	$33.7m	$0.0m	6%	100%	0%
P: DCC transfer pricing	$0.0m/yr.	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	0%	43%	57%
Q: Taxpayer subsidy	$0.0m/yr.	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	0%	43%	57%
	$50.4m/yr.	$2,797m	$1,305m	$1,492m	$568m	$268m	$300m	100.0%		
			46.6%	53.4%		47.1%	52.9%			

See report for explanation of model & assumptions.

Financial summary

Initial cost summary	**Undiscounted**	**PV**
1: Initial hard costs (exc. softs, contingency)	-$561.9m	-$360.2m
2: Initial soft costs	-$86.9m	-$60.1m
3: Initial CapEx (inc. softs, contingency)	-$648.8m	-$420.3m
Overall (pre-finance) cash flow summary		
4: Total life cycle revenues	$2,797.1m	$567.7m
5: Total life cycle costs (inc. replacement etc)	-$2,287.5m	-$673.5m
6: Net benefit (cost) *before finance*	**$510m**	**-$106m**
7: Benefit/revenue (subsidy/cost) per capita/yr	$55/yr	-$55/yr
8: Benefit/revenue (subsidy/cost) per home/yr	$138/yr	-$138/yr
9: Real discount rate (general inflation adjusted @ 1.2%pa)		6.3%
11: Estimated IRR before tax & finance		Not calculable
Finance adjusted cash flow summary		
12: Long term finance rate		5.07%
13: Profit (loss) after LT finance	**-$64m**	**-$37m**
14: Estimated required total dividend (subsidy)	-$123m	N/A

Resource recovery summary

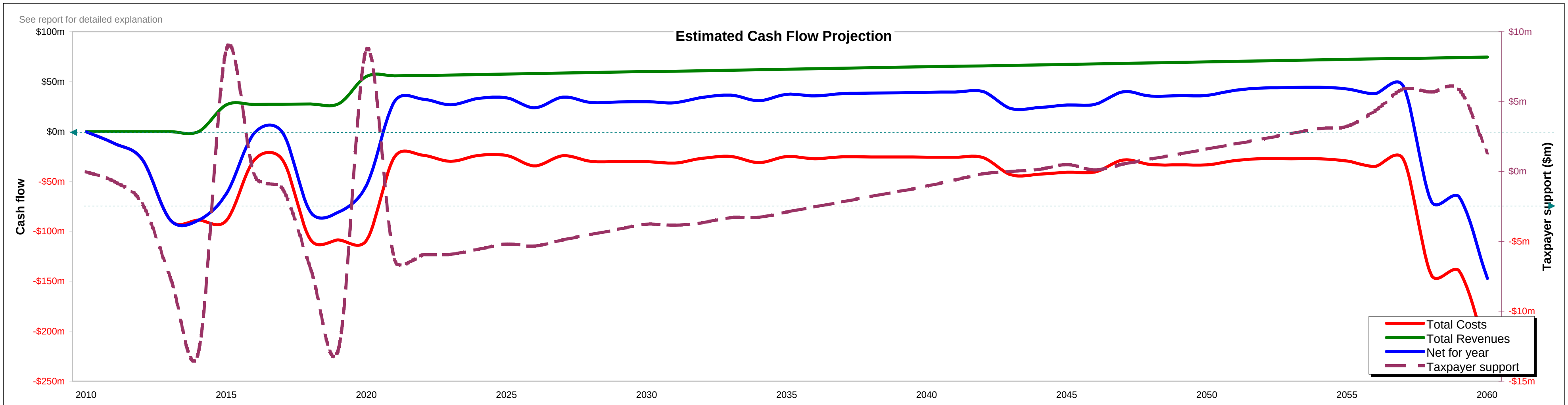
	Volume pa	**Total volume**
Solid waste wet tonnes/year (input charge)	74,974 tonnes	4,353,157 tonnes
Biosolid dry tonnes/year (input charge)	7,290 tonnes	384,431 tonnes
Electricity from cogeneration	88,790 MWh	5,131,702 MWh
Heat from cogeneration & industry (high temp)	528,381 GJ	30,679,071 GJ
Heat from wastewater (lower temp)	678,482 GJ	35,778,227 GJ
Heat from industry (medium temp)	450,371 GJ	23,749,297 GJ
Energy sold to public organizations - 25.0% of supply	418,368 GJ	23,037,898 GJ
Cold from wastewater	0 GJ	0 GJ
Microhydro from waste water	0 tonnes	0 tonnes
Energy - biofuels	0 GJ	0 GJ
Reclaimed water (total)	48,545,000 m3	2,559,910,505 m3
Reclaimed water (identified saleable)	2,004,515 m3	105,703,554 m3
Struvite from waste water treatment	0 tonnes	0 tonnes
Residuals from anaerobic digestion	29,577 tonnes	1,717,301 tonnes
Residuals from gassification	0 tonnes	0 tonnes
GHG reductions - total	208,941 tCO2e	11,908,884 tCO2e
GHG reductions - marketable	187,894 tCO2e	10,709,286 tCO2e
Relative shadow price of carbon (unmarketed)	-$8m	-$432m

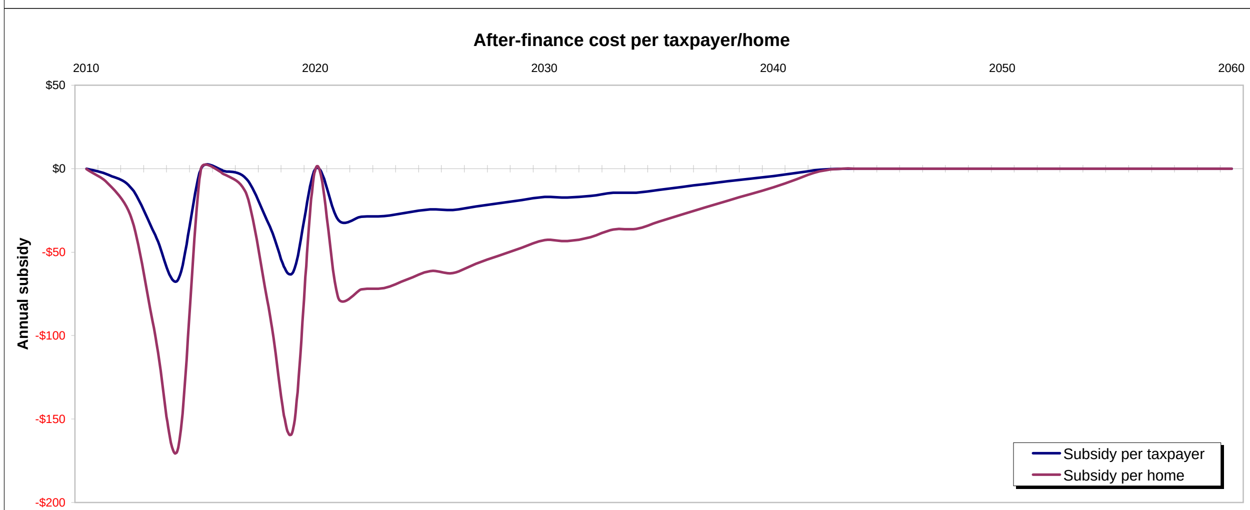
Input Stream Summary (pre-finance)

2010 dollars	**Liquid**	**Solid**	**Total**
Total revenues	$1,305m	$1,492m	$2,797m
Total costs	-$1,583m	-$705m	-$2,288m
Profit (loss)	-$278m	$788m	$510m
Present Value	**Liquid**	**Solid**	**Total**
Total revenues	$268m	$300m	$568m
Total costs	-$427m	-$246m	-$673m
Profit (loss)	-$160m	$54m	-$106m

Taxpayer Summary

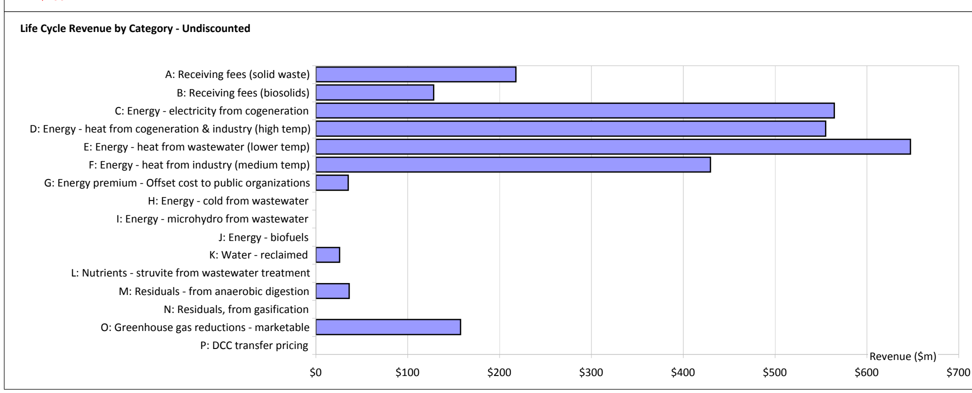
	Maximum	**Average**
15: Subsidy per capita/yr	-$67/yr	-$19/yr
16: Subsidy per home/yr	-$168/yr	-$48/yr
17: Duration of taxpayer subsidy	31yrs	N/A
18: Total subsidy per taxpayer	-$586	N/A
19: Total subsidy per home	-$1,476	N/A
20: Taxpayer ROI	-52%	N/A

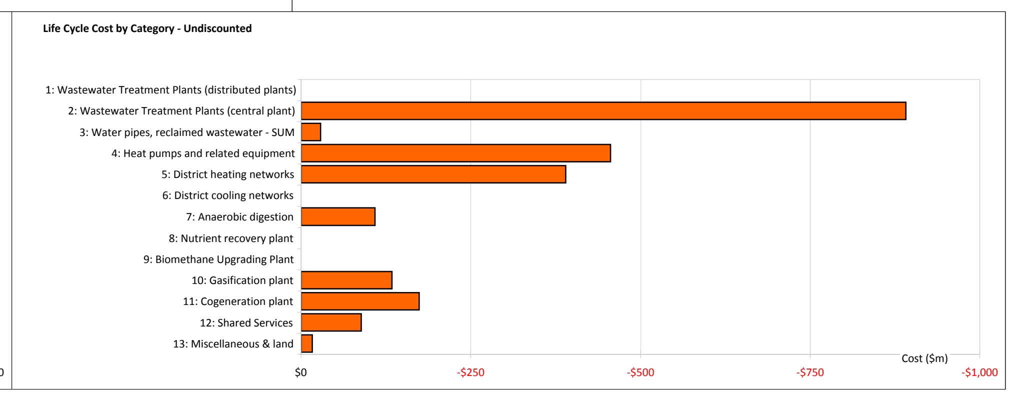




Summary of major input assumptions to the model

Analysis starts: 2010. Analysis ends: 2060. Duration: 50yrs.
Metro population growth model active
North Shore 2010 population : 186,000
North Shore 2010 homes : 74,000
Long term finance (Life cycle) @ 5.07%
Soft costs apportioned pre-/during construction: 75%/25%
Soft costs for CapEx replacement & incremental plant @ 33% of base
General inflation: 1.20%. Constrn inflation @ 1.40%. O&M inflation @ 2.10%
All risks discount rate @ 6.30%, reversionary/term cap. rate @ 9.00%
Positive balances accrue at 3%
DCC/Levy: Off
Cost items 6, 8 & 9 omitted from reporting (not used for current scenarios)





Scenario: 3. McKeen WW Treatment, Maplewood Energy Plant, 90% Diversion

Cost	Today CapEx	Undiscounted life cycle costs CapEx	O&M	Total @ yr	$Liquid	$Solid	PV life cycle costs CapEx	O&M	Total, PV	$Liquid PV	$Solid PV	Analysis Cost as %	%Liquid	%Solid
1: Wastewater Treatment Plants (distributed plants)	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	0.0%	100.0%	0.0%
2: Wastewater Treatment Plants (central plant)	-$292.2m	-$565.9m	-$325.3m	-$891.2m	-$891.2m	$0.0m	-$177.6m	-$58.2m	-$235.8m	-$235.8m	$0.0m	34.3%	100.0%	0.0%
3: Water pipes, reclaimed wastewater - SUM	-$7.9m	-$18.9m	-$9.8m	-$28.7m	-$28.7m	$0.0m	-$6.4m	-$2.2m	-$8.6m	-$8.6m	$0.0m	1.2%	100.0%	0.0%
4: Heat pumps and related equipment	-$42.5m	-$109.6m	-$328.8m	-$438.4m	-$438.4m	$0.0m	-$30.6m	-$58.8m	-$89.4m	-$89.4m	$0.0m	13.0%	100.0%	0.0%
5: District heating networks	-$181.6m	-$253.1m	-$137.0m	-$390.0m	-$206.7m	-$183.3m	-$139.9m	-$30.1m	-$170.0m	-$90.1m	-$79.9m	24.7%	53.0%	47.0%
6: District cooling networks	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	0.0%	0.0%	100.0%
7: Anaerobic digestion	-$24.8m	-$57.2m	-$75.5m	-$132.7m	$0.0m	-$132.7m	-$22.2m	-$16.6m	-$38.8m	$0.0m	-$38.8m	5.6%	0.0%	100.0%
8: Nutrient recovery plant	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	0.0%	100.0%	0.0%
9: Biomethane Upgrading Plant	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	0.0%	0.0%	100.0%
10: Gasification plant	-$22.6m	-$73.8m	-$67.9m	-$141.7m	$0.0m	-$141.7m	-$28.6m	-$14.9m	-$43.5m	$0.0m	-$43.5m	6.3%	0.0%	100.0%
11: Cogeneration plant	-$20.1m	-$93.8m	-$99.4m	-$193.2m	$0.0m	-$193.2m	-$26.4m	-$21.8m	-$48.2m	$0.0m	-$48.2m	7.0%	0.0%	100.0%
12: Shared Services	-$35.9m	-$51.6m	-$41.9m	-$93.6m	$0.0m	-$93.6m	-$30.5m	-$9.2m	-$39.8m	$0.0m	-$39.8m	5.8%	0.0%	100.0%
13: Miscellaneous & land	-$15.7m	-$16.4m	$0.0m	-$16.4m	$0.0m	-$16.4m	-$13.7m	$0.0m	-$13.7m	$0.0m	-$13.7m	2.0%	0.0%	100.0%
	-$643m	-$1,240m	-$1,086m	-$2,326m	-$1,565.0m	-$760.9m	-$476m	-$212m	-$688m	-$423.9m	-$263.8m	100%		
		53.3%	46.7%				69.2%	30.8%						

Revenue	Today Total	Undiscounted life cycle revenues Total @ yr	$Liquid	$Solid	PV life cycle revenues Total	$Liquid	$Solid	Analysis Revenue as %	%Liquid	%Solid
A: Receiving fees (solid waste)	$4.5m/yr.	$262.6m	$0.0m	$262.6m	$58.2m	$0.0m	$58.2m	10%	0%	100%
B: Receiving fees (biosolids)	$2.4m/yr.	$128.1m	$128.1m	$0.0m	$23.3m	$23.3m	$0.0m	4%	100%	0%
C: Energy - electricity from cogeneration	$11.0m/yr.	$635.1m	$29.0m	$606.1m	$139.5m	$7.0m	$132.6m	23%	5%	95%
D: Energy - heat from cogeneration & industry (high temp)	$10.5m/yr.	$611.8m	$0.0m	$611.8m	$135.5m	$0.0m	$135.5m	22%	0%	100%
E: Energy - heat from wastewater (lower temp)	$11.8m/yr.	$621.5m	$621.5m	$0.0m	$113.0m	$113.0m	$0.0m	19%	100%	0%
F: Energy - heat from industry (medium temp)	$7.7m/yr.	$403.9m	$403.9m	$0.0m	$73.4m	$73.4m	$0.0m	12%	100%	0%
G: Energy premium - Offset cost to public organizations	$0.6m/yr.	$35.4m	$17.8m	$17.6m	$7.1m	$3.8m	$3.4m	1%	53%	47%
H: Energy - cold from wastewater	$0.0m/yr.	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	0%	100%	0%
I: Energy - microhydro from wastewater	$0.0m/yr.	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	0%	0%	100%
J: Energy - biofuels	$0.0m/yr.	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	0%	0%	100%
K: Water - reclaimed	$0.5m/yr.	$25.9m	$25.9m	$0.0m	$4.7m	$4.7m	$0.0m	1%	100%	0%
L: Nutrients - struvite from wastewater treatment	$0.0m/yr.	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	0%	100%	0%
M: Residuals - from anaerobic digestion	$0.8m/yr.	$45.7m	$0.0m	$45.7m	$10.1m	$0.0m	$10.1m	2%	0%	100%
N: Residuals, from gasification	$0.0m/yr.	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	0%	0%	100%
O: Greenhouse gas reductions - marketable	$3.3m/yr.	$186.3m	$34.5m	$151.8m	$39.9m	$39.9m	$0.0m	7%	100%	0%
P: DCC transfer pricing	$0.0m/yr.	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	0%	43%	57%
Q: Taxpayer subsidy	$0.0m/yr.	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	0%	43%	57%
	$53.1m/yr.	$2,956m	$1,261m	$1,696m	$605m	$265m	$340m	100.0%		
			42.6%	57.4%		43.8%	56.2%			

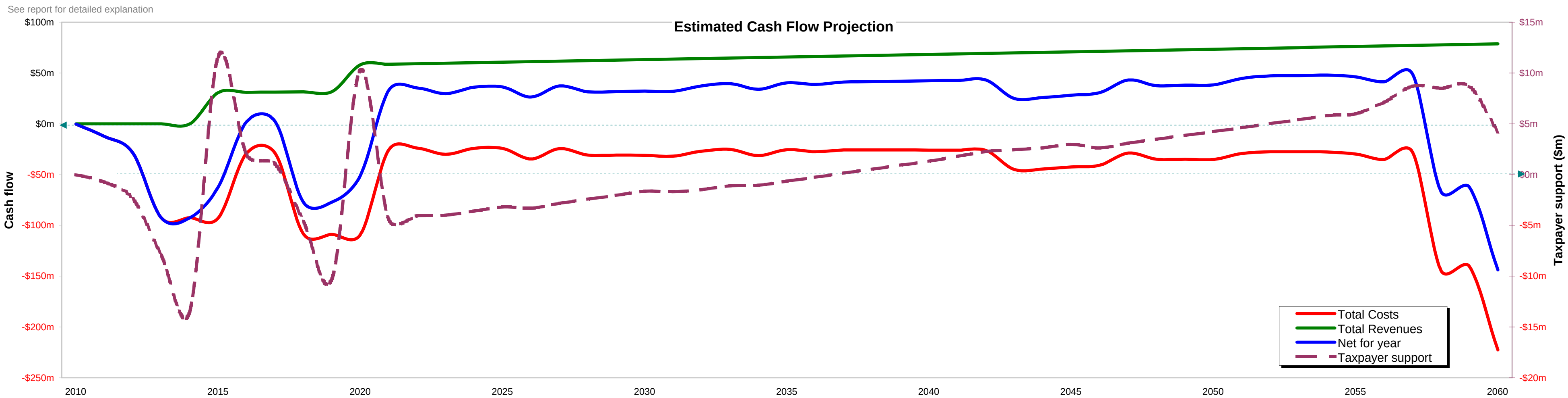
See report for explanation of model & assumptions.

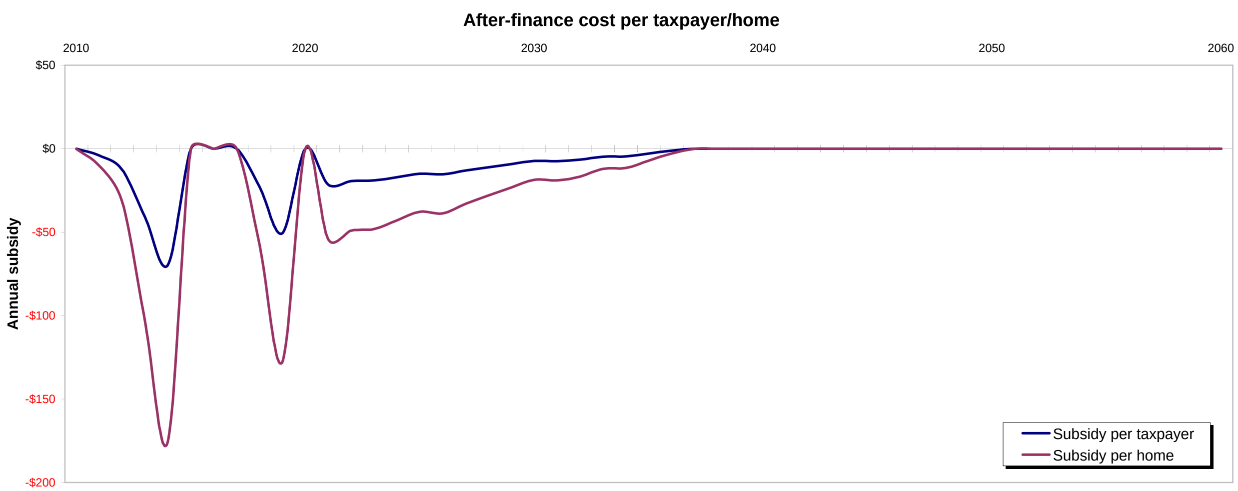
Financial summary		
Initial cost summary	**Undiscounted**	**PV**
1: Initial hard costs (exc. softs, contingency)	-$571.9m	-$367.7m
2: Initial soft costs	-$88.1m	-$61.2m
3: Initial CapEx (inc. softs, contingency)	-$660.0m	-$428.9m
Overall (pre-finance) cash flow summary		
4: Total life cycle revenues	$2,956.3m	$604.7m
5: Total life cycle costs (inc. replacement etc)	-$2,325.9m	-$687.7m
6: Net benefit (cost) *before finance*	**$630m**	**-$83m**
7: Benefit/revenue (subsidy/cost) per capita/yr	$68/yr	-$43/yr
8: Benefit/revenue (subsidy/cost) per home/yr	$170/yr	-$109/yr
9: Real discount rate (general inflation adjusted @ 1.2%pa)		6.3%
11: Estimated IRR before tax & finance		Not calculable
Finance adjusted cash flow summary		
12: Long term finance rate		5.07%
13: Profit (loss) after LT finance	**$44m**	**-$8m**
14: Estimated required total dividend (subsidy)	-$77m	N/A

Resource recovery summary	Volume pa	Total volume
Solid waste wet tonnes/year (input charge)	90,464 tonnes	5,252,540 tonnes
Biosolid dry tonnes/year (input charge)	7,290 tonnes	384,431 tonnes
Electricity from cogeneration	99,900 MWh	5,773,799 MWh
Heat from cogeneration & industry (high temp)	582,444 GJ	33,818,046 GJ
Heat from wastewater (lower temp)	651,451 GJ	34,352,805 GJ
Heat from industry (medium temp)	423,340 GJ	22,323,875 GJ
Energy sold to public organizations - 25.0% of supply	418,368 GJ	23,114,207 GJ
Cold from wastewater	0 GJ	0 GJ
Microhydro from waste water	0 tonnes	0 tonnes
Energy - biofuels	0 GJ	0 GJ
Reclaimed water (total)	48,545,000 m3	2,559,910,505 m3
Reclaimed water (identified saleable)	2,004,515 m3	105,703,554 m3
Struvite from waste water treatment	0 tonnes	0 tonnes
Residuals from anaerobic digestion	38,216 tonnes	2,218,904 tonnes
Residuals from gassification	0 tonnes	0 tonnes
GHG reductions - total	243,418 tCO2e	13,873,935 tCO2e
GHG reductions - marketable	222,371 tCO2e	12,674,336 tCO2e
Relative shadow price of carbon (unmarketed)	$0m	$0m

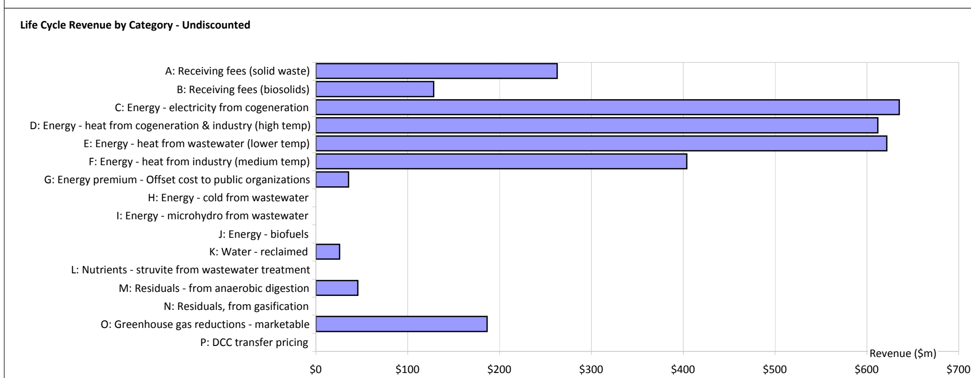
Input Stream Summary (pre-finance)			
2010 dollars	**Liquid**	**Solid**	**Total**
Total revenues	$1,261m	$1,696m	$2,956m
Total costs	-$1,565m	-$761m	-$2,326m
Profit (loss)	-$304m	$935m	$630m
Present Value	**Liquid**	**Solid**	**Total**
Total revenues	$265m	$340m	$605m
Total costs	-$424m	-$264m	-$688m
Profit (loss)	-$159m	$76m	-$83m

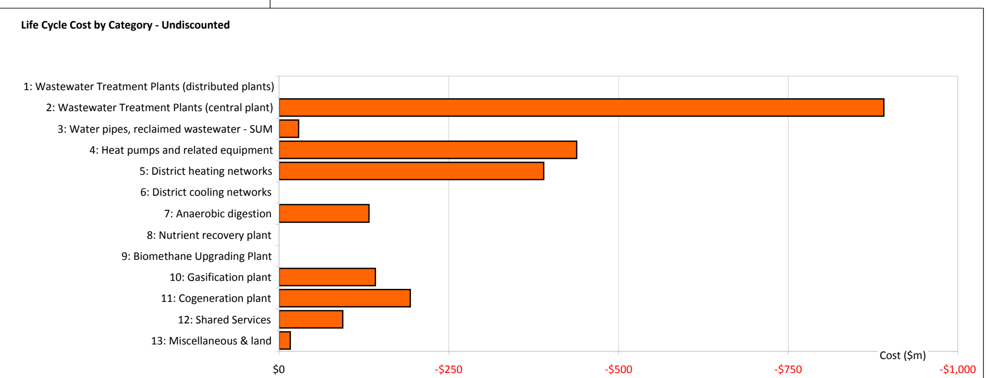
Taxpayer Summary	Maximum	Average
15: Subsidy per capita/yr	-$70/yr	-$16/yr
16: Subsidy per home/yr	-$175/yr	-$41/yr
17: Duration of taxpayer subsidy	23yrs	N/A
18: Total subsidy per taxpayer	-$377	N/A
19: Total subsidy per home	-$951	N/A
20: Taxpayer ROI	57%	N/A





Summary of major input assumptions to the model
Analysis starts: 2010. Analysis ends: 2060. Duration: 50yrs.
Metro population growth model active
North Shore 2010 population : 186,000
North Shore 2010 homes : 74,000
Long term finance (Life cycle) @ 5.07%
Soft costs apportioned pre-/during construction: 75%/25%
Soft costs for CapEx replacement & incremental plant @ 33% of base
General inflation: 1.20%. Constrn inflation @ 1.40%. O&M inflation @ 2.10%
All risks discount rate @ 6.30%, reversionary/term cap. rate @ 9.00%
Positive balances accrue at 3%
DCC/Levy: Off
Cost items 6, 8 & 9 omitted from reporting (not used for current scenarios)





Scenario: 4. McKeen WW Treatment, Maplewood Energy Plant, Current Transfer Station Volume

	Today	Undiscounted life cycle costs					PV life cycle costs					Analysis		
Cost	**CapEx**	**CapEx**	**O&M**	**Total @ yr**	**$Liquid**	**$Solid**	**CapEx**	**O&M**	**Total, PV**	**$Liquid PV**	**$Solid PV**	**Cost as %**	**%Liquid**	**%Solid**
1: Wastewater Treatment Plants (distributed plants)	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	0.0%	100.0%	0.0%
2: Wastewater Treatment Plants (central plant)	-$292.2m	-$565.9m	-$325.3m	-$891.2m	-$891.2m	$0.0m	-$177.6m	-$58.2m	-$235.8m	-$235.8m	$0.0m	32.0%	100.0%	0.0%
3: Water pipes, reclaimed wastewater - SUM	-$7.9m	-$18.9m	-$9.8m	-$28.7m	-$28.7m	$0.0m	-$6.4m	-$2.2m	-$8.6m	-$8.6m	$0.0m	1.2%	100.0%	0.0%
4: Heat pumps and related equipment	-$38.5m	-$101.5m	-$281.7m	-$383.2m	-$383.2m	$0.0m	-$28.2m	-$50.4m	-$78.6m	-$78.6m	$0.0m	10.7%	100.0%	0.0%
5: District heating networks	-$181.6m	-$253.1m	-$137.0m	-$390.0m	-$206.7m	-$183.3m	-$139.9m	-$30.1m	-$170.0m	-$90.1m	-$79.9m	23.1%	53.0%	47.0%
6: District cooling networks	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	0.0%	0.0%	100.0%
7: Anaerobic digestion	-$30.8m	-$69.1m	-$100.5m	-$169.6m	$0.0m	-$169.6m	-$27.2m	-$22.0m	-$49.3m	$0.0m	-$49.3m	6.7%	0.0%	100.0%
8: Nutrient recovery plant	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	0.0%	100.0%	0.0%
9: Biomethane Upgrading Plant	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	0.0%	0.0%	100.0%
10: Gasification plant	-$40.2m	-$120.3m	-$89.0m	-$209.3m	$0.0m	-$209.3m	-$49.1m	-$19.5m	-$68.7m	$0.0m	-$68.7m	9.3%	0.0%	100.0%
11: Cogeneration plant	-$26.9m	-$120.0m	-$136.6m	-$256.7m	$0.0m	-$256.7m	-$34.4m	-$30.0m	-$64.4m	$0.0m	-$64.4m	8.7%	0.0%	100.0%
12: Shared Services	-$44.9m	-$60.8m	-$46.6m	-$107.4m	$0.0m	-$107.4m	-$37.4m	-$10.2m	-$47.6m	$0.0m	-$47.6m	6.5%	0.0%	100.0%
13: Miscellaneous & land	-$15.7m	-$16.4m	$0.0m	-$16.4m	$0.0m	-$16.4m	-$13.7m	$0.0m	-$13.7m	$0.0m	-$13.7m	1.9%	0.0%	100.0%
	-$679m	-$1,326m	-$1,127m	-$2,452m	-$1,509.9m	-$942.6m	-$514m	-$223m	-$737m	-$413.0m	-$323.6m	100%		
		54.1%	45.9%				69.8%	30.2%						

	Today	Undiscounted life cycle revenues			PV life cycle revenues			Analysis		
Revenue	**Total**	**Total @ yr**	**$Liquid**	**$Solid**	**Total**	**$Liquid**	**$Solid**	**Revenue as %**	**%Liquid**	**%Solid**
A: Receiving fees (solid waste)	$6.8m/yr.	$395.4m	$0.0m	$395.4m	$87.6m	$0.0m	$87.6m	12%	0%	100%
B: Receiving fees (biosolids)	$2.4m/yr.	$128.1m	$128.1m	$0.0m	$23.3m	$23.3m	$0.0m	3%	100%	0%
C: Energy - electricity from cogeneration	$15.1m/yr.	$872.8m	$39.8m	$833.0m	$191.8m	$9.6m	$182.2m	27%	5%	95%
D: Energy - heat from cogeneration & industry (high temp)	$13.2m/yr.	$769.0m	$0.0m	$769.0m	$170.3m	$0.0m	$170.3m	24%	0%	100%
E: Energy - heat from wastewater (lower temp)	$10.1m/yr.	$534.7m	$534.7m	$0.0m	$97.2m	$97.2m	$0.0m	14%	100%	0%
F: Energy - heat from industry (medium temp)	$6.6m/yr.	$347.9m	$347.9m	$0.0m	$63.2m	$63.2m	$0.0m	9%	100%	0%
G: Energy premium - Offset cost to public organizations	$0.6m/yr.	$35.7m	$14.6m	$21.1m	$7.3m	$3.2m	$4.2m	1%	43%	57%
H: Energy - cold from wastewater	$0.0m/yr.	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	0%	100%	0%
I: Energy - microhydro from wastewater	$0.0m/yr.	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	0%	0%	100%
J: Energy - biofuels	$0.0m/yr.	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	0%	0%	100%
K: Water - reclaimed	$0.5m/yr.	$25.9m	$25.9m	$0.0m	$4.7m	$4.7m	$0.0m	1%	100%	0%
L: Nutrients - struvite from wastewater treatment	$0.0m/yr.	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	0%	100%	0%
M: Residuals - from anaerobic digestion	$1.1m/yr.	$66.6m	$0.0m	$66.6m	$14.7m	$0.0m	$14.7m	2%	0%	100%
N: Residuals, from gasification	$0.0m/yr.	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	0%	0%	100%
O: Greenhouse gas reductions - marketable	$4.3m/yr.	$246.1m	$45.5m	$200.5m	$52.7m	$52.7m	$0.0m	7%	100%	0%
P: DCC transfer pricing	$0.0m/yr.	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	0%	43%	57%
Q: Taxpayer subsidy	$0.0m/yr.	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	0%	43%	57%
	$60.9m/yr.	$3,422m	$1,137m	$2,286m	$713m	$254m	$459m	100.0%		
			33.2%	66.8%		35.6%	64.4%			

See report for explanation of model & assumptions.

Financial summary

Initial cost summary	**Undiscounted**	**PV**
1: Initial hard costs (exc. softs, contingency)	-$609.1m	-$395.9m
2: Initial soft costs	-$92.8m	-$65.1m
3: Initial CapEx (inc. softs, contingency)	-$701.9m	-$461.1m
Overall (pre-finance) cash flow summary		
4: Total life cycle revenues	$3,422.2m	$712.9m
5: Total life cycle costs (inc. replacement etc)	-$2,452.5m	-$736.6m
6: Net benefit (cost) *before finance*	**$970m**	**-$24m**
7: Benefit/revenue (subsidy/cost) per capita/yr	$104/yr	-$12/yr
8: Benefit/revenue (subsidy/cost) per home/yr	$262/yr	-$31/yr
9: Real discount rate (general inflation adjusted @ 1.2%pa)		6.3%
11: Estimated IRR before tax & finance		Not calculable
Finance adjusted cash flow summary		
12: Long term finance rate		5.07%
13: Profit (loss) after LT finance	**$336m**	**$76m**
14: Estimated required total dividend (subsidy)	-$32m	N/A

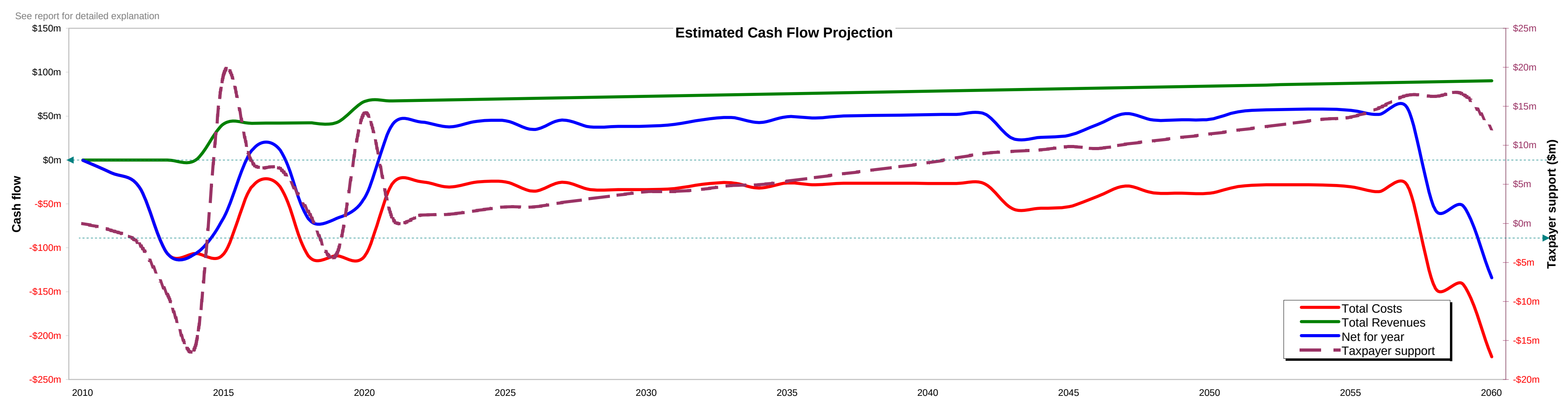
Resource recovery summary	**Volume pa**	**Total volume**
Solid waste wet tonnes/year (input charge)	136,202 tonnes	7,908,200 tonnes
Biosolid dry tonnes/year (input charge)	7,290 tonnes	384,431 tonnes
Electricity from cogeneration	137,291 MWh	7,934,878 MWh
Heat from cogeneration & industry (high temp)	732,060 GJ	42,505,115 GJ
Heat from wastewater (lower temp)	560,474 GJ	29,555,322 GJ
Heat from industry (medium temp)	364,701 GJ	19,231,686 GJ
Energy sold to public organizations - 25.0% of supply	418,368 GJ	23,324,559 GJ
Cold from wastewater	0 GJ	0 GJ
Microhydro from waste water	0 tonnes	0 tonnes
Energy - biofuels	0 GJ	0 GJ
Reclaimed water (total)	48,545,000 m3	2,559,910,505 m3
Reclaimed water (identified saleable)	2,004,515 m3	105,703,554 m3
Struvite from waste water treatment	0 tonnes	0 tonnes
Residuals from anaerobic digestion	56,034 tonnes	3,253,464 tonnes
Residuals from gassification	0 tonnes	0 tonnes
GHG reductions - total	314,738 tCO2e	17,938,953 tCO2e
GHG reductions - marketable	293,691 tCO2e	16,739,354 tCO2e
Relative shadow price of carbon (unmarketed)	$18m	$893m

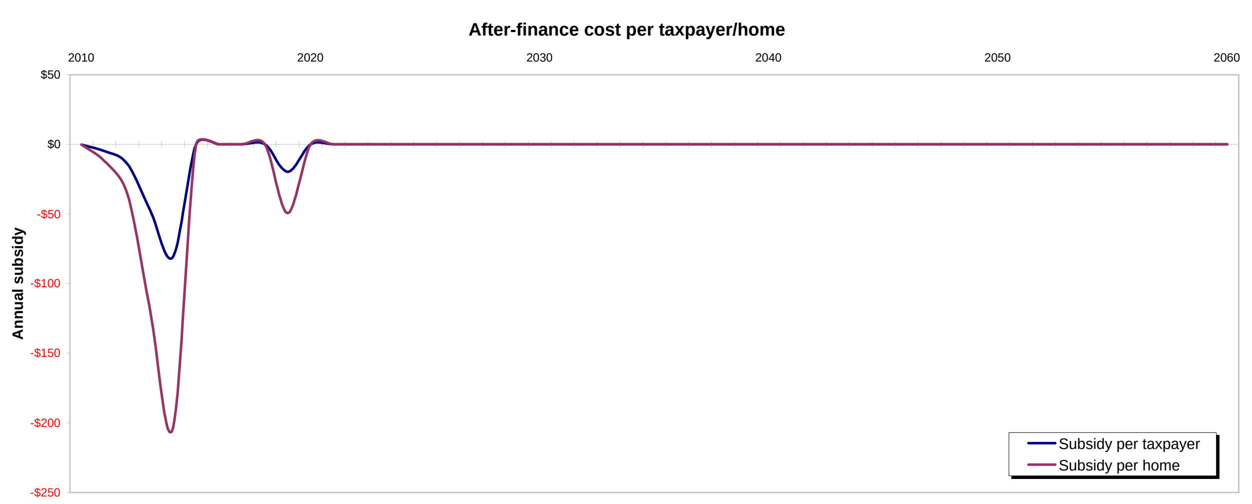
Input Stream Summary (pre-finance)

2010 dollars	**Liquid**	**Solid**	**Total**
Total revenues	$1,137m	$2,286m	$3,422m
Total costs	-$1,510m	-$943m	-$2,452m
Profit (loss)	-$373m	$1,343m	$970m
Present Value	**Liquid**	**Solid**	**Total**
Total revenues	$254m	$459m	$713m
Total costs	-$413m	-$324m	-$737m
Profit (loss)	-$159m	$135m	-$24m

Taxpayer Summary

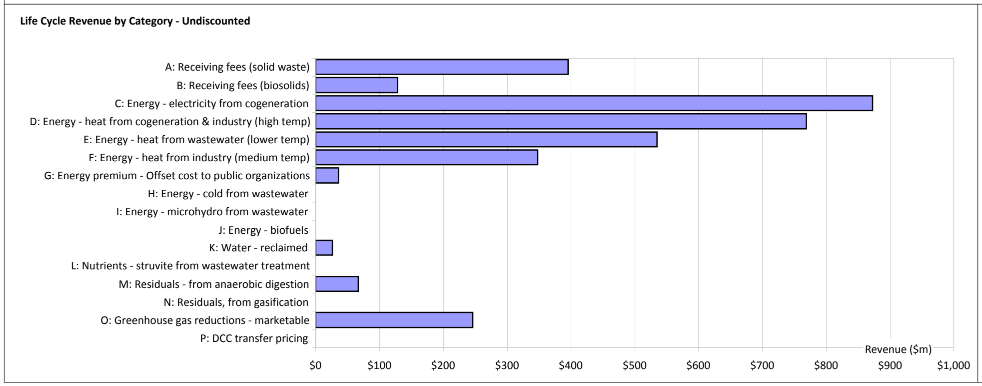
	Maximum	**Average**
15: Subsidy per capita/yr	-$81/yr	-$28/yr
16: Subsidy per home/yr	-$203/yr	-$70/yr
17: Duration of taxpayer subsidy	6yrs	N/A
18: Total subsidy per taxpayer	-$167	N/A
19: Total subsidy per home	-$420	N/A
20: Taxpayer ROI	1,041%	N/A

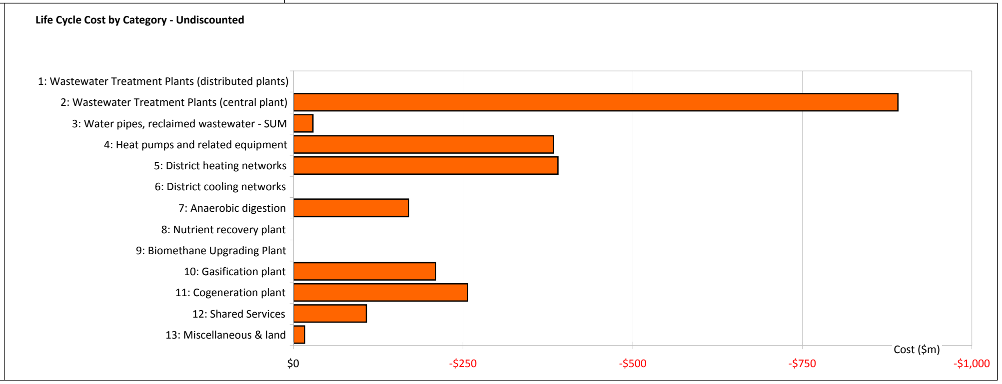




Summary of major input assumptions to the model

Analysis starts: 2010. Analysis ends: 2060. Duration: 50yrs.
Metro population growth model active
North Shore 2010 population : 186,000
North Shore 2010 homes : 74,000
Long term finance (Life cycle) @ 5.07%
Soft costs apportioned pre-/during construction: 75%/25%
Soft costs for CapEx replacement & incremental plant @ 33% of base
General inflation: 1.20%. Constrn inflation @ 1.40%. O&M inflation @ 2.10%
All risks discount rate @ 6.30%, reversionary/term cap. rate @ 9.00%
Positive balances accrue at 3%
DCC/Levy: Off
Cost items 6, 8 & 9 omitted from reporting (not used for current scenarios)





Scenario: 5. McKeen WW Treatment, Maplewood Energy Plant, 70% Diversion, Revenue Modified

	Today	Undiscounted life cycle costs					PV life cycle costs					Analysis		
Cost	**CapEx**	**CapEx**	**O&M**	**Total @ yr**	**$Liquid**	**$Solid**	**CapEx**	**O&M**	**Total, PV**	**$Liquid PV**	**$Solid PV**	**Cost as %**	**%Liquid**	**%Solid**
1: Wastewater Treatment Plants (distributed plants)	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	0.0%	100.0%	0.0%
2: Wastewater Treatment Plants (central plant)	-$292.2m	-$565.9m	-$325.3m	-$891.2m	-$891.2m	$0.0m	-$177.6m	-$58.2m	-$235.8m	-$235.8m	$0.0m	35.5%	100.0%	0.0%
3: Water pipes, reclaimed wastewater - SUM	-$7.9m	-$18.9m	-$9.8m	-$28.7m	-$28.7m	$0.0m	-$6.4m	-$2.2m	-$8.6m	-$8.6m	$0.0m	1.3%	100.0%	0.0%
4: Heat pumps and related equipment	-$50.3m	-$125.1m	-$472.7m	-$597.8m	-$597.8m	$0.0m	-$35.4m	-$84.6m	-$119.9m	-$119.9m	$0.0m	18.0%	100.0%	0.0%
5: District heating networks	-$174.4m	-$245.8m	-$133.2m	-$379.0m	-$200.9m	-$178.1m	-$134.5m	-$29.2m	-$163.7m	-$86.8m	-$77.0m	24.6%	53.0%	47.0%
6: District cooling networks	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	0.0%	0.0%	100.0%
7: Anaerobic digestion	-$19.1m	-$45.9m	-$55.8m	-$101.8m	$0.0m	-$101.8m	-$17.4m	-$12.3m	-$29.6m	$0.0m	-$29.6m	4.5%	0.0%	100.0%
8: Nutrient recovery plant	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	0.0%	100.0%	0.0%
9: Biomethane Upgrading Plant	-$3.2m	-$16.7m	-$7.2m	-$24.0m	$0.0m	-$24.0m	-$5.0m	-$1.6m	-$6.6m	$0.0m	-$6.6m	1.0%	0.0%	100.0%
10: Gasification plant	-$13.4m	-$49.6m	-$88.2m	-$137.8m	$0.0m	-$137.8m	-$17.9m	-$19.4m	-$37.3m	$0.0m	-$37.3m	5.6%	0.0%	100.0%
11: Cogeneration plant	-$9.4m	-$52.5m	-$47.2m	-$99.7m	$0.0m	-$99.7m	-$13.7m	-$10.4m	-$24.1m	$0.0m	-$24.1m	3.6%	0.0%	100.0%
12: Shared Services	-$23.0m	-$38.7m	-$21.8m	-$60.5m	$0.0m	-$60.5m	-$20.9m	-$4.8m	-$25.6m	$0.0m	-$25.6m	3.9%	0.0%	100.0%
13: Miscellaneous & land	-$15.7m	-$16.4m	$0.0m	-$16.4m	$0.0m	-$16.4m	-$13.7m	$0.0m	-$13.7m	$0.0m	-$13.7m	2.1%	0.0%	100.0%
	-$609m	-$1,176m	-$1,161m	-$2,337m	-$1,718.6m	-$618.3m	-$442m	-$223m	-$665m	-$451.1m	-$213.9m	100%		
		50.3%	49.7%				66.5%	33.5%						

	Today	Undiscounted life cycle revenues			PV life cycle revenues			Analysis		
Revenue	**Total**	**Total @ yr**	**$Liquid**	**$Solid**	**Total**	**$Liquid**	**$Solid**	**Revenue as %**	**%Liquid**	**%Solid**
A: Receiving fees (solid waste)	$1.5m/yr.	$85.7m	$0.0m	$85.7m	$19.0m	$0.0m	$19.0m	4%	0%	100%
B: Receiving fees (biosolids)	$0.0m/yr.	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	0%	100%	0%
C: Energy - electricity from cogeneration	$5.0m/yr.	$287.7m	$13.1m	$274.6m	$63.2m	$3.2m	$60.1m	14%	5%	95%
D: Energy - heat from cogeneration & industry (high temp)	$4.2m/yr.	$242.6m	$0.0m	$242.6m	$53.7m	$0.0m	$53.7m	12%	0%	100%
E: Energy - heat from wastewater (lower temp)	$25.8m/yr.	$1,360.7m	$1,360.7m	$0.0m	$247.3m	$247.3m	$0.0m	54%	100%	0%
F: Energy - heat from industry (medium temp)	$0.0m/yr.	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	0%	100%	0%
G: Energy premium - Offset cost to public organizations	$0.6m/yr.	$34.3m	$29.1m	$5.2m	$6.4m	$5.5m	$0.9m	1%	86%	14%
H: Energy - cold from wastewater	$0.0m/yr.	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	0%	100%	0%
I: Energy - microhydro from wastewater	$0.0m/yr.	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	0%	0%	100%
J: Energy - biofuels	$1.7m/yr.	$96.2m	$0.0m	$96.2m	$21.3m	$0.0m	$21.3m	5%	0%	100%
K: Water - reclaimed	$0.5m/yr.	$25.9m	$25.9m	$0.0m	$4.7m	$4.7m	$0.0m	1%	100%	0%
L: Nutrients - struvite from wastewater treatment	$0.0m/yr.	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	0%	100%	0%
M: Residuals - from anaerobic digestion	$0.7m/yr.	$40.9m	$0.0m	$40.9m	$9.1m	$0.0m	$9.1m	2%	0%	100%
N: Residuals, from gasification	$0.0m/yr.	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	0%	0%	100%
O: Greenhouse gas reductions - marketable	$2.8m/yr.	$158.7m	$29.4m	$129.3m	$34.0m	$34.0m	$0.0m	7%	100%	0%
P: DCC transfer pricing	$0.0m/yr.	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	0%	43%	57%
Q: Taxpayer subsidy	$0.0m/yr.	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	0%	43%	57%
	$42.7m/yr.	$2,333m	$1,458m	$874m	$459m	$295m	$164m	100.0%		
			62.5%	37.5%		64.2%	35.8%			

See report for explanation of model & assumptions.

Financial summary

Initial cost summary	**Undiscounted**	**PV**
1: Initial hard costs (exc. softs, contingency)	-$538.1m	-$341.4m
2: Initial soft costs	-$83.9m	-$57.5m
3: Initial CapEx (inc. softs, contingency)	-$622.0m	-$399.0m
Overall (pre-finance) cash flow summary		
4: Total life cycle revenues	$2,332.5m	$458.7m
5: Total life cycle costs (inc. replacement etc)	-$2,336.9m	-$665.0m
6: Net benefit (cost) *before finance*	**-$4m**	**-$206m**
7: Benefit/revenue (subsidy/cost) per capita/yr	-$0/yr	-$107/yr
8: Benefit/revenue (subsidy/cost) per home/yr	-$1/yr	-$270/yr
9: Real discount rate (general inflation adjusted @ 1.2%pa)		6.3%
11: Estimated IRR before tax & finance		Not calculable
Finance adjusted cash flow summary		
12: Long term finance rate		5.07%
13: Profit (loss) after LT finance	**-$542m**	**-$144m**
14: Estimated required total dividend (subsidy)	-$544m	N/A

Resource recovery summary

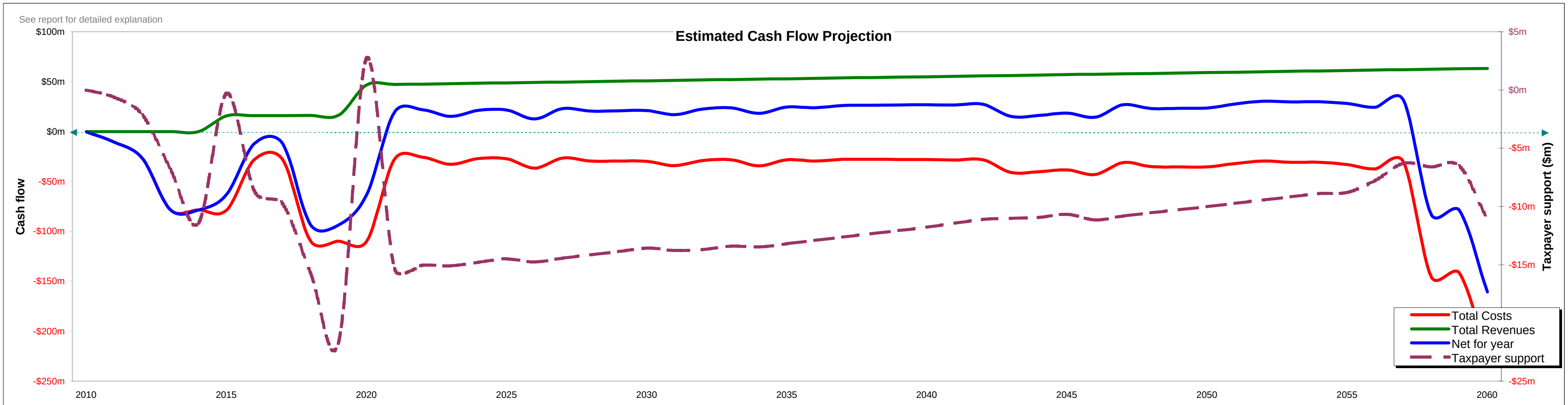
	Volume pa	**Total volume**
Solid waste wet tonnes/year (input charge)	29,534 tonnes	1,714,821 tonnes
Biosolid dry tonnes/year (input charge)	0 tonnes	0 tonnes
Electricity from cogeneration	47,454 MWh	2,742,667 MWh
Heat from cogeneration & industry (high temp)	230,922 GJ	13,407,881 GJ
Heat from wastewater (lower temp)	1,426,313 GJ	75,213,368 GJ
Heat from industry (medium temp)	0 GJ	0 GJ
Energy sold to public organizations - 25.0% of supply	418,368 GJ	22,372,383 GJ
Cold from wastewater	0 GJ	0 GJ
Microhydro from waste water	0 tonnes	0 tonnes
Energy - biofuels	187,755 GJ	10,901,504 GJ
Reclaimed water (total)	48,545,000 m3	2,559,910,505 m3
Reclaimed water (identified saleable)	2,004,515 m3	105,703,554 m3
Struvite from waste water treatment	0 tonnes	0 tonnes
Residuals from anaerobic digestion	30,701 tonnes	1,782,579 tonnes
Residuals from gassification	0 tonnes	0 tonnes
GHG reductions - total	210,428 tCO2e	11,993,652 tCO2e
GHG reductions - marketable	189,381 tCO2e	10,794,053 tCO2e
Relative shadow price of carbon (unmarketed)	-$8m	-$413m

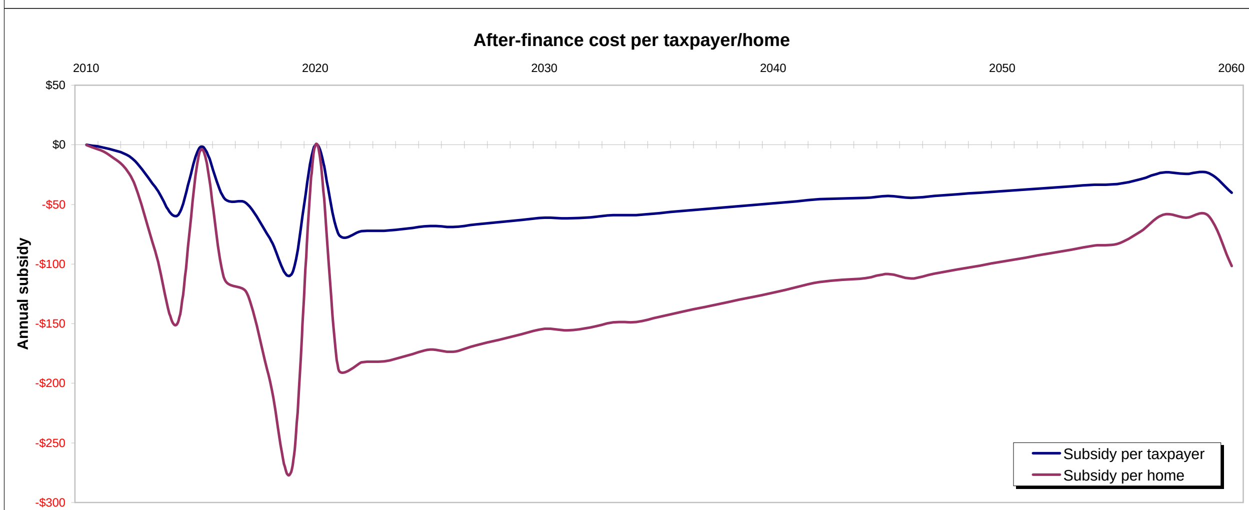
Input Stream Summary (pre-finance)

2010 dollars	**Liquid**	**Solid**	**Total**
Total revenues	$1,458m	$874m	$2,333m
Total costs	-$1,719m	-$618m	-$2,337m
Profit (loss)	-$260m	$256m	-$4m
Present Value	**Liquid**	**Solid**	**Total**
Total revenues	$295m	$164m	$459m
Total costs	-$451m	-$214m	-$665m
Profit (loss)	-$156m	-$50m	-$206m

Taxpayer Summary

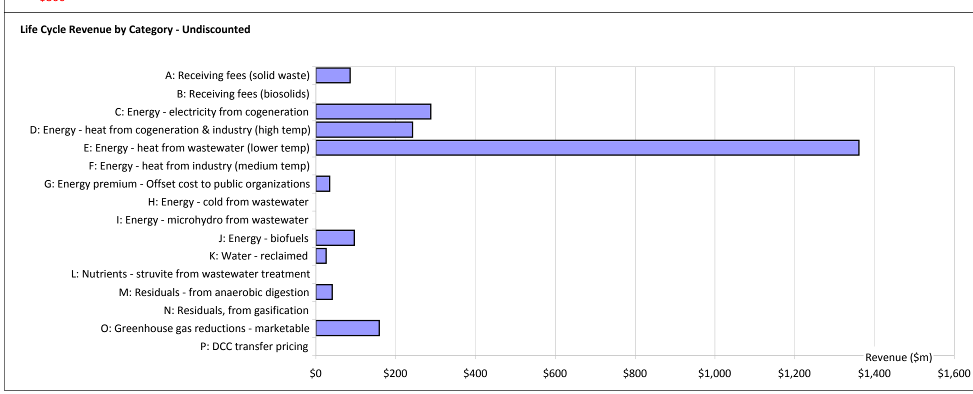
	Maximum	**Average**
15: Subsidy per capita/yr	-$107/yr	-$48/yr
16: Subsidy per home/yr	-$269/yr	-$120/yr
17: Duration of taxpayer subsidy	50yrs	N/A
18: Total subsidy per taxpayer	-$2,380	N/A
19: Total subsidy per home	-$5,999	N/A
20: Taxpayer ROI	-100%	N/A

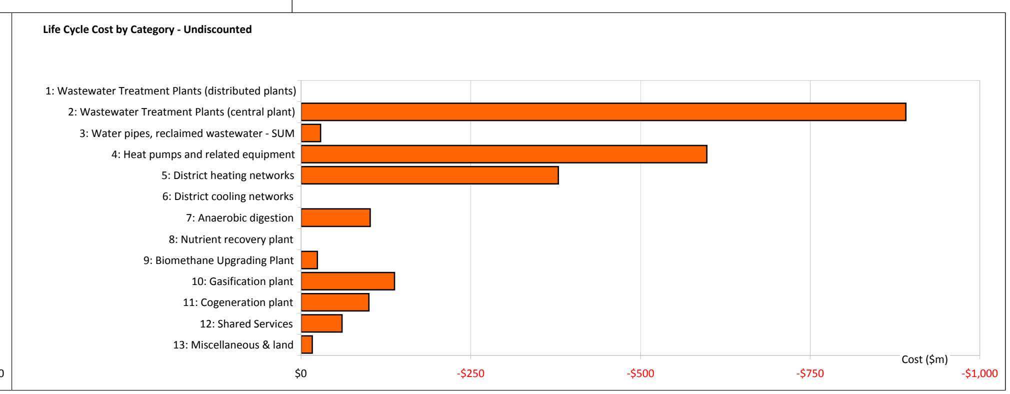




Summary of major input assumptions to the model

Analysis starts: 2010. Analysis ends: 2060. Duration: 50yrs.
Metro population growth model active
North Shore 2010 population : 186,000
North Shore 2010 homes : 74,000
Long term finance (Life cycle) @ 5.07%
Soft costs apportioned pre-/during construction: 75%/25%
Soft costs for CapEx replacement & incremental plant @ 33% of base
General inflation: 1.20%. Constrn inflation @ 1.40%. O&M inflation @ 2.10%
All risks discount rate @ 6.30%, reversionary/term cap. rate @ 9.00%
Positive balances accrue at 3%
DCC/Levy: Off
Cost items 6, 8 & 9 omitted from reporting (not used for current scenarios)





Scenario: 6. McKeen WW Treatment, Heat Recovery from Wastewater Only

	Today	Undiscounted life cycle costs					PV life cycle costs					Analysis		
Cost	**CapEx**	**CapEx**	**O&M**	**Total @ yr**	**$Liquid**	**$Solid**	**CapEx**	**O&M**	**Total, PV**	**$Liquid PV**	**$Solid PV**	**Cost as %**	**%Liquid**	**%Solid**
1: Wastewater Treatment Plants (distributed plants)	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	0.0%	100.0%	0.0%
2: Wastewater Treatment Plants (central plant)	-$292.2m	-$565.9m	-$325.3m	-$891.2m	-$891.2m	$0.0m	-$177.6m	-$58.2m	-$235.8m	-$235.8m	$0.0m	41.4%	100.0%	0.0%
3: Water pipes, reclaimed wastewater - SUM	-$7.9m	-$18.9m	-$9.8m	-$28.7m	-$28.7m	$0.0m	-$6.4m	-$2.2m	-$8.6m	-$8.6m	$0.0m	1.5%	100.0%	0.0%
4: Heat pumps and related equipment	-$55.4m	-$135.4m	-$549.7m	-$685.0m	-$685.0m	$0.0m	-$38.5m	-$98.3m	-$136.8m	-$136.8m	$0.0m	24.0%	100.0%	0.0%
5: District heating networks	-$174.4m	-$245.8m	-$150.5m	-$396.3m	-$210.0m	-$186.2m	-$134.5m	-$33.0m	-$167.5m	-$88.8m	-$78.7m	29.4%	53.0%	47.0%
6: District cooling networks	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	0.0%	0.0%	100.0%
7: Anaerobic digestion	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	0.0%	0.0%	100.0%
8: Nutrient recovery plant	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	0.0%	100.0%	0.0%
9: Biomethane Upgrading Plant	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	0.0%	0.0%	100.0%
10: Gasification plant	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	0.0%	0.0%	100.0%
11: Cogeneration plant	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	0.0%	0.0%	100.0%
12: Shared Services	-$4.0m	-$19.5m	$0.0m	-$19.5m	$0.0m	-$19.5m	-$6.5m	$0.0m	-$6.5m	$0.0m	-$6.5m	1.1%	0.0%	100.0%
13: Miscellaneous & land	-$15.7m	-$16.4m	$0.0m	-$16.4m	$0.0m	-$16.4m	-$13.7m	$0.0m	-$13.7m	$0.0m	-$13.7m	2.4%	0.0%	100.0%
	-$550m	-$1,002m	-$1,035m	-$2,037m	-$1,815.0m	-$222.1m	-$377m	-$192m	-$569m	-$470.0m	-$98.9m	100%		
		49.2%	50.8%				66.3%	33.7%						

	Today	Undiscounted life cycle revenues			PV life cycle revenues			Analysis		
Revenue	**Total**	**Total @ yr**	**$Liquid**	**$Solid**	**Total**	**$Liquid**	**$Solid**	**Revenue as %**	**%Liquid**	**%Solid**
A: Receiving fees (solid waste)	$0.0m/yr.	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	0%	0%	100%
B: Receiving fees (biosolids)	$0.0m/yr.	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	0%	100%	0%
C: Energy - electricity from cogeneration	$0.0m/yr.	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	0%	5%	95%
D: Energy - heat from cogeneration & industry (high temp)	$0.0m/yr.	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	0%	0%	100%
E: Energy - heat from wastewater (lower temp)	$30.0m/yr.	$1,581.0m	$1,581.0m	$0.0m	$287.3m	$287.3m	$0.0m	92%	100%	0%
F: Energy - heat from industry (medium temp)	$0.0m/yr.	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	0%	100%	0%
G: Energy premium - Offset cost to public organizations	$0.6m/yr.	$33.8m	$33.8m	$0.0m	$6.1m	$6.1m	$0.0m	2%	100%	0%
H: Energy - cold from wastewater	$0.0m/yr.	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	0%	100%	0%
I: Energy - microhydro from wastewater	$0.0m/yr.	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	0%	0%	100%
J: Energy - biofuels	$0.0m/yr.	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	0%	0%	100%
K: Water - reclaimed	$0.5m/yr.	$25.9m	$25.9m	$0.0m	$4.7m	$4.7m	$0.0m	2%	100%	0%
L: Nutrients - struvite from wastewater treatment	$0.0m/yr.	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	0%	100%	0%
M: Residuals - from anaerobic digestion	$0.0m/yr.	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	0%	0%	100%
N: Residuals, from gasification	$0.0m/yr.	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	0%	0%	100%
O: Greenhouse gas reductions - marketable	$1.0m/yr.	$58.5m	$10.8m	$47.7m	$12.5m	$12.5m	$0.0m	4%	100%	0%
P: DCC transfer pricing	$0.0m/yr.	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	0%	43%	57%
Q: Taxpayer subsidy	$0.0m/yr.	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	$0.0m	0%	43%	57%
	$32.1m/yr.	$1,699m	$1,651m	$48m	$311m	$311m	$0m	100.0%		
			97.2%	2.8%		100.0%	0.0%			

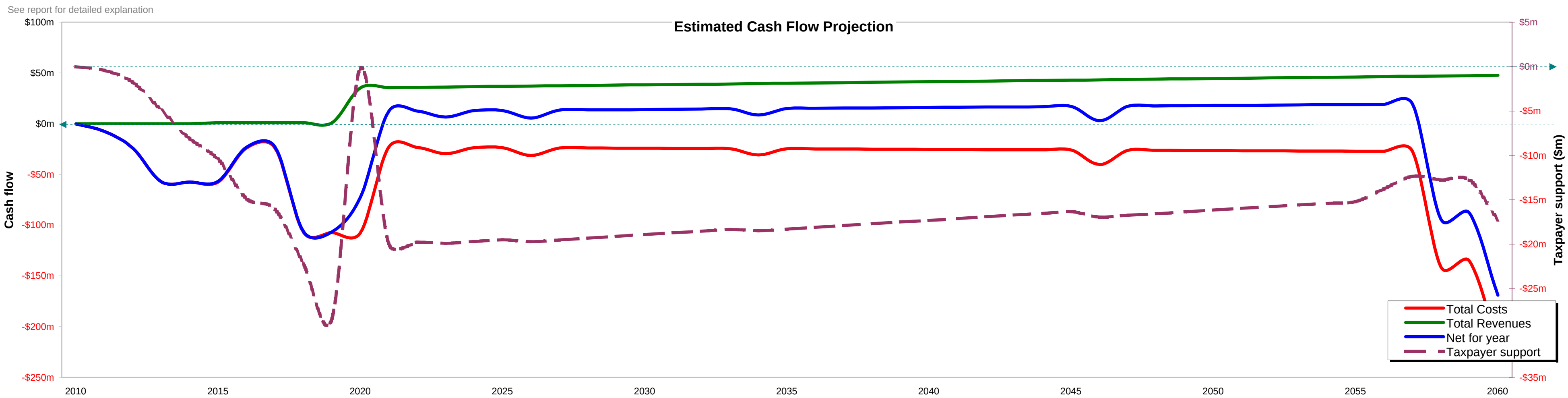
See report for explanation of model & assumptions.

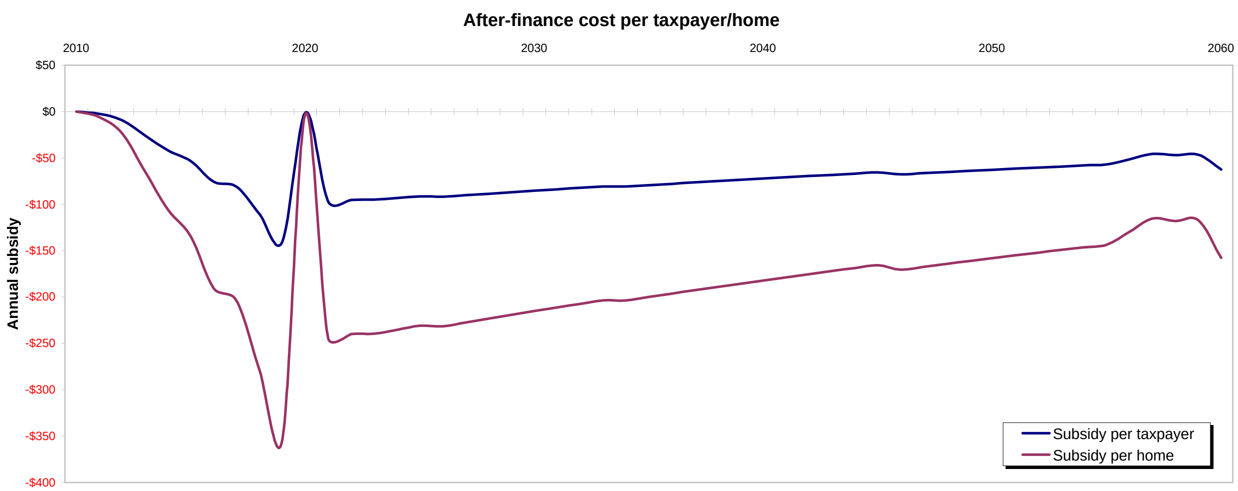
Financial summary		
Initial cost summary	**Undiscounted**	**PV**
1: Initial hard costs (exc. softs, contingency)	-$481.1m	-$298.5m
2: Initial soft costs	-$76.8m	-$51.5m
3: Initial CapEx (inc. softs, contingency)	-$557.9m	-$350.0m
Overall (pre-finance) cash flow summary		
4: Total life cycle revenues	$1,699.2m	$310.7m
5: Total life cycle costs (inc. replacement etc)	-$2,037.1m	-$568.9m
6: Net benefit (cost) *before finance*	**-$338m**	**-$258m**
7: Benefit/revenue (subsidy/cost) per capita/yr	-$36/yr	-$134/yr
8: Benefit/revenue (subsidy/cost) per home/yr	-$91/yr	-$338/yr
9: Real discount rate (general inflation adjusted @ 1.2%pa)		6.3%
11: Estimated IRR before tax & finance		Not calculable
Finance adjusted cash flow summary		
12: Long term finance rate		5.07%
13: Profit (loss) after LT finance	**-$797m**	**-$203m**
14: Estimated required total dividend (subsidy)	-$797m	N/A

Resource recovery summary	Volume pa	Total volume
Solid waste wet tonnes/year (input charge)	0 tonnes	0 tonnes
Biosolid dry tonnes/year (input charge)	0 tonnes	0 tonnes
Electricity from cogeneration	0 MWh	0 MWh
Heat from cogeneration & industry (high temp)	0 GJ	0 GJ
Heat from wastewater (lower temp)	1,657,235 GJ	87,390,522 GJ
Heat from industry (medium temp)	0 GJ	0 GJ
Energy sold to public organizations - 25.0% of supply	418,368 GJ	22,061,686 GJ
Cold from wastewater	0 GJ	0 GJ
Microhydro from waste water	0 tonnes	0 tonnes
Energy - biofuels	0 GJ	0 GJ
Reclaimed water (total)	48,545,000 m3	2,559,910,505 m3
Reclaimed water (identified saleable)	2,004,515 m3	105,703,554 m3
Struvite from waste water treatment	0 tonnes	0 tonnes
Residuals from anaerobic digestion	0 tonnes	0 tonnes
Residuals from gassification	0 tonnes	0 tonnes
GHG reductions - total	90,911 tCO2e	5,181,617 tCO2e
GHG reductions - marketable	69,864 tCO2e	3,982,018 tCO2e
Relative shadow price of carbon (unmarketed)	-$37m	-$1,910m

Input Stream Summary (pre-finance)			
2010 dollars	**Liquid**	**Solid**	**Total**
Total revenues	$1,651m	$48m	$1,699m
Total costs	-$1,815m	-$222m	-$2,037m
Profit (loss)	-$164m	-$174m	-$338m
Present Value	**Liquid**	**Solid**	**Total**
Total revenues	$311m	$0m	$311m
Total costs	-$470m	-$99m	-$569m
Profit (loss)	-$159m	-$99m	-$258m

Taxpayer Summary		
	Maximum	**Average**
15: Subsidy per capita/yr	-$140/yr	-$69/yr
16: Subsidy per home/yr	-$353/yr	-$174/yr
17: Duration of taxpayer subsidy	50yrs	N/A
18: Total subsidy per taxpayer	-$3,456	N/A
19: Total subsidy per home	-$8,710	N/A
20: Taxpayer ROI	-100%	N/A





Summary of major input assumptions to the model

Analysis starts: 2010. Analysis ends: 2060. Duration: 50yrs.
Metro population growth model active
North Shore 2010 population : 186,000
North Shore 2010 homes : 74,000
Long term finance (Life cycle) @ 5.07%
Soft costs apportioned pre-/during construction: 75%/25%
Soft costs for CapEx replacement & incremental plant @ 33% of base
General inflation: 1.20%. Constrn inflation @ 1.40%. O&M inflation @ 2.10%
All risks discount rate @ 6.30%, reversionary/term cap. rate @ 9.00%
Positive balances accrue at 3%
DCC/Levy: Off
Cost items 6, 8 & 9 omitted from reporting (not used for current scenarios)