Canadian Team Report

Green Building Challenge 2002

Case Study Projects

and GBC Process

July 2002

Alex Zimmerman
Team Leader

azimmerman@bcbc.bc.ca
Table of Contents

OVERVIEW .......................................................................................................................... 4

CANADIAN GREEN BUILDING CHALLENGE 2002 TEAM ........................................ 4
WORK OF THE TEAM ......................................................................................................... 4

NOTES AND COMMENTS ON GBTOOL ....................................................................... 7

REGIONAL OR BUILDING TYPE ADAPTATIONS MADE ............................................... 7
Canadian Team Issue Weights ...................................................................................... 7

COMMENTS ON USE OF GBTool .................................................................................. 9
Mayo School - Assessors Comments: ................................................................. 9
Red River College – Assessor’s Comments: .................................................... 10
Jackson Triggs Winery – Assessor’s Comments .................................................... 11

CASE STUDY: MAYO SCHOOL .................................................................................. 12

DESCRIPTION .................................................................................................................. 12
DESIGN TEAM COMMENTS ......................................................................................... 12
ASSESSOR’S COMMENTS ............................................................................................. 13
DRAWINGS & PHOTOS .................................................................................................. 15

GBTool Report worksheet .......................................................................................... 17

GBTool Results worksheet .......................................................................................... 23
Environmental Sustainability Indicators ................................................................. 23
Total and Performance Issues .................................................................................. 23
Levels of Performance for Design at Category Levels ......................................... 24

CASE STUDY: RED RIVER COLLEGE PRINCESS ST CAMPUS ............................... 27

DESCRIPTION .................................................................................................................. 27
DESIGN TEAM COMMENTS ......................................................................................... 27
ASSESSMENT TEAM COMMENTS .............................................................................. 29
DRAWINGS & PHOTOS .................................................................................................. 31

GBTool Report WORKSHEETS .................................................................................... 33

GBTool RESULTS WORKSHEET .................................................................................. 37
Environmental Sustainability Indicators ................................................................. 37
Total and Performance Issues .................................................................................. 37
Levels of Performance for Design at Category Levels ......................................... 38

CASE STUDY: JACKSON TRIGGS ESTATE WINERY ............................................... 41
Overview

**Canadian Green Building Challenge 2002 Team**

The GBC-2002 Canadian Team is composed of volunteer professionals representing a broad cross-section of architects, engineers and other practitioners in the field from across Canada. Team Members include:

- Alex Zimmerman   B.C. Buildings Corporation (Team Leader)
- H. Robert Bach   Engineering Interface Limited
- Marc Beaudoin   RCMP
- Raymond Cole   University of British Columbia
- Curt Hepting / Chris Jones   Enersys Analytics
- Kevin Hydes   Keen Engineering Ltd.
- Woytke Kujawski   Inpol Consulting
- Nils Larsson   iiSBE/NRCan
- Stephen Pope   Natural Resources Canada
- Gord Shymko   G.F. Shymko & Associates Ltd.
- Jiri Skopek   ECD Canada Ltd.
- Wayne Trusty/ Jamie Meil   Athena Institute for Sustainable Materials

**Work of the Team**

The GBC-2002 Canadian Team had a number of objectives in participating in GBC 2002 International process:

- Assess the potential environmental performance of buildings at the completion of the design stage;
- Encourage the transfer of the knowledge gained to all sectors of the industry;
  - Design
  - Regulation
  - Construction
- Promote the “Greening” of the construction industry in Canada
- Contribute to and learn from the development of an international evaluation tool in order to benefit efforts to adapt or adopt a tool for the building industry in Canada and to foster market transformation;

In determining the scope of effort for buildings to be assessed, the Canadian Team decided, as in GBC ’98 and GBC 2000, to issue a public call for participation and selection of buildings to be assessed. A significant shift of emphasis for this round was to have, as one of the selection criteria, sustainability improvement is a major objective, rather than pure green performance. The primary purpose of participation would change
from assessing pure green performance results of leading-edge green projects to one of reporting on the real world experience of projects attempting to incorporate a green design process from their inception, using GBC 2002 framework as the assessment tool.

The Team decided to attempt full assessment of three projects, and feature additional “poster” projects. Selection of all projects were based on ranking against pre-determined criteria, as follows:

Eligibility

Projects submitted for consideration must be built, under construction, or at 100% completion of working drawings by mid-January of 2002. Private or public buildings are eligible, as are renovations if the retrofit affects all major building systems and responds to the judging criteria.

Judging Criteria

Submissions will be assessed based on:

- Sustainability as a major objective of the project.
- Availability of data (including energy simulations) and co-operation of owner
- Evidence of use of integrated design process or design facilitator
- Repeatability of project, including economic viability
- Representation of climatic and regional variation across Canada
- Architectural quality
Phases of Work of the Canadian Team:

<table>
<thead>
<tr>
<th>Task / Milestone</th>
<th>2001</th>
<th>2002</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assemble Canadian Team</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Draft Canadian Team Plan</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solicit Candidate Buildings</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Select Buildings</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Finalise Funding Action Plans</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Secure Funding</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initial Draft Framework from IFC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Final Version of Framework fr. IFC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adapt Core Framework</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Develop Reference Buildings</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gather Info about selected bldgs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy Simulations</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Embodied Energy Calculations</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Specialist Reviews</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perform Assessments</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interim Progress Meeting</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Finalise Detailed Assessment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prepare Canadian Entry</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feedback to IFC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Team Mtg to Review Finished Work</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Final Submissions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prepare Display Materials for Oslo</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conference, Oslo</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Technology Transfer</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Assessed Projects

<table>
<thead>
<tr>
<th>Project Name</th>
<th>Location</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jackson Triggs Estate Winery</td>
<td>Niagara-on-the-Lake, Ontario</td>
<td>Other</td>
</tr>
<tr>
<td>Mayo School</td>
<td>Mayo, Yukon Territory</td>
<td>Education</td>
</tr>
<tr>
<td>Red River College, Princess Street</td>
<td>Winnipeg, Manitoba</td>
<td>Education</td>
</tr>
</tbody>
</table>

Non-Assessed “Poster” Projects

<table>
<thead>
<tr>
<th>Project Name</th>
<th>Location</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vancouver Island Technology Park</td>
<td>Victoria, British Columbia</td>
<td>Office</td>
</tr>
<tr>
<td>Nicola Valley School</td>
<td>Merritt, British Columbia</td>
<td>Education</td>
</tr>
<tr>
<td>Northwest Community College</td>
<td>Prince Rupert, British Columbia</td>
<td>Education</td>
</tr>
<tr>
<td>Concordia University Integrated</td>
<td>Montreal, Quebec</td>
<td>Education</td>
</tr>
<tr>
<td>Sir Sanford Fleming College</td>
<td>Kingston, Ontario</td>
<td>Education</td>
</tr>
</tbody>
</table>
Notes and Comments on GBTool

Regional or building type adaptations made

The Canadian Team believed, given the building types chosen for full assessment, that no major adaptations of GBTool need be made to accommodate them. The issues of weighting, benchmarking and scoring were approached at a national or regional and project level as shown in the following table, with one exception noted later:

<table>
<thead>
<tr>
<th></th>
<th>National</th>
<th>Regional / Project</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emissions &amp; Context</td>
<td>N/A</td>
<td>Done at regional level</td>
</tr>
<tr>
<td>Benchmarking</td>
<td>N/A</td>
<td>Done at regional level</td>
</tr>
<tr>
<td>Weighting: Issue</td>
<td>Done at national level</td>
<td>N/A</td>
</tr>
<tr>
<td>Weighting: Category</td>
<td>N/A</td>
<td>Done at regional level</td>
</tr>
<tr>
<td>Weighting: Criteria &amp; Sub-criteria</td>
<td>GBTool sets these</td>
<td>GBTool sets these</td>
</tr>
<tr>
<td>Scoring / Assessment</td>
<td>N/A</td>
<td>Done at project level</td>
</tr>
</tbody>
</table>

Canadian Team Issue Weights

<table>
<thead>
<tr>
<th>Issue</th>
<th>GBC Default</th>
<th>Canadian Team Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>R RESOURCE CONSUMPTION</td>
<td>20</td>
<td>27</td>
</tr>
<tr>
<td>L LOADINGS</td>
<td>25</td>
<td>22</td>
</tr>
<tr>
<td>Q INDOOR ENVIRONMENTAL QUALITY</td>
<td>20</td>
<td>27</td>
</tr>
<tr>
<td>S SERVICE QUALITY</td>
<td>15</td>
<td>8</td>
</tr>
<tr>
<td>E ECONOMICS</td>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td>M PRE-OPERATIONS MANAGEMENT</td>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td>T COMMUTING TRANSPORT</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Canadian Team Weighting of Relative Importance of Embodied and Operating Energy

A significant debate arose among members of the Canadian Team late in the assessment of the case studies over how to treat the relative weighting of embodied energy and annual operating energy and the emissions effects that arise from these effects. GBTool annualizes the embodied energy over the set live of the building and fixes the values of the weights at the criterion level in R1.1 and L1.1 at 50% each in order to give more weight to the immediate effects of the energy consumed in producing materials. The team
felt that this approach is incorrect for an assessment scheme intended to measure environmental effects and not intended to reward designers or building owners for the degree of effort expended in attempting to go green.

The team felt there are two reasons for being concerned about assessing environmental impact of net primary energy use, either embodied or operating (apart from providing an "incentive" that the IFC agreed that GBC will not do):

1. Energy (net primary non-renewable) is a scarce resource.
2. The contribution to global warming from the use of that energy.

Both the scarcity argument and the global warming potential (because of the long atmospheric dwell time in the hundreds of years, well beyond the building life) argument would lead one to conclude that there is no difference in environmental importance between a unit of energy consumed in producing materials or in one consumed operation of the building at any point in the building's life.

Therefore, we should be measuring impacts or effects strictly additively or cumulatively and not discounting or otherwise spreading out effects incurred in any one year. In accounting for anticipated operating energy impacts over the life of the building, we need to assume a life for the building. This will always be somewhat arbitrary, but most of us seem to agree that 75 years or so is a reasonable length of time to expect buildings built today to be operating without being torn down or totally re-configured for some other purpose.

The weights under consideration here are used only to establish relative importance of embodied vs. operating effects, so once you have concluded that they are of equal importance on a unitary basis, the weights must be set such that a unit of operating energy gets equal weight to a unit of embodied energy. The only way to do that is to set the weights directly proportional to the absolute value of the energy used in the actual building. Any other weighting misrepresents one or the other of the energy used, including if the weighting is set to the proportions of the benchmark building, which could be very different than the actual.

The foregoing also would also lead us not to weight embodied energy higher than its absolute value because of Kyoto commitments. That is essentially an incentive type argument, which we have agreed that GBC does not do. A unit of energy expended today on embodied energy is equally damaging to one expended 50 years from now as part of operating energy.

The scoring will take care of how well a given building does relative to practice in that region because the embodied is scored against benchmark practice independently from operating. Either one can go up or down from the benchmark without affecting the score of the other. Scoring will also account for the regional transportation issue because the embodied energy calculation done for the Canadian team by Athena Sustainable Materials Institute takes into account the transportation losses, whether for benchmark or for actual.
In summary, the Canadian Team has changed the relative weights of embodied energy vs. operating energy in R1.1 and their related emissions effects in L1.1 proportional to the amount of energy of each. More detail on these proportions can be found in the Athena report in Appendix 1 of this report.

**Comments on use of GBTool**

The three assessment teams worked mostly independently and had different experiences with the tool. Comments from the three case study assessors are as follows.

**Mayo School - Assessors Comments:**

As is too often the case, the review started late and the assessor had too limited an understanding of the software in the initial couple of days. What may be unusual is that the assessor completed all of the activities on his own, not following the recommended process. While this was a response of pure expediency, it is suggested that it represents the way the assessment tool would be used by industry as opposed to the research community. The assessor was familiar with the building but had no vested interest in the level of its performance.

Outside of the usual anxieties in cases such as this, the perception a couple of weeks after the dust settled is that the assessment went reasonably quickly and that the features of the tool are more or less helpful, useful, and appropriate. It takes at least one pass through the tool to know this.

There are two significant reservations to the above paragraph. First, realizing that the operating and embodied energy models feeding into the assessment develop detailed assembly and material lists, there is too much duplication of material descriptions in the GBTool (Area & Materials Worksheets). Second there seems to be an imbalance between detailed information requirements and general information in the assessment. This suggests that the amount of information required could be further limited, or that its presentation could be significantly re-arranged.

All GBTool assessments have an operating energy figure entered. To get this figure, a detailed model must be made of at least the shell, interior lighting, and heating, cooling, and ventilation systems of the building. For those who are calculating the embodied energy of the building an even more detailed model must be developed providing areas of materials and assemblies throughout the entire building. Given the detailed character of the energy models already prepared for the assessment it would make more sense to use the areas of materials and material properties developed from one of the energy models for reasons of economy of effort and consistency of modelling.

This in turn suggests that the Area and Materials Worksheets could be significantly revised. Even with the diversity of choices available in the Area worksheet, the exact construction of the Mayo School was not available for description. The block structure presents the appearance of the ability to make a detailed model but ultimately cannot complete the task in adequate detail, making it appear arbitrary. The ability to describe assemblies and materials already on site and being reused is necessary and needs to be present, but needs no direct link with the other models. Because the assembly
descriptions did not match the materials used for Mayo School the idea of describing the school in blocks (as was done for the embodied energy model) was abandoned.

The materials worksheet could have caused a significant amount of aggravation, as many of the measurements are not available commonly. Part of that aggravation is that it is describing assemblies in many cases not simple materials, or just materials in others where assemblies are more pertinent. Composite calculations for weight and recycled percentages must be made that are complex and non-trivial and already included in the embodied energy calculation. Because the Mayo School did not re-use any of the material on site the Materials worksheet could be avoided. For all of the serious scoring of embodied energy it was the ATHENA model results that were used. The lack of any entry on the Materials worksheet did not seem to affect the assessment, raising questions about its necessity.

By making use of the information held in the energy models it might be possible to again reduce the amount of inputs in the GBTool. Revisions to the Area and Materials worksheets would allow a fairly rapid progress through the data entry and improve the usability of the tool.

Specific miscellaneous comments:

Benchmark building inputs

B17 STC class for windows – STC class ratings were developed for indicating the ability to control sound frequencies in the speech range, and are not applicable to low frequency noises and vibration. Accordingly they are not commonly used in describing window performance. Another measure may be more desirable.

B42 should be measured in kPa not MPa. The strength of materials is measured in MPa, but occupant floor loads are only single digit kPa, presenting a “0” MPa load once rounded up in the input box.

B66-B71 The benchmark fuel source input should allow all fuel sources considered in the EnGen tab. For the Mayo School, the benchmark building heating would be oil not natural gas.

Red River College – Assessor’s Comments:

The assessment was done in several stages by a team of two people. Only the first stage was conducted with the team members in the same room, as a matter of simple logistics as the team members were physically located 5,000 km apart and travel is expensive.

The necessity for more than one stage arises because of the difficulty in ensuring, even with best efforts beforehand, that all the required input is present and the information correct. It is never apparent that information is missing until the assessment actually commences, but this is common to all such assessment processes and is not unique to GBTool.

The single, most time consuming difficulty the assessment team faced was doing reasonableness checks on the data that the assessment was based on. That is, the score for a given sub-criteria did not seem reasonable given the team’s general knowledge of the building characteristics. There was two aspects to this difficulty.
The first is ongoing technical difficulties with formula errors that showed up in the versions being worked on that were not present in the master file. This remains an unresolved problem but it meant a great deal of time was spent in tracking down correct formulae.

The second aspect is that there was frequently missing or incorrect data in the input. It is not easy to know which input produces which result on the assessment worksheet. The method we adopted was to start at the end and use the “trace precedents” feature of Excel to track down all of the inputs and verify them. This usually involves several steps and a lot of time. This was particularly problematic during the latter stages when the communication was by teleconference. However, given the nature of the basic tool, an Excel spreadsheet, it is hard to know how one would get around this difficulty. One possibility would be to generate a conceptual map that shows all the inputs for a given assessment sub-criteria, but this would be a lot of work and only worthwhile if the tool were truly stable for a long period of time.

The spreadsheet does retain the virtue of transparency so that calculations are traceable.

**Jackson Triggs Winery – Assessor’s Comments**

- The tool explores the various environmental impacts very well.
- The numerous revisions to the tool slowed down the process considerably.
- The lack of normalized input format lead to the potential for inconsistent input and the need to go back to gather data. As there is no questionnaire, assessors either have to construct their own, or worse, rely on the collective memory of the team, which is not always reliable.
- Relying on the proponent to fill in the data, can make it difficult to verify them and could lead to distortion of the building's performance to show it better than it is.
- There are some difficulties in ensuring that the data gathered was complete. This is typically discovered only after the graph is generated and is can lead to a time-consuming effort to make the assessment work.
Case Study: Mayo School

Description
The Mayo School is a new K-12 school and community campus facility with a floor area of 3,300 m², located in the Village of Mayo, Yukon Territory, northern Canada (Lat. 63º 34’ N, 135º 52’ W)

The Mayo School project team included the following:
Owner: Yukon Territory Government & Dep’t of Education
Architect: Kobayashi + Zedda Design Group, Whitehorse
Structural: Fast & Epp Partners, Vancouver
Mechanical: Northern Climate Engineering, Whitehorse
Electrical: Dorward Engineering Services Ltd., Whitehorse
Landscaping: Inukshuk Planning and Development
C-2000 facilitation: G.F. Shymko & Associates, Calgary
Energy engineering and Simulation: G.F. Shymko & Associates, Calgary
Assessment team: Stephen Pope, NRCan (team leader), Marc Beaudoin, RCMP; Curt Hepting/ Chris Jones, ENERSYS (Simulation Advice);

Design Team Comments
The school has received the maximum grant allowable under the Natural Resources Canada (NRCan) Commercial Buildings Incentive Program in recognition of energy efficient design. It also conforms to the requirements of the NRCan C-2000 Program for Advanced Commercial Buildings demonstrating low energy consumption, low water consumption, and good indoor environmental quality, assessed at the completion of design. Construction has been recently completed.

In addition to good building performance the Mayo School demonstrates a strong community integration. It provides separate teaching spaces for elementary and high school level students, and serves as a community and recreation centre, library, and disaster relief centre for a largely First Nations community. It replaces a previous school assembled out of trailers. The project presents a strong combination of “best practices” design and construction detailing plus a significant community integration. The attention to the benefits of local labour and the multiple programmed use of the facility address the social impacts and benefits that take the project from good operational performance to the broader scope of community sustainability. Through the participation in the C-2000
program, the project also demonstrated the successful use of integrated design, a design method that delivers better environmental performance by reworking the relationships between the various disciplines on the design team and their respective relationship to the client. Another benefit of this approach is the addition of operations energy simulation as a support for design decisions while the design process is ongoing. The school is built using wood frame technology that is familiar to local construction teams, allowing the completion of the project without the requirement of importing specialty labour crews from the south. Engineered wood products are used throughout the facility eliminating any need for old growth structural lumber, and making efficient use of materials. A summary of the efficiency measures follows:

- Siting – in keeping with the community focus of the facility, the main entrance is aligned with the main street and forms its terminus;
- Passive Solar – east/west orientation of the long axis of the school maximizes the passive solar potential;
- Insulation – Nominal R28 (RSI 4.93) walls and R60 (RSI 10.57) ceilings;
- Windows – aluminum and vinyl framed windows with spectrally selective soft-coat low-e films were used. Large overhangs and sun screens control summer sun and heat gain while allowing low angle sun in shoulder seasons;
- Daylighting – extensive use of natural light reduces need for artificial illumination;
- Lighting – T8 fluorescent lamps with DDC controls including daylight sensors and occupancy sensors. Fluorescent high bay lamps also used in Gymnasium;
- Ventilation – 100% outdoor air delivered to fan coils in teaching areas. Controls on the ventilation system provide the ability to bring fresh air only to classrooms that are in use. Operable windows on opposite faces of classrooms provide the potential for natural ventilation. Indoor air quality is addressed at source with use of low VOC latex paints and a majority of floor and wall finishes in linoleum and wood. Little carpet is used.
- Heating – both heating and cooling are provided by fan coils in the crawl space feeding full room width distribution cabinets. Return air is taken at a high level in the room and ducted down the walls;
- Ground water cooling – chilled water for cooling coils is taken from available ground water, reducing system complexity and maintenance.

**Assessor’s Comments**

My first instinct is that the scoring for the overall building seems a bit low (2.9), but not too far off where I thought it should have been. When one looks at the detailed results the building has areas that are very high - a full 5 for cooling with no CFC or HCFC based products, and well above 3 for IAQ (4.1), thermal comfort (3.2), and illumination (4.5). These category level results conform very closely to what I expected when observed on site in March 2002.
The operating energy, IEQ and Service Quality are also all above 3.0 (3.5, 3.6 and 3.4 respectively) which corresponds to what I know about the design and construction. Resource use and loadings are lower than I expected, but still respectable (2.3 and 2.6). The low scores may be a product of the relationship to the local norms and best practices. The YTG-PMA (local authority) design guidelines describe a level of performance that is higher than the bare minimum, responding to the desire to minimize maintenance and complaints in a harsh environment. This means that the same building scored against the MNECB or ASHRAE 90.1 would score even better.

The building also has areas that are very low. Solid waste got -1.2 which may be a bit harsh for the amount of waste that will likely be generated, but a fair reflection of the consideration given to solid waste handling in the area. It is true that solid waste isn't much of an issue, but if everything that was disposed of in the Yukon could be turned into some other useful feedstock an enormous amount of energy and money would stay in the community that currently leaves it.

The low scores in the assessment have more to do with the current state of thinking on the part of the YTG-PMA than on the amount of waste or harmful conditions generated. When the authorities realize that things like waste and building materials reuse are valuable opportunities rather than liabilities then I would expect projects like Mayo School to score around 4.5 rather than sub 3.0. There is more learning required to realize the opportunities that are (or may be) present.

Other low scores are reasonable. The 2.7 for acoustics is probably representative of the project. It has insulated walls between the classrooms and lay-in tile ceilings in the office areas, but the public spaces may be a bit live.

The balance of the remaining indicators do not seem unreasonable. This building is part of the C-2000 program, whose focus is energy, and there are many other issues to be covered under the whole green building banner. I am satisfied that the results of the assessment are reasonable.
Drawings & Photos
**Case Study: Mayo School**

**GBTool Report worksheet**

<table>
<thead>
<tr>
<th><strong>Occupancy and Basic Info</strong></th>
<th>Bmark</th>
<th>Design</th>
<th>Units</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Occupancy Type 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Occupancy Type 2</td>
<td></td>
<td>School</td>
<td>occupancy</td>
<td></td>
</tr>
<tr>
<td>Occupancy Type 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Occupancy Type 4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Largest occupancy type</td>
<td>largest occupancy is School</td>
<td></td>
<td></td>
<td>Area by occupancy: Residential 0 %, School 100 %, FALSE</td>
</tr>
<tr>
<td>Predicted service life of the building, assuming current uses</td>
<td>75</td>
<td>75</td>
<td>years</td>
<td></td>
</tr>
<tr>
<td>Avg. building population during main operating hours</td>
<td>333</td>
<td>333</td>
<td>persons</td>
<td></td>
</tr>
<tr>
<td>Not applicable</td>
<td>0</td>
<td>0</td>
<td>aph</td>
<td></td>
</tr>
<tr>
<td>Person-hours of occupancy per year for School</td>
<td>644,597</td>
<td>644,597</td>
<td>aph</td>
<td></td>
</tr>
<tr>
<td>Not applicable</td>
<td>0</td>
<td>0</td>
<td>aph</td>
<td></td>
</tr>
<tr>
<td>Person-hours of occupancy per year, all occupancies</td>
<td>644,597</td>
<td>644,597</td>
<td>aph</td>
<td></td>
</tr>
<tr>
<td>Person-hours of occupancy per year per m², all occupancies</td>
<td>213</td>
<td>213</td>
<td>aph / m²</td>
<td></td>
</tr>
<tr>
<td>Thousand person-hours of occ. per year per m², all occupancies</td>
<td>0.213</td>
<td>0.213</td>
<td>kaph / m²</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Other General Building Data</strong></th>
<th>Bmark</th>
<th>Design</th>
<th>Units</th>
<th>Design/ Bmark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total construction cost</td>
<td>$4,000,000</td>
<td>$4,000,000</td>
<td>$US</td>
<td>1.00</td>
</tr>
<tr>
<td>Predicted total annual energy cost</td>
<td>$211,000</td>
<td>$102,000</td>
<td>$US/year</td>
<td>0.48</td>
</tr>
<tr>
<td>Predicted annual other operating cost</td>
<td>$40,000</td>
<td>$40,000</td>
<td>$US/year</td>
<td>1.00</td>
</tr>
<tr>
<td>Predicted annual maintenance cost</td>
<td>$80,000</td>
<td>$80,000</td>
<td>$US/year</td>
<td>1.00</td>
</tr>
<tr>
<td>Construction cost, excluding land, per m² of total net area</td>
<td>$1,319</td>
<td>$1,319</td>
<td>$US/m² . yr</td>
<td>1.00</td>
</tr>
<tr>
<td>Predicted total annual O&amp;M cost per m² of total net area</td>
<td>$109</td>
<td>$73</td>
<td>$US/m² . yr</td>
<td>0.67</td>
</tr>
<tr>
<td>Number of distinct blocks or elements in the project</td>
<td>1</td>
<td>1</td>
<td>number</td>
<td></td>
</tr>
<tr>
<td>Maximum number of floors above grade of any block or element</td>
<td>1</td>
<td>1</td>
<td>number</td>
<td></td>
</tr>
<tr>
<td>Gross floor area above and below grade available in existing structure on the site</td>
<td>0</td>
<td>0</td>
<td>m²</td>
<td></td>
</tr>
<tr>
<td>Gross floor area above and below grade of the existing structure actually used as part of the Design</td>
<td>0</td>
<td>0</td>
<td>m²</td>
<td></td>
</tr>
<tr>
<td>Gross floor area above and below grade</td>
<td>3,225</td>
<td>3,225</td>
<td>m²</td>
<td></td>
</tr>
<tr>
<td>Net floor area above grade</td>
<td>3,032</td>
<td>3,032</td>
<td>m²</td>
<td></td>
</tr>
<tr>
<td>Net floor area above and below grade</td>
<td>3,032</td>
<td>3,032</td>
<td>m²</td>
<td></td>
</tr>
<tr>
<td>Gross Floor Area Ratio (Gross area above grade v. site area)</td>
<td>0.2</td>
<td>0.2</td>
<td>ratio</td>
<td></td>
</tr>
<tr>
<td>Floor plan efficiency above grade</td>
<td>94%</td>
<td>94%</td>
<td>percent</td>
<td></td>
</tr>
</tbody>
</table>
### Other General Building Data

<table>
<thead>
<tr>
<th></th>
<th>Bmark</th>
<th>Design</th>
<th>Units</th>
<th>Design/ Bmark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total net floor area for School</td>
<td>3,032</td>
<td>3,032</td>
<td>m²</td>
<td></td>
</tr>
<tr>
<td>Surface area to volume ratio above grade</td>
<td>31%</td>
<td>71%</td>
<td>percent</td>
<td>2.31</td>
</tr>
<tr>
<td>Average window to wall ratio</td>
<td>20%</td>
<td>21%</td>
<td>percent</td>
<td>1.07</td>
</tr>
<tr>
<td>Overall glazing SHGC</td>
<td>0.70</td>
<td>0.27</td>
<td>ratio</td>
<td>0.39</td>
</tr>
<tr>
<td>Overall window STC in wall exposed to most noise</td>
<td>30.00</td>
<td>33.00</td>
<td>ratio</td>
<td>1.10</td>
</tr>
<tr>
<td>Overall window U-value</td>
<td>2.10</td>
<td>1.03</td>
<td>W/m² °C</td>
<td>0.49</td>
</tr>
<tr>
<td>Overall exterior roof U-value</td>
<td>6.00</td>
<td>0.10</td>
<td>W/m² °C</td>
<td>0.02</td>
</tr>
<tr>
<td>Overall exterior solid wall U-value</td>
<td>6.00</td>
<td>0.16</td>
<td>W/m² °C</td>
<td>0.03</td>
</tr>
<tr>
<td>Overall exterior solid wall RSI-value</td>
<td>0.17</td>
<td>6.07</td>
<td>m²°C/W</td>
<td>36.43</td>
</tr>
<tr>
<td>Average reflectance of horizontal roof surfaces and hard-paved site areas</td>
<td>0.15</td>
<td>0.06</td>
<td>number</td>
<td>0.44</td>
</tr>
<tr>
<td>The vertical angle measured from the building line on the ground of the nearest adjacent property to the roof line of the case-study building is (0 to 90 degrees):</td>
<td>0°</td>
<td>0°</td>
<td>degrees</td>
<td>0.00</td>
</tr>
<tr>
<td>Estimated percent of the southerly facing building façade of an adjacent property south of the case-study building, that is shaded by it at 12 noon on Summer Solstice</td>
<td>0%</td>
<td>0%</td>
<td>percent</td>
<td>0.00</td>
</tr>
<tr>
<td>Estimated Daylight Factor</td>
<td>1.5%</td>
<td>4.5%</td>
<td>percent</td>
<td>3.03</td>
</tr>
<tr>
<td>Predicted minimum relative humidity during heating season</td>
<td>20.0%</td>
<td>20.0%</td>
<td>percent</td>
<td>1.00</td>
</tr>
<tr>
<td>Predicted maximum relative humidity during cooling season</td>
<td>60.0%</td>
<td>60.0%</td>
<td>percent</td>
<td>1.00</td>
</tr>
<tr>
<td>Percentage of net floor area of the building that is mechanically ventilated and cooled</td>
<td>100.0%</td>
<td>100.0%</td>
<td>percent</td>
<td>1.00</td>
</tr>
<tr>
<td>Ratio of openable window area or other controllable openings to all net primary area in naturally ventilated areas</td>
<td>NA</td>
<td>6.0%</td>
<td>percent</td>
<td></td>
</tr>
<tr>
<td><strong>Normalized General Building Data</strong></td>
<td>Normalized by net area</td>
<td>Normalized by net area and occupancy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----------------------------------</td>
<td>------------------------</td>
<td>----------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Units</strong></td>
<td><strong>Benchmark</strong></td>
<td><strong>Design</strong></td>
<td><strong>Units</strong></td>
<td><strong>Benchmark</strong></td>
</tr>
<tr>
<td>Net area of land used for building and related purposes</td>
<td>2.38</td>
<td>2.38</td>
<td>m² / m² of net area</td>
<td>21.67</td>
</tr>
<tr>
<td>Annual potable water consumption for all building uses per unit area</td>
<td>0.6</td>
<td>0.6</td>
<td>m³ / m² yr</td>
<td>2.8</td>
</tr>
<tr>
<td>Annual potable water consumption for all building uses</td>
<td>5.4</td>
<td>5.4</td>
<td>m³ / occupant yr</td>
<td>8</td>
</tr>
<tr>
<td>Annual greywater and rainwater use for all building uses</td>
<td>0.0</td>
<td>0.0</td>
<td>m³ / occupant yr</td>
<td>0</td>
</tr>
<tr>
<td>Sanitary waste water not leaving the site</td>
<td>0.0000</td>
<td>0.0000</td>
<td>m³ / m² yr</td>
<td>0.0000</td>
</tr>
<tr>
<td>Storm water not leaving the site</td>
<td>0.33</td>
<td>0.33</td>
<td>m³ / m² yr</td>
<td>1.545</td>
</tr>
<tr>
<td>The proportion of the structure of an existing building on the site that is retained as part of the new building</td>
<td>0%</td>
<td>0%</td>
<td>percent by floor area</td>
<td></td>
</tr>
<tr>
<td>Approx. weight of steel in an existing structure(s) on the site that is actually taken off-site for re-use or recycling, in addition to structure re-used on site as part of the new design (see R55)</td>
<td>0%</td>
<td>0%</td>
<td>percent by weight</td>
<td></td>
</tr>
<tr>
<td>The amount of other materials salvaged from existing structure(s) on the site that is re-used off-site, in addition to materials re-used on site as part of the new design, (see R55),</td>
<td>0%</td>
<td>0%</td>
<td>percent by weight</td>
<td></td>
</tr>
<tr>
<td>The amount of materials used in the building that originate from off-site salvaged sources</td>
<td>0%</td>
<td>0%</td>
<td>percent by weight</td>
<td></td>
</tr>
<tr>
<td>The total amount of materials used in the building that originate from on-site or off-site salvaged sources</td>
<td>0%</td>
<td>0%</td>
<td>percent by weight</td>
<td></td>
</tr>
<tr>
<td>The recycled content in materials used in the building, obtained from off-site sources</td>
<td>0%</td>
<td>0%</td>
<td>percent by weight</td>
<td></td>
</tr>
<tr>
<td>Percent of materials obtained from local sources (within 900 km)</td>
<td>0%</td>
<td>82%</td>
<td>percent by weight</td>
<td></td>
</tr>
<tr>
<td>The percentage of interior finish materials that conform to the VOC limit values of a recognized certification agency</td>
<td>0%</td>
<td>0%</td>
<td>percent by area</td>
<td></td>
</tr>
<tr>
<td>Percentage of materials of wood origin certified to conform to requirement for sustainable forestry practice guidelines</td>
<td>50%</td>
<td>56%</td>
<td>percent by area</td>
<td></td>
</tr>
<tr>
<td>The volume of solid wastes resulting from the clearance of existing structures on the site that will not be sent to a solid waste facility</td>
<td>0%</td>
<td>0%</td>
<td>ratio by weight</td>
<td></td>
</tr>
<tr>
<td>The volume of solid wastes resulting from the construction process that will not be sent to a solid waste facility</td>
<td>0%</td>
<td>0%</td>
<td>ratio by weight</td>
<td></td>
</tr>
<tr>
<td>Not applicable</td>
<td>0.00</td>
<td>0.00</td>
<td>L/s per occupant</td>
<td>0.00</td>
</tr>
<tr>
<td>Outdoor air rate ventilation in primary areas of School occupancy</td>
<td>7.28</td>
<td>7.28</td>
<td>L/s per occupant</td>
<td>1.00</td>
</tr>
<tr>
<td>Not applicable</td>
<td>0.00</td>
<td>0.00</td>
<td>L/s per occupant</td>
<td>0.00</td>
</tr>
<tr>
<td>Annual consumption of delivered energy (presumed purchased)</td>
<td>1,931</td>
<td>1,012</td>
<td>MJ / m² yr</td>
<td>9,083</td>
</tr>
<tr>
<td>Annualized embodied energy for above- and below-grade structure and building envelope</td>
<td>33</td>
<td>36</td>
<td>MJ / m² yr</td>
<td>153</td>
</tr>
<tr>
<td>Total of annualized embodied energy and annual delivered energy</td>
<td>1,964</td>
<td>1,048</td>
<td>MJ / m² yr</td>
<td>9,236</td>
</tr>
<tr>
<td>Total primary non-renewable fuels used on-site and for generation of electricity, annual basis</td>
<td>1,724</td>
<td>806</td>
<td>MJ / m² yr</td>
<td>8,110</td>
</tr>
<tr>
<td>Predicted Greenhouse Gas Emissions from annual operations</td>
<td>88.0</td>
<td>41.1</td>
<td>Kg / m² yr</td>
<td>414</td>
</tr>
<tr>
<td>Crude estimate of annualized embodied GHG emissions, Kg. CO2 equivalent (based on kg CO2 equivalent per GJ)</td>
<td>1.8</td>
<td>2.0</td>
<td>Kg / m² yr</td>
<td>9</td>
</tr>
<tr>
<td>Predicted total Greenhouse Gas Emissions from annual operations and annualized embodied emissions</td>
<td>89.9</td>
<td>43.2</td>
<td>Kg / m² yr</td>
<td>423</td>
</tr>
</tbody>
</table>
### Greenhouse Gas Equivalent calculations for operations

<table>
<thead>
<tr>
<th></th>
<th>Bmark</th>
<th>Max</th>
<th>Bmark Best</th>
<th>Design</th>
<th>Incomplete because of missing data on emissions from nuclear, hydro reservoirs, geothermal, biomass etc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greenhouse Gas Equivalent, kg. per year CO₂ kg+CH₄ g^ 21/1000</td>
<td>266,897</td>
<td>133,531</td>
<td>124,757</td>
<td>Kg. CO₂ equiv. per year</td>
<td></td>
</tr>
<tr>
<td>GGE per kg in kg. per unit net area</td>
<td>88</td>
<td>44</td>
<td>41</td>
<td>Kg. Equiv / m² * yr</td>
<td></td>
</tr>
<tr>
<td>Ratio of Design to Benchmark GGE per year for net area</td>
<td>100%</td>
<td>50%</td>
<td>47%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Predicted annual GGE, normalized to area and occupancy</td>
<td>414</td>
<td>207</td>
<td>194</td>
<td>(Kg. Equiv / m²) / (kaph / m²) * yr</td>
<td></td>
</tr>
<tr>
<td>Ratio of Design to Benchmark, for occupancy-adjusted GGE</td>
<td>100%</td>
<td>50%</td>
<td>47%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Ozone Depletion Calculations for operations

<table>
<thead>
<tr>
<th></th>
<th>Bmark</th>
<th>Design</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Ozone Depletion from leakage of CFC-11 equivalent, in gm per yr.</td>
<td>0.00</td>
<td>0.00</td>
<td>gm CFC-11 equiv. per year</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Predicted CFC-11 equivalent leakage per year in gm. per unit net area</td>
<td>0.00000</td>
<td>0.00000</td>
<td>gm CFC-11 equiv / m² * year</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ratio of Design to Benchmark leakage of CFC-11 equivalent per year for net area</td>
<td>100%</td>
<td>0%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Predicted leakage of annual CFC-11 equivalent, normalized to area and occupancy</td>
<td>0.00000</td>
<td>0.00000</td>
<td>(gm CFC-11 equiv / m²) / (kaph * m²) * yr</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ratio of Design to Benchmark, for occupancy-adjusted net area of CFC-11 equivalent annual leakage</td>
<td>100%</td>
<td>0%</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Acidification calculations for building operations

<table>
<thead>
<tr>
<th></th>
<th>Bmark</th>
<th>Design</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Acidification Equivalent, SO₂ kg. per year</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SO₂ kg+(NO₂<em>0.7+NO</em>1.07+NH₃<em>1.88+HF</em>1.6+HCl*0.88)</td>
<td>158</td>
<td>75</td>
<td>Kg. SO₂ equiv. per year</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SO₂ Equiv. per year in kg. per unit area net</td>
<td>0.05</td>
<td>0.02</td>
<td>Kg. SO₂ equiv / m² * year</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ratio of Design to Benchmark SO₂ Equiv. per year for net area</td>
<td>100%</td>
<td>47%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Predicted annual SO₂ Equiv., normalized to area and occupancy</td>
<td>0.25</td>
<td>0.12</td>
<td>(Kg. SO₂ equiv / m²) / (kaph / m²) * yr</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ratio of Design to Benchmark, for occupancy-adjusted net area of SO₂ Equiv.</td>
<td>100%</td>
<td>47%</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Photo-Oxidant calculations for building operations

<table>
<thead>
<tr>
<th></th>
<th>Bmark</th>
<th>Design</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Photo-oxidants, ethene-equivalent kg. per year</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(CH₄<em>0.007+VOC</em>0.337)</td>
<td>0.76</td>
<td>0.36</td>
<td>Kg. CFC-11 equiv. per year</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ethene equiv. per year in gm per net unit area</td>
<td>0.2507</td>
<td>0.1172</td>
<td>gm Ethene equiv / m² * year</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ratio of Design to Benchmark ethene equiv. per year for net area</td>
<td>100%</td>
<td>47%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Predicted annual ethene equiv., normalized to area and occupancy</td>
<td>1.1791</td>
<td>0.5511</td>
<td>(gm Ethene equiv / m²) / (kaph / m²) * year</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ratio of Design to Benchmark, for occupancy-adjusted net area ethene equivalent</td>
<td>100%</td>
<td>47%</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Eutrophication calculations for building operations

<table>
<thead>
<tr>
<th></th>
<th>Bmark</th>
<th>Design</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Eutrophication , PO₄-equivalent kg. per year</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(NO₂<em>0.13+NO</em>0.2+NH₃*0.35)</td>
<td>156.31</td>
<td>74.14</td>
<td>Kg. PO₄-equiv. Per year</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PO₄-equiv. per year in kg. per unit area net</td>
<td>0.0516</td>
<td>0.0245</td>
<td>Kg. PO₄-equiv / m² * year</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ratio of Design to Benchmark PO₄-equiv. per year for net area</td>
<td>100%</td>
<td>47%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Predicted annual PO₄-equiv., normalized to area and occupancy</td>
<td>0.2425</td>
<td>0.1150</td>
<td>(Kg. PO₄-equiv / m³) / (kaph / m²) * yr</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ratio of Design to Benchmark, for occupancy-adjusted net area PO₄-equivalent</td>
<td>100%</td>
<td>47%</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Case Study: Mayo School

#### Annual Net Consumption of Delivered Energy by Fuel Type

<table>
<thead>
<tr>
<th>Type</th>
<th>Bmark Standard</th>
<th>Bmark Best</th>
<th>Design</th>
<th>Bmark Standard</th>
<th>Bmark Best</th>
<th>Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual delivered fuel consumption</td>
<td>1,621</td>
<td>811</td>
<td>758</td>
<td>7,625</td>
<td>3,815</td>
<td>3,564</td>
</tr>
<tr>
<td>Annual delivered electrical</td>
<td>310</td>
<td>140</td>
<td>254</td>
<td>1,458</td>
<td>656</td>
<td>1,194</td>
</tr>
<tr>
<td>consumption per unit net area</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total annual consumption of delivered energy</td>
<td>1,931</td>
<td>951</td>
<td>1,012</td>
<td>9,083</td>
<td>4,471</td>
<td>4,758</td>
</tr>
</tbody>
</table>

#### Annual Gross Consumption of Primary Energy by Fuel Type

<table>
<thead>
<tr>
<th>Type</th>
<th>Bmark Standard</th>
<th>Bmark Best</th>
<th>Design</th>
<th>Bmark Standard</th>
<th>Bmark Best</th>
<th>Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual delivered fuel consumption</td>
<td>1,621</td>
<td>811</td>
<td>758</td>
<td>7,625</td>
<td>3,815</td>
<td>3,564</td>
</tr>
<tr>
<td>Annual primary electrical</td>
<td>338</td>
<td>152</td>
<td>277</td>
<td>1,590</td>
<td>715</td>
<td>1,302</td>
</tr>
<tr>
<td>consumption per unit net area</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total annual consumption of primary energy</td>
<td>1,959</td>
<td>963</td>
<td>1,035</td>
<td>9,214</td>
<td>4,530</td>
<td>4,866</td>
</tr>
</tbody>
</table>

#### Annual Consumption of Primary Non-Renewable Energy Sources

<table>
<thead>
<tr>
<th>Source</th>
<th>Bmark Standard</th>
<th>Bmark Best</th>
<th>Design</th>
<th>Bmark Standard</th>
<th>Bmark Best</th>
<th>Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total primary non-renewable fuels</td>
<td>1,724</td>
<td>849</td>
<td>806</td>
<td>8,110</td>
<td>3,992</td>
<td>3,791</td>
</tr>
<tr>
<td>used on-site and for generation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>of electricity, annual basis</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Total and Annualized Consumption of Primary Embodied Energy

<table>
<thead>
<tr>
<th>Structure</th>
<th>Bmark Standard</th>
<th>Bmark Best</th>
<th>Design</th>
<th>Bmark Standard</th>
<th>Bmark Best</th>
<th>Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary embodied energy for above-</td>
<td>7883</td>
<td>6321</td>
<td>8816</td>
<td>37</td>
<td>30</td>
<td>41</td>
</tr>
<tr>
<td>and below-grade structure and</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>building envelope, MJ/m²</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary embodied energy for above-</td>
<td>2.4</td>
<td>2.0</td>
<td>2.7</td>
<td>11.5</td>
<td>9.2</td>
<td>12.9</td>
</tr>
<tr>
<td>and below-grade structure and</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>building envelope, GJ/m²</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annualized primary embodied energy</td>
<td>33</td>
<td>28</td>
<td>36</td>
<td>153</td>
<td>131</td>
<td>171</td>
</tr>
<tr>
<td>above- and below-grade structure</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>and building envelope, MJ/m²/year</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Annualized Consumption of Primary Embodied Energy plus Annual Primary Non-Renewable Operating Energy

<table>
<thead>
<tr>
<th>Structure</th>
<th>Bmark Standard</th>
<th>Bmark Best</th>
<th>Design</th>
<th>Bmark Standard</th>
<th>Bmark Best</th>
<th>Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annualized primary embodied energy</td>
<td>1,757</td>
<td>876</td>
<td>842</td>
<td>8,263</td>
<td>4,123</td>
<td>3,962</td>
</tr>
<tr>
<td>above- and below-grade structure</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>and building envelope, MJ/m²</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### GBTool Results worksheet

#### Environmental Sustainability Indicators

<table>
<thead>
<tr>
<th>Selected Environmental Sustainability Indicators for the Design</th>
<th>per m² only</th>
<th>by area &amp; by occupancy</th>
</tr>
</thead>
<tbody>
<tr>
<td>ESI-1 Total net consumption of primary embodied energy, GJ</td>
<td>2.7</td>
<td>12.9 (MJ/m²) / (kaph/m²)</td>
</tr>
<tr>
<td>ESI-2 Net annualized consumption of primary embodied energy, MJ</td>
<td>36</td>
<td>171 (MJ/m²) / (kaph/m²)</td>
</tr>
<tr>
<td>ESI-3 Net annual consumption of primary energy for building operations, MJ</td>
<td>1035</td>
<td>4866 (MJ/m²) / (kaph/m²)</td>
</tr>
<tr>
<td>ESI-4 Net annual consumption of primary non-renewable energy for building operations, MJ</td>
<td>806</td>
<td>3791 (MJ/m²) / (kaph/m²)</td>
</tr>
<tr>
<td>ESI-5 Net annualized primary embodied energy and annual operating primary energy, MJ</td>
<td>842</td>
<td>3962 (MJ/m²) / (kaph/m²)</td>
</tr>
<tr>
<td>ESI-6 Net area of land consumed for building and related works, m²</td>
<td>2.4</td>
<td>21.7 m² / occupant</td>
</tr>
<tr>
<td>ESI-7 Net annual consumption of potable water for building operations, m³</td>
<td>5</td>
<td>8 (m³ / (aph/m²) * yr)</td>
</tr>
<tr>
<td>ESI-8 Annual use of grey water and rainwater for building operations, m³</td>
<td>0</td>
<td>0 (m³ / (aph/m²) * yr)</td>
</tr>
<tr>
<td>ESI-9 Net annual GHG emissions from building operations, Kg. CO₂ equivalent</td>
<td>41</td>
<td>194 (Kg. eCO2 / m²) / (kaph / m²)</td>
</tr>
<tr>
<td>ESI-10 Predicted CFC-11 equivalent leakage per year in gm.</td>
<td>0.000000</td>
<td>0.000000 (gm / (m²) / 100 kg CFC-11 equiv / m²)</td>
</tr>
<tr>
<td>ESI-11 Total weight of materials re-used in Design from on-site or off-site uses, kg.</td>
<td>0</td>
<td>0 (kg / (aph/m²) * yr)</td>
</tr>
<tr>
<td>ESI-12 Total weight of new materials used in Design from off-site uses, kg.</td>
<td>370</td>
<td>1741 (kg / (aph/m²) * yr)</td>
</tr>
</tbody>
</table>

#### Total and Performance Issues

<table>
<thead>
<tr>
<th>Resources</th>
<th>Loadings</th>
<th>IEQ</th>
<th>Service Quality</th>
<th>Economics</th>
<th>Management</th>
<th>Transport</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.6</td>
<td>1.7</td>
<td>2.7</td>
<td>3.3</td>
<td>3.3</td>
<td>0.7</td>
<td>0.0</td>
</tr>
</tbody>
</table>

**Total Score for Resources, Loadings and IEQ:** 2.4
Levels of Performance for Design at Category Levels

Resource Consumption

![Bar chart showing resource consumption for Energy, Land, Water, Building reuse, and New Materials.]

Environmental Loadings

![Bar chart showing environmental loadings for GHG, ODS, Acidification, Solid waste, Effluent, and Site impacts.]

4.1 0.4 0.0 0.0 1.3
-2.0
-1.0
0.0
1.0
2.0
3.0
4.0
5.0

Energy  Land  Water  Building re-use  New Materials

4.2 0.0 2.6 0.6 0.0 0.5
-2.0
-1.0
0.0
1.0
2.0
3.0
4.0
5.0

GHG  ODS  Acidification  Solid waste  Effluent  Site impacts
**Indoor Environment Quality**

![Graph showing IAQ, Thermal Comfort, Illumination, Acoustics, EMF ratings]

**Service Quality**

![Graph showing Adaptability, Controllability, Maintain, Amenity ratings]

**Economics and Pre-operations Management**

![Graph showing Economics, Construction, Tuning, Operations ratings]
Case Study: Red River College Princess St Campus

Description

The project is a large educational facility in downtown Winnipeg, Manitoba. It includes extensive renovation of existing facades and new construction inserted behind. The total project will contain 20,500 m² in buildings that range from one to five storeys, and will be completed in 2003.

The Red River College project team included the following:

Owner: Princess Street Consortium Inc. The consortium is comprised of the following companies: Ada Holding Co. Ltd., A. Akman & Son(1991) Ltd., Corbett Cibinel Architects and J.J. Barnicke Winnipeg.

Client: Manitoba Government Services and Red River College

Project Manager: Accomodations, Development Division, Manitoba Gov't Services.

Architect: Doug Corbett, Corbett Cibinel Architects, Winnipeg, Manitoba

Assessment Team: Woytek Kujawski, INPOL Consulting (team leader), Alex Zimmerman, BCBC; Energy analysis: Chris Jones/ Curt Hepting, ENERSYS; Embodied energy analysis: Jamie Meil, Athena Sustainable Materials Institute

Design Team Comments

This project is a $31.5 million satellite campus for Red River College in Downtown Winnipeg. It will be home to approximately 2000 students and 200 staff involved in media and information technology programs. The Princess Street Campus is not only is the first C-2000 project in Manitoba, it also the largest and most complex C-2000 project yet undertaken in Canada. The project is also eligible for funding under the NRCan Commercial Building Incentive Program (CBIP). The project includes three phases that will be linked by a central atrium: Phase One involves the reuse of an existing early 1900's warehouse building with an annex added; Phase Two will incorporate a row of historic facades of some of the oldest buildings in Winnipeg; and Phase Three will be an entirely new building. Construction is underway with Phase One scheduled to open in September 2002.

A number of features are of environmental interest:

- Site development - The site was previously almost 100% buildings and hard surfaces. The new project will be similar but with a green roof and some new landscaping to mitigate habitat, groundwater and micro-climate effects. The new building profiles
will be similar to the old with regard to shading and view obstruction of neighbours to
the north and east. There will be some additional shading to the west.

- Water consumption - The campus is being fitted with water-conserving fixtures and
  controls. The vegetated roof will be irrigated exclusively with precipitation once
  established.

- Re-use of existing structures and materials - Phase One is primarily an adaptation of a
  4600 m² existing bldg. with a new roof and an addition. Subsequent phases will
  incorporate the reconstructed heritage facades along Princess Street. All heritage
  millwork suitable/or salvageable was removed for reuse, as were some windows and
  doors and interior tile and glass. A high rate of brick and stone recovery for reuse
  from demolition was achieved through hand methods. Timber trusses, castiron
  columns and reusable lumber were salvaged as well as many other miscellaneous
  items. Records have been kept of materials recovered.

- Use of local and recycled materials - Purchasing from local and Canadian sources has
  been emphasized where possible, using Manitoba's Sustainable Development
  Procurement Guidelines. Further recycled content is found in materials such as steel,
  copper and ceiling tiles. Records of materials specified and purchased are being kept
  for assessment.

- Emissions of Greenhouse Gases - The aggressive energy consumption targets
  demanded by the C-2000 program ensure reduced environmental loading from
  operating energy. Building materials have been selected with low effective
  environmental loading as a criterion.

- Emissions of ozone-depleting substances - Major refrigeration compressors employ
  134A refrigerant. Smaller units use the lowest ozone depletion rated commercially-
  available refrigerant. Non-HCFC rigid insulation materials are being researched.

- Emission leading to acidification from building operations - This is expected to be
  minimal. Natural gas flue venting from condensing-efficiency burners will be the
  only emissions.

- Construction and demolition wastes - The contractor has initiated a site waste
  recovery program. Demolition waste records are available for buildings removed and
  for pending construction.

- Indoor air quality - The HVAC design has a high ventilation effectiveness and
  excellent air distribution. Operable windows will be used throughout to promote
  natural ventilation during appropriate conditions. Dedicated exhausts are provided in
  equipment areas where pollutants may develop. Low toxicity interior materials will
  be emphasized to reduce pollutant loads.

- Thermal comfort - Solar control to reduce overheating is achieved by spectrally-
  selective glazing and window and shading device design. The high performance
  glazing also mitigates winter radiant heat loss from occupants, eliminating the need
  for perimeter radiation in most glazed areas. A four-pipe fan coil HVAC system
  provides tight zoning as well as stable temperature control.
• Daylighting - Daylight design for instructional and office areas and common areas has been given emphasis, including an unconditioned atrium circulation spine. Spectrally selective glazing admits 71% of visible light and is tuned by exposure and visual and thermal comfort needs.

• Adaptability and flexibility - The steel frame new structure is as adaptive as possible for this size and occupancy compared to concrete and masonry. Relatively lightweight and independent interior construction methods are used. Flexibility is achieved through planning for various instructional methods in the same spaces thereby reducing need for renovations. The fan coil HVAC systems are modular in nature, as are the suspended lighting systems used in most areas.

• Controllability of systems - Operable windows are used in key locations. Occupancy sensors control ventilation and lighting. Daylight sensors are used in strategic locations where energy benefits can be expected.

• Maintenance of performance - The facility will be leased by the development consortium to the College, with the consortium assuming financial and functional responsibility for operation and maintenance. This will promote ongoing sustainability of performance.

• Privacy and access to sunlight and views - Sunlight control is the main design concern for instructional spaces. Views of Winnipeg and the downtown heritage exchange area are provided from all elevations.

Assessment Team Comments

This project started with an ambitious sustainability agenda considering the local context. The region in which the project is located would not have been considered at the leading edge in terms of sustainability thinking or practice within the country when the project started. Energy prices in the city are the second lowest in North America, new material availability is not an issue, waste management is not seen to be a problem and there is not a strong tradition or ethic of conservation in the area. In addition to the pure functional requirements of the project, the project was viewed as a major urban redevelopment anchor and also needed to consider the heritage aspect of the downtown district it is located in and the buildings on site. This last requirement is not common in Canada. The final ownership of project was also in question until very recently. The project started out as a “public private partnership” and construction started without it being clear whether the project was to be owned by private sector investors or the public agency for whom the project is being built. This uncertainty added to the challenges faced by the design team in making decisions that affected first cost/operating cost tradeoffs. In addition, the project was done as a design-build, which meant that many of the decisions traditionally under the direct control of the consultant design team needed to be approached differently.

In the face of all of these potential difficulties, the project has achieved a great deal.

Resource Use

One existing building was retained in its entirety and adapted to the new uses. A lot of work went into reducing operating energy and that is reflected in the score for that aspect.
Embodied effects were mixed. The embodied energy did not fare as well compared to the benchmark, due in part to the use of high-performance aluminum curtainwall to reduce heating energy requirements in this cold climate, which trade-off was, to some degree a conscious choice. Since the site was an existing built-out city block and the design also has that characteristic, the effect on land use is neutral. Re-use of the materials from existing buildings was significant but the recycled content of new materials was not high. Operating water use compared to the benchmark was much lower due largely to the virtual elimination of water in the mechanical systems but there is no on-site or alternative treatment of sewage generated by the building.

Loadings

With regard to embodied effects of emissions, the benchmark is steel, whereas the design is concrete-dominated, so the CO2 emissions are higher. Emissions for operating energy are low as a by-product of the attention paid to this aspect and the energy mix for the electricity in the region, which is dominated by hydro. Ozone depleting substances have been eliminated and acidification is moderately low, again due to fuel effects.

Indoor Environment Quality

The overall score in this category is significantly better than the benchmark for the area, but this masks significant variation in the sub-criteria scores. The building scored high on moisture, ventilation and pollution control issues but the practice in other areas such as thermal comfort and daylighting is at, or only slightly better than, benchmark practice. No areas were worse than benchmark.

Service Quality

The overall score for this category is also significantly better than the benchmark, but again there are important differences in the sub-categories. Flexibility and the ability to maintain future performance scored high, but there is no provision for sub-metering or leak detection systems, which reduced the overall score.

Economics

The economic performance of this project is actually very good. The capital cost was less than 1% more than the benchmark, which in itself is an accomplishment. The life cycle cost is 26.5% better than benchmark, which is of major importance to the institutional owner of the building.

Management

The score here is better than benchmark due to the additional attention paid to construction management, commissioning and building flush-out, which is better than standard practice in the area. There does not appear to have been as much additional attention paid to training of O&M staff. This may reflect the uncertainty in the ownership arrangements as the project was being designed and during initial construction.
### GBTool Report worksheets

<table>
<thead>
<tr>
<th><strong>Occupancy and Basic Info</strong></th>
<th>Bmark</th>
<th>Design</th>
<th>Units</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Occupancy Type 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Occupancy Type 2</td>
<td></td>
<td>College/University</td>
<td>occupancy</td>
<td></td>
</tr>
<tr>
<td>Occupancy Type 3</td>
<td></td>
<td>Local Retail</td>
<td>occupancy</td>
<td></td>
</tr>
<tr>
<td>Occupancy Type 4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Largest occupancy type</td>
<td></td>
<td>largest occupancy is College/University</td>
<td>Area by occupancy: Residential 0 %, College/University 96 %, Local Retail 4 %,</td>
<td></td>
</tr>
<tr>
<td>Predicted service life of the building, assuming current uses</td>
<td>75</td>
<td>75</td>
<td>years</td>
<td></td>
</tr>
<tr>
<td>Avg. building population during main operating hours</td>
<td>1,955</td>
<td>1,955</td>
<td>persons</td>
<td></td>
</tr>
<tr>
<td>Not applicable</td>
<td></td>
<td>0</td>
<td>aph</td>
<td></td>
</tr>
<tr>
<td>Person-hours of occupancy per year for College/University</td>
<td>5,109,440</td>
<td>5,109,440</td>
<td>aph</td>
<td></td>
</tr>
<tr>
<td>Person-hours of occupancy per year for Local Retail</td>
<td>436,128</td>
<td>436,128</td>
<td>aph</td>
<td></td>
</tr>
<tr>
<td>Not applicable</td>
<td></td>
<td>0</td>
<td>aph</td>
<td></td>
</tr>
<tr>
<td>Person-hours of occupancy per year, all occupancies</td>
<td>5,545,568</td>
<td>5,545,568</td>
<td>aph</td>
<td></td>
</tr>
<tr>
<td>Person-hours of occupancy per year per m², all occupancies</td>
<td>315</td>
<td>315</td>
<td>aph / m²</td>
<td></td>
</tr>
<tr>
<td>Thousand person-hours of occ. per year per m², all occupancies</td>
<td>0.315</td>
<td>0.315</td>
<td>kaph / m²</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Other General Building Data</strong></th>
<th>Bmark</th>
<th>Design</th>
<th>Units</th>
<th>Design/ Bmark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total construction cost</td>
<td>$21,506,500</td>
<td>$21,688,300</td>
<td>$US</td>
<td>1.01</td>
</tr>
<tr>
<td>Predicted total annual energy cost</td>
<td>$229,644</td>
<td>$122,699</td>
<td>$US/year</td>
<td>0.53</td>
</tr>
<tr>
<td>Predicted annual other operating cost</td>
<td>$795,741</td>
<td>$542,208</td>
<td>$US/year</td>
<td>0.68</td>
</tr>
<tr>
<td>Predicted annual maintenance cost</td>
<td>$232,391</td>
<td>$232,391</td>
<td>$US/year</td>
<td>1.00</td>
</tr>
<tr>
<td>Construction cost, excluding land, per m² of total net area</td>
<td>$1,221</td>
<td>$1,232</td>
<td>$US/m² · yr</td>
<td>1.01</td>
</tr>
<tr>
<td>Predicted total annual O&amp;M cost per m² of total net area</td>
<td>$71</td>
<td>$51</td>
<td>$US/m² · yr</td>
<td>0.71</td>
</tr>
<tr>
<td>Number of distinct blocks or elements in the project</td>
<td>4</td>
<td>4</td>
<td>number</td>
<td></td>
</tr>
<tr>
<td>Maximum number of floors above grade of any block or element</td>
<td>6</td>
<td>6</td>
<td>number</td>
<td></td>
</tr>
<tr>
<td>Gross floor area above and below grade available in existing structure on the site</td>
<td>13,157</td>
<td>13,157</td>
<td>m²</td>
<td></td>
</tr>
<tr>
<td>Gross floor area above and below grade actually used as part of the Design</td>
<td>0</td>
<td>4,469</td>
<td>m²</td>
<td></td>
</tr>
<tr>
<td>Gross floor area above and below grade</td>
<td>19,006</td>
<td>19,006</td>
<td>m²</td>
<td></td>
</tr>
<tr>
<td>Net floor area above grade</td>
<td>17,004</td>
<td>17,004</td>
<td>m²</td>
<td></td>
</tr>
<tr>
<td>Net floor area above and below grade</td>
<td>17,609</td>
<td>17,609</td>
<td>m²</td>
<td></td>
</tr>
<tr>
<td>Gross Floor Area Ratio (Gross area above grade v. site area)</td>
<td>3.2</td>
<td>3.2</td>
<td>ratio</td>
<td></td>
</tr>
<tr>
<td>Floor plan efficiency above grade</td>
<td>93%</td>
<td>93%</td>
<td>percent</td>
<td></td>
</tr>
</tbody>
</table>
### Normalized General Building Data

<table>
<thead>
<tr>
<th></th>
<th>Benchmark</th>
<th>Design</th>
<th>Units</th>
<th>Benchmark</th>
<th>Design</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net area of land used for building and related purposes</td>
<td>0.33</td>
<td>0.33</td>
<td>m²/land / m² of net area</td>
<td>2.94</td>
<td>2.93</td>
<td>m² / occupant</td>
</tr>
<tr>
<td>Annual potable water consumption for all building uses per unit area</td>
<td>1.3</td>
<td>0.5</td>
<td>(m³ / m²) * yr</td>
<td>4.1</td>
<td>1.4</td>
<td>(m³/m²) / (kaph/m²) * yr</td>
</tr>
<tr>
<td>Annual potable water consumption for all building uses</td>
<td>11.7</td>
<td>4.1</td>
<td>(m³ / occup) * yr</td>
<td>73</td>
<td>25</td>
<td>(m³ / (aph/m²)) * yr</td>
</tr>
<tr>
<td>Annual greywater and rainwater use for all building uses</td>
<td>0.0</td>
<td>0.0</td>
<td>(m³ / m²) * yr</td>
<td>0</td>
<td>0</td>
<td>(m³ / (aph/m²)) * yr</td>
</tr>
<tr>
<td>Sanitary waste water not leaving the site</td>
<td>0.0000</td>
<td>0.0000</td>
<td>(m³ / m²) * yr</td>
<td>0.0000</td>
<td>0.0000</td>
<td>(m³/m²) / (kaph/m²) * yr</td>
</tr>
<tr>
<td>Storm water not leaving the site</td>
<td>0.02</td>
<td>0.00</td>
<td>(m³ / (m²)* yr</td>
<td>0.051</td>
<td>0.000</td>
<td>(m³/m²) / (kaph/m²) * yr</td>
</tr>
<tr>
<td>The proportion of the structure of an existing building on the site that is retained as part of the new building</td>
<td>0%</td>
<td>34%</td>
<td>percent by floor area</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Approx. weight of steel in an existing structure(s) on the site that is actually taken off-site for re-use or recycling, in addition to structure re-used on site as part of the new design</td>
<td>50%</td>
<td>100%</td>
<td>percent by weight</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The amount of other materials salvaged from existing structure(s) on the site that is re-used off-site, in addition to materials re-used on site as part of the new design</td>
<td>10%</td>
<td>11%</td>
<td>percent by weight</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The amount of materials used in the building that originate from off-site salvaged sources</td>
<td>0%</td>
<td>0%</td>
<td>percent by weight</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The total amount of materials used in the building that originate from on-site or off-site salvaged sources</td>
<td>1%</td>
<td>1%</td>
<td>percent by weight</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The recycled content in materials used in the building, obtained from off-site sources</td>
<td>5%</td>
<td>2%</td>
<td>percent by weight</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percent of materials obtained from local sources (within 200 km)</td>
<td>25%</td>
<td>0%</td>
<td>percent by weight</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The percentage of interior finish materials that conform to the VOC limit values of a recognized certification agency</td>
<td>0%</td>
<td>0%</td>
<td>percent by area</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percentage of materials of wood origin certified to conform to requirement for sustainable forestry practice guidelines</td>
<td>0%</td>
<td>0%</td>
<td>percent by weight</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The volume of solid wastes resulting from the clearance of existing structures on the site that will not be sent to a solid waste facility</td>
<td>10%</td>
<td>50%</td>
<td>ratio by weight</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The volume of solid wastes resulting from the construction process that will not be sent to a solid waste facility</td>
<td>0%</td>
<td>60%</td>
<td>ratio by weight</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

This is a renovation project. An existing structure has a total area of about 13157 m². From Cntxt worksheet: An existing structure on the site is possibly suitable for the intended function; About 5 tonnes or less of steel per 100 m² can be economically salvaged from an existing structure on the site, in addition to the part of building re-used directly. Many of the materials or elements in the existing structure are clearly suitable for the intended function (not including part of building re-used directly).
### Greenhouse Gas Equivalent calculations for operations

<table>
<thead>
<tr>
<th></th>
<th>Bmark Standard</th>
<th>Bmark Best</th>
<th>Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greenhouse Gas Equivalent, kg. per year CO₂ kg+CH₄g²/10000</td>
<td>1,424,145</td>
<td>547,266</td>
<td>715,011 Kg. CO₂ equiv. per year</td>
</tr>
<tr>
<td>GGE per year in kg. per unit net area</td>
<td>81</td>
<td>31</td>
<td>41 Kg. Equiv / m² * yr</td>
</tr>
<tr>
<td>Ratio of Design to Benchmark GGE per year for net area</td>
<td>100%</td>
<td>38%</td>
<td>50%</td>
</tr>
<tr>
<td>Predicted annual GGE, normalized to area and occupancy</td>
<td>257</td>
<td>99</td>
<td>129 (Kg. Equiv / m²) / (kaph / m³) * yr</td>
</tr>
<tr>
<td>Ratio of Design to Benchmark, for occupancy-adjusted GGE</td>
<td>100%</td>
<td>38%</td>
<td>50%</td>
</tr>
</tbody>
</table>

### Acidification calculations for building operations

<table>
<thead>
<tr>
<th></th>
<th>Bmark Standard</th>
<th>Design</th>
<th>Partial because of missing HCl data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acidification Equivalent, SO₂ kg. per year</td>
<td>22,886</td>
<td>11,292 Kg. SO₂ equiv. per year</td>
<td></td>
</tr>
<tr>
<td>SO₂ Equiv. per year in gm per unit area net</td>
<td>1.30</td>
<td>0.64 Kg. SO₂ equiv / m² * year</td>
<td></td>
</tr>
<tr>
<td>Ratio of Design to Benchmark SO₂ Equiv. per year for net area</td>
<td>100%</td>
<td>49%</td>
<td></td>
</tr>
<tr>
<td>Predicted annual SO₂ Equiv., normalized to area and occupancy</td>
<td>4.13</td>
<td>2.04 (Kg. SO₂ equiv / m²) / (kaph / m³) * year</td>
<td></td>
</tr>
<tr>
<td>Ratio of Design to Benchmark, for occupancy-adjusted net area SO₂ Equivalents</td>
<td>100%</td>
<td>49%</td>
<td></td>
</tr>
</tbody>
</table>

### Photo-Oxidant calculations for building operations

<table>
<thead>
<tr>
<th></th>
<th>Bmark Standard</th>
<th>Design</th>
<th>100%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Photo-oxidants, ethene-equivalent kg. per year</td>
<td>1,660</td>
<td>803 Kg. CFC-11 equiv. per year</td>
<td></td>
</tr>
<tr>
<td>Ethene equiv. per year in gm per unit area net</td>
<td>94,2700</td>
<td>45,6017 gm Ethene equiv / m² * year</td>
<td></td>
</tr>
<tr>
<td>Ratio of Design to Benchmark ethene equiv. per year for net area</td>
<td>100%</td>
<td>48%</td>
<td></td>
</tr>
<tr>
<td>Predicted annual ethene equiv., normalized to area and occupancy</td>
<td>299.3381</td>
<td>144.8003 (gm Ethene equiv / m²) / (kaph / m³) * year</td>
<td></td>
</tr>
<tr>
<td>Ratio of Design to Benchmark, for occupancy-adjusted net area ethene equivalent</td>
<td>100%</td>
<td>48%</td>
<td></td>
</tr>
</tbody>
</table>

### Eutrophication calculations for building operations

<table>
<thead>
<tr>
<th></th>
<th>Bmark Standard</th>
<th>Design</th>
<th>Partial because of missing COD, BOD, total nitrogen, orthophosphate and phosphorus data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eutrophication, PO₄-equivalent kg. per year</td>
<td>547</td>
<td>272 Kg. PO₄-equiv. Per year</td>
<td></td>
</tr>
<tr>
<td>PO₄-equiv. per year in kg. per unit area net</td>
<td>0.0311</td>
<td>0.0154 Kg. PO₄-equiv / m² * year</td>
<td></td>
</tr>
<tr>
<td>Ratio of Design to Benchmark PO₄-equiv. per year for net area</td>
<td>100%</td>
<td>50%</td>
<td></td>
</tr>
<tr>
<td>Predicted annual PO₄-equiv., normalized to area and occupancy</td>
<td>0.0986</td>
<td>0.0450 (Kg. PO₄-equiv / m²) / (kaph / m³) * year</td>
<td></td>
</tr>
<tr>
<td>Ratio of Design to Benchmark, for occupancy-adjusted net area PO₄-equivalents</td>
<td>100%</td>
<td>50%</td>
<td></td>
</tr>
</tbody>
</table>

### Annual Net Consumption of Delivered Energy by Fuel Type

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>MJ/m²</td>
<td>MJ/m²</td>
<td>MJ/m²</td>
<td>Normalized for area &amp; occ, (MJ/m²)/(kaph/m²)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annual delivered fuel consumption</td>
<td>1,229</td>
<td>430</td>
<td>559</td>
<td>3,901</td>
<td>1,365</td>
<td>1,776</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annual delivered electrical consumption</td>
<td>469</td>
<td>297</td>
<td>395</td>
<td>1,490</td>
<td>943</td>
<td>1,255</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annual consumption of delivered energy per unit net area</td>
<td>1,698</td>
<td>727</td>
<td>954</td>
<td>5,391</td>
<td>2,308</td>
<td>3,031</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Annual Gross Consumption of Primary Energy by Fuel Type

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>MJ/m²</td>
<td>MJ/m²</td>
<td>MJ/m²</td>
<td>Normalized for area &amp; occ, (MJ/m²)/(kaph/m²)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annual delivered fuel consumption</td>
<td>1,229</td>
<td>430</td>
<td>559</td>
<td>3,901</td>
<td>1,365</td>
<td>1,776</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annual primary electrical consumption</td>
<td>548</td>
<td>347</td>
<td>461</td>
<td>1,739</td>
<td>1,100</td>
<td>1,464</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annual consumption of primary energy per unit net area</td>
<td>1,776</td>
<td>777</td>
<td>1,020</td>
<td>5,640</td>
<td>2,466</td>
<td>3,240</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Annual Consumption of Primary Non-Renewable Energy Sources

<table>
<thead>
<tr>
<th></th>
<th>Bmark Standard</th>
<th>Bmark Best</th>
<th>Design</th>
<th>Bmark Standard</th>
<th>Bmark Best</th>
<th>Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>MJ/m²</td>
<td>MJ/m²</td>
<td>MJ/m²</td>
<td>Normalized for area &amp; occ, (MJ/m²)/(kaph/m²)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total primary non-renewable fuels used on-site and for generation of electricity, annual basis</td>
<td>1,432</td>
<td>613</td>
<td>667</td>
<td>4,547</td>
<td>1,947</td>
<td>2,118</td>
</tr>
</tbody>
</table>
### Total and Annualized Consumption of Primary Embodied Energy

<table>
<thead>
<tr>
<th></th>
<th>Bmark Standard</th>
<th>Bmark Best</th>
<th>Design</th>
<th>Bmark Standard</th>
<th>Bmark Best</th>
<th>Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary embodied energy for above- and below-grade structure and building envelope, GJ/m²</td>
<td>66182</td>
<td>52076</td>
<td>89052</td>
<td>210</td>
<td>165</td>
<td>283</td>
</tr>
<tr>
<td>Primary embodied energy for above- and below-grade structure and building envelope, MJ/m²</td>
<td>3.5</td>
<td>2.7</td>
<td>4.7</td>
<td>11.1</td>
<td>8.7</td>
<td>14.9</td>
</tr>
<tr>
<td>Annualized primary embodied energy for above- and below-grade structure and building envelope, MJ/m²/year</td>
<td>46</td>
<td>39</td>
<td>62</td>
<td>147</td>
<td>125</td>
<td>198</td>
</tr>
</tbody>
</table>

### Annualized Consumption of Primary Embodied Energy plus Annual Primary Non-Renewable Operating Energy

<table>
<thead>
<tr>
<th></th>
<th>Bmark Standard</th>
<th>Bmark Best</th>
<th>Design</th>
<th>Bmark Standard</th>
<th>Bmark Best</th>
<th>Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annualized primary embodied energy for above- and below-grade structure and building envelope, plus annual primary non-renewable operating energy, MJ/m²</td>
<td>1,478</td>
<td>653</td>
<td>730</td>
<td>4,694</td>
<td>2,072</td>
<td>2,317</td>
</tr>
</tbody>
</table>
**GBTool Results worksheet**

**Environmental Sustainability Indicators**

<table>
<thead>
<tr>
<th>Selected Environmental Sustainability Indicators for the Design</th>
<th>per m² only</th>
<th>by area &amp; by occupancy</th>
</tr>
</thead>
<tbody>
<tr>
<td>ESI-1 Total net consumption of primary embodied energy, GJ</td>
<td>4.7</td>
<td>14.9</td>
</tr>
<tr>
<td>ESI-2 Net annualized consumption of primary embodied energy, MJ</td>
<td>62</td>
<td>198</td>
</tr>
<tr>
<td>ESI-3 Net annual consumption of primary energy for building operations, MJ</td>
<td>1020</td>
<td>3240</td>
</tr>
<tr>
<td>ESI-4 Net annual consumption of primary non-renewable energy for building operations, MJ</td>
<td>667</td>
<td>2118</td>
</tr>
<tr>
<td>ESI-5 Net annualized primary embodied energy and annual operating primary energy, MJ</td>
<td>730</td>
<td>2317</td>
</tr>
<tr>
<td>ESI-6 Net area of land consumed for building and related works, m²</td>
<td>0.3</td>
<td>2.9</td>
</tr>
<tr>
<td>ESI-7 Net annual consumption of potable water for building operations, m³</td>
<td>4</td>
<td>25</td>
</tr>
<tr>
<td>ESI-8 Annual use of grey water and rainwater for building operations, m³</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>ESI-9 Net annual GHG emissions from building operations, kg. CO₂ equivalent</td>
<td>41</td>
<td>129</td>
</tr>
<tr>
<td>ESI-10 Predicted CFC-11 equivalent leakage per year in gm.</td>
<td>0.00000000</td>
<td>0.00000000</td>
</tr>
<tr>
<td>ESI-11 Total weight of materials re-used in Design from on-site or off-site uses, kg.</td>
<td>202</td>
<td>640</td>
</tr>
<tr>
<td>ESI-12 Total weight of new materials used in Design from off-site uses, kg.</td>
<td>1288</td>
<td>4090</td>
</tr>
</tbody>
</table>

**Total and Performance Issues**

![Graph showing Total Score for Resources, Loadings and IEQ]

- Total Score for Resources, Loadings and IEQ: 2.5

![Bar chart showing Resources, Loadings, IEQ, Service Quality, Economics, Management, and Transport]

- Resources: 3.0
- Loadings: 2.5
- IEQ: 2.0
- Service Quality: 2.8
- Economics: 3.0
- Management: 2.1
- Transport: 0.0
Levels of Performance for Design at Category Levels

Resource Consumption

<table>
<thead>
<tr>
<th>Category</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy</td>
<td>4.1</td>
</tr>
<tr>
<td>Land</td>
<td>0.0</td>
</tr>
<tr>
<td>Water</td>
<td>3.2</td>
</tr>
<tr>
<td>Building re-use</td>
<td>2.2</td>
</tr>
<tr>
<td>New materials</td>
<td>-0.7</td>
</tr>
</tbody>
</table>

Environmental Loadings

<table>
<thead>
<tr>
<th>Category</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>GHG</td>
<td>3.6</td>
</tr>
<tr>
<td>ODS</td>
<td>5.0</td>
</tr>
<tr>
<td>Acidification</td>
<td>2.5</td>
</tr>
<tr>
<td>Solid waste</td>
<td>1.8</td>
</tr>
<tr>
<td>Effluent</td>
<td>-1.0</td>
</tr>
<tr>
<td>Site impacts</td>
<td>1.9</td>
</tr>
</tbody>
</table>
**Indoor Environment Quality**

![Graph showing Indoor Environment Quality metrics]

- **IAQ**: 2.9
- **Thermal Comfort**: 0.5
- **Illumination**: 2.2
- **Acoustics**: 2.1
- **EMF**: 2.0

**Service Quality**

![Graph showing Service Quality metrics]

- **Adaptability**: 3.8
- **Controllability**: 2.5
- **Maintain Performance**: 1.6
- **Amenity**: 4.0
Economics and Pre-operations Management

[Diagram showing bar graphs for Economics, Construction, Tuning, and Operations with respective values]
Case Study: Jackson Triggs Estate Winery

Description

The Jackson-Triggs Winery is a winery production and retail facility in wine-growing region of the Niagara peninsula at Niagara-on-the-Lake, Ontario, Canada. The two-storey structure contains approximately 4,000 m², and was completed in July, 2001.

Owner: Vincor International
Architects: Kuwabara Payne McKenna Blumberg Architects
Structural: Blackwell Engineering
Mechanical: Keen Engineering
Electrical: Carinci Burt Rogers
Landscape: Janet Rosenberg & Associates
Lighting: Suzanne Powadiuk Design
Contractor: Merit Contractors of Niagara

Assessment Team: Jiri Skopek (team leader); H. Robert Bach, Engineering Interface Limited; Nils Larsson, NRCan, Gord Shymko, G.F. Shymko & Associates; Chris Jones, Enersys Analytics, (Energy Analysis); Jamie Meil, Athena Sustainable Materials Institute, (Embodied Energy Analysis).

Design Team Comments

The designers of the 4,000 m² Jackson Triggs Winery were given three environmental objectives:

- The building should be agrarian in nature.
- Building systems should be just as conservationist as the wine-making process.
- Emissions of CO2 are to be minimized

A design charrette was used to weigh green design versus business issues and to integrate the design process. The charrette was attended by the Project Architects, Design Consultants and the Owner.

The winery is divided into two principal components. The public space is located at the eastern end of the building and includes the tasting areas, a retail shop, and entertaining and administration areas. The western half houses the fermentation tanks as well as storage and barrel cellars, all of which are accessible to the public as part of the winery tour. The large, double height Great Hall acts as both the link and the buffer between public and production areas.

The Great Hall is just one of several features used to address environmental issues. The production spaces are organized to use gravity flow in the wine-making process, and
storage spaces are located in the cave-like basement, where the heat sink effect of the surrounding earth maintains a stable, cool and humid environment.

A number of the environmental and mechanical features include:

- An on-site storm water collection system discharges to "soak away" pits.
- An East/West building orientation and five to one floor plate ratio, maximizing south facing passive solar gain.
- Daylighting is maximized to reduce reliance on artificial illumination systems—reduces cooling loads and costs.
- A 5 m roof overhang on the south-west and east faces minimizes direct solar heat gain and reduces the cooling energy requirements.
- Natural ventilation is maximized in all areas through the use of operable windows during shoulder (Spring and Fall) seasons to reduce the reliance on building heating and cooling systems.
- A displacement ventilation system is used for office, boardroom and lounge areas where high ceilings allows stratification, subsequent energy reductions and improvement in indoor air quality.
- Air to air heat exchangers are used for pre-heating of fresh air for the building.
- A radiant floor heating system uses concrete mass for storage and a thermal flywheel effect.

**Assessment Team Comments**

The Jackson-Triggs Winery assessment presented the following challenges:

- The winery represents a rather specialized building type, which made it difficult to find a suitable benchmarking facility and gather benchmarking data. The benchmark facility that was finally selected mirrored the functional area of the winery including the cellar spaces, while accommodating the functions of a utilitarian architecture more commonly found in light industrial parks or farm buildings, where production space is typically located adjacent to appointed office and administrative spaces but not necessarily within the same building.

- The close integration of production, office and retail functions also meant that production information was sometimes difficult to separate from building data information. Sorting out of the two types of data required considerable judgment. Obtaining comparable benchmark data posed an added challenge.

The assessment was carried out through a combination of means. The proponent of the project, KEEN Engineering, conducted data gathering; and specialists were contracted to perform embodied energy calculations and operating energy simulations. The assessors volunteered their time to perform the final assessments, including the regional adjustments to the default baseline, completion of the input and the building performance evaluation.

Several issue were highlighted during the assessment:
Case Study: Jackson Triggs Estate Winery

- The building achieves excellent water economies, through water conservation measures. For example, using the force of gravity avoids the need of large quantities of water to be pumped for processes such as cleaning the vats.

- The site impact is also substantially minimalized due to the building’s water discharge measures such as "soak away" pits.

- The energy performance of the building is also exceptional due to the integration of natural lighting, which reduces the electrical load as well as innovative industrial practices such as use of gravity to move the wine from vessel to vessel as it is processed. This not only saves energy but improves wine quality as well.

- Despite the building’s good energy performance, it does have a negative impact in terms of acidification, due to the composition of the Ontario’s energy mix, which relies on coal-powered power plants supplying the marginal electrical load.

- The building appears to have marginally higher embodied energy consumption compared to the benchmark building. This can be explained by the use of architectural elements such as the extensive use of clerestory glazing and the lightweight metal roof. On the other hand, the high quality architectural solution, as compared to its industrial park archetype, has been achieved at only a marginally higher cost to the environment due to the embodied effects of the building structure and envelope.
Drawings & photos.
Case Study: Jackson Triggs Estate Winery

GREEN APPLICATION - “DOUBLE DUTY”
JACKSON TRIGGS REFRIGERATION
### GBTool Report worksheets

#### Occupancy and Basic Info

<table>
<thead>
<tr>
<th>Occupancy Type</th>
<th>Bmark</th>
<th>Design</th>
<th>Units</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Occupancy Type 1</td>
<td>Local Retail</td>
<td>occupancy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Occupancy Type 2</td>
<td>Office</td>
<td>occupancy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Occupancy Type 3</td>
<td>Industrial</td>
<td>occupancy</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Largest occupancy type: largest occupancy is Industrial

Area by occupancy: Residential 0 %, Local Retail 19 %, Office 8 %, Industrial 73 %

- Predicted service life of the building, assuming current uses: 75 years
- Avg. building population during main operating hours: 107 persons
- Person-hours of occupancy per year for Local Retail: 216,000 aph
- Person-hours of occupancy per year for Office: 35,602 aph
- Person-hours of occupancy per year for Industrial: 125,823 aph
- Person-hours of occupancy per year, all occupancies: 377,425 aph

- Person-hours of occupancy per year per m², all occupancies: 109 aph / m²
- Thousand person-hours of occ. per year per m², all occupancies: 0.109 kaph / m²

#### Other General Building Data

<table>
<thead>
<tr>
<th>Bmark</th>
<th>Design</th>
<th>Units</th>
<th>Design/ Bmark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total construction cost: $6,000,000</td>
<td>$6,000,000</td>
<td>$US</td>
<td>1.00</td>
</tr>
<tr>
<td>Predicted total annual energy cost: $200,000</td>
<td>$100,000</td>
<td>$US/year</td>
<td>0.50</td>
</tr>
<tr>
<td>Predicted annual other operating cost: $0</td>
<td>$0</td>
<td>$US/year</td>
<td>0.00</td>
</tr>
<tr>
<td>Predicted annual maintenance cost: $120,000</td>
<td>$132,000</td>
<td>$US/year</td>
<td>1.10</td>
</tr>
<tr>
<td>Construction cost, excluding land, per m² of total net area: $1,739</td>
<td>$1,739</td>
<td>$US/m² . yr</td>
<td>1.00</td>
</tr>
<tr>
<td>Predicted total annual O&amp;M cost per m² of total net area: $93</td>
<td>$67</td>
<td>$US/m² . yr</td>
<td>0.73</td>
</tr>
<tr>
<td>Number of distinct blocks or elements in the project: 1</td>
<td>1</td>
<td>number</td>
<td></td>
</tr>
<tr>
<td>Maximum number of floors above grade of any block or element: 2</td>
<td>2</td>
<td>number</td>
<td></td>
</tr>
<tr>
<td>Gross floor area above and below grade available in existing structure on the site: 0 m²</td>
<td>0 m²</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Gross floor area above and below grade of the existing structure actually used as part of the Design: 3,451 m²</td>
<td>3,451 m²</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gross floor area above and below grade: 1,942 m²</td>
<td>1,942 m²</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Net floor area above and below grade: 3,451 m²</td>
<td>3,451 m²</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gross Floor Area Ratio (Gross area above grade v. site area): 0.0 ratio</td>
<td>0.0 ratio</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Floor plan efficiency above grade: 100% percent</td>
<td>100% percent</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Other General Building Data

<table>
<thead>
<tr>
<th></th>
<th>Bmark</th>
<th>Design</th>
<th>Units</th>
<th>Design/Bmark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not applicable</td>
<td>0</td>
<td>0</td>
<td>m²</td>
<td></td>
</tr>
<tr>
<td>Total net floor area for Local Retail</td>
<td>654</td>
<td>654</td>
<td>m²</td>
<td></td>
</tr>
<tr>
<td>Total net floor area for Office</td>
<td>288</td>
<td>288</td>
<td>m²</td>
<td></td>
</tr>
<tr>
<td>Total net floor area for Industrial</td>
<td>2,509</td>
<td>2,509</td>
<td>m²</td>
<td></td>
</tr>
<tr>
<td>Surface area to volume ratio above grade</td>
<td>0%</td>
<td>68%</td>
<td>percent</td>
<td>0.00</td>
</tr>
<tr>
<td>Average window to wall ratio</td>
<td>0%</td>
<td>75%</td>
<td>percent</td>
<td>0.00</td>
</tr>
<tr>
<td>Overall glazing SHGC</td>
<td>0.80</td>
<td>0.80</td>
<td>ratio</td>
<td>0.75</td>
</tr>
<tr>
<td>Overall window STC in wall exposed to most noise</td>
<td>27.50</td>
<td>30.00</td>
<td>ratio</td>
<td>1.09</td>
</tr>
<tr>
<td>Overall window U-value</td>
<td>2.80</td>
<td>1.89</td>
<td>W/m² * OC</td>
<td>0.68</td>
</tr>
<tr>
<td>Overall exterior roof U-value</td>
<td>0.33</td>
<td>0.19</td>
<td>W/m² * OC</td>
<td>0.57</td>
</tr>
<tr>
<td>Overall exterior solid wall U-value</td>
<td>0.33</td>
<td>0.00</td>
<td>W/m² * OC</td>
<td>0.00</td>
</tr>
<tr>
<td>Overall exterior solid wall RSI-value</td>
<td>3.03</td>
<td>0.00</td>
<td>m² * OC/W</td>
<td>0.00</td>
</tr>
<tr>
<td>Average reflectance of horizontal roof surfaces and hard-paved site areas</td>
<td>0.32</td>
<td>0.90</td>
<td>number</td>
<td>2.80</td>
</tr>
<tr>
<td>The vertical angle measured from the building line on the ground of the nearest adjacent property to the roof line of the case-study building is (0 to 90 degrees):</td>
<td>0</td>
<td>0</td>
<td>degrees</td>
<td>0.00</td>
</tr>
<tr>
<td>Estimated percent of the southerly facing building façade of an adjacent property south of the case-study building, that is shaded by it at 12 noon on Summer Solstice</td>
<td>0%</td>
<td>0%</td>
<td>percent</td>
<td>0.00</td>
</tr>
<tr>
<td>Estimated Daylight Factor</td>
<td>2.0%</td>
<td>4.5%</td>
<td>percent</td>
<td>2.25</td>
</tr>
<tr>
<td>Predicted minimum relative humidity during heating season</td>
<td>28.6%</td>
<td>30.0%</td>
<td>percent</td>
<td>1.05</td>
</tr>
<tr>
<td>Predicted maximum relative humidity during cooling season</td>
<td>76.3%</td>
<td>80.0%</td>
<td>percent</td>
<td>1.05</td>
</tr>
<tr>
<td>Percentage of net floor area of the building that is mechanically ventilated and cooled</td>
<td>100.0%</td>
<td>100.0%</td>
<td>percent</td>
<td>1.00</td>
</tr>
<tr>
<td>Ratio of openable window area or other controllable openings to all net primary area in naturally ventilated areas</td>
<td>NA</td>
<td>9.0%</td>
<td>percent</td>
<td></td>
</tr>
<tr>
<td>Normalized General Building Data</td>
<td>Normalized by net area</td>
<td>Units</td>
<td>Normalized by net area and occupancy</td>
<td>Units</td>
</tr>
<tr>
<td>---------------------------------</td>
<td>------------------------</td>
<td>-------</td>
<td>-------------------------------------</td>
<td>-------</td>
</tr>
<tr>
<td>Net area of land used for building and related purposes</td>
<td>5.01</td>
<td>4.57</td>
<td>m² land / m² of net area</td>
<td>162.36</td>
</tr>
<tr>
<td>Annual potable water consumption for all building uses per unit area</td>
<td>44.4</td>
<td>3.5</td>
<td>(m³ / m²) * yr</td>
<td>405.8</td>
</tr>
<tr>
<td>Annual potable water consumption for all building uses</td>
<td>1,437</td>
<td>113</td>
<td>(m³ / occ) * yr</td>
<td>1,400</td>
</tr>
<tr>
<td>Annual greywater and rainwater use for all building uses</td>
<td>0.0</td>
<td>7.5</td>
<td>(m³ / occ) * yr</td>
<td>0</td>
</tr>
<tr>
<td>Sanitary waste water not leaving the site</td>
<td>0.0000</td>
<td>0.2318</td>
<td>(m³ / m²) * yr</td>
<td>0.000</td>
</tr>
<tr>
<td>Storm water not leaving the site</td>
<td>0.42</td>
<td>0.42</td>
<td>(m³ / m²) * yr</td>
<td>3.796</td>
</tr>
<tr>
<td>The proportion of the structure of an existing building on the site that is retained as part of the new building</td>
<td>0%</td>
<td>0%</td>
<td>percent by floor area</td>
<td></td>
</tr>
<tr>
<td>Approx. weight of steel in an existing structure(s) on the site that is actually taken off-site for re-use or recycling, in addition to structure re-used on site as part of the new design. (see R55)</td>
<td>0%</td>
<td>0%</td>
<td>percent by weight</td>
<td></td>
</tr>
<tr>
<td>The amount of other materials salvaged from existing structure(s) on the site that is re-used off-site, in addition to materials re-used on site as part of the new design, (see R55)</td>
<td>0%</td>
<td>0%</td>
<td>percent by weight</td>
<td></td>
</tr>
<tr>
<td>The amount of materials used in the building that originate from off-site salvaged sources</td>
<td>0%</td>
<td>0%</td>
<td>percent by weight</td>
<td></td>
</tr>
<tr>
<td>The total amount of materials used in the building that originate from on-site or off-site salvaged sources</td>
<td>0%</td>
<td>0%</td>
<td>percent by weight</td>
<td></td>
</tr>
<tr>
<td>The recycled content in materials used in the building, obtained from off-site sources</td>
<td>0%</td>
<td>0%</td>
<td>percent by weight</td>
<td></td>
</tr>
<tr>
<td>Percent of materials obtained from local sources (within 300 km)</td>
<td>75%</td>
<td>0%</td>
<td>percent by weight</td>
<td></td>
</tr>
<tr>
<td>The percentage of interior finish materials that conform to the VOC limit values of a recognized certification agency.</td>
<td>0%</td>
<td>95%</td>
<td>percent by area</td>
<td></td>
</tr>
<tr>
<td>Percentage of materials of wood origin certified to conform to requirement for sustainable forestry practice guidelines.</td>
<td>0%</td>
<td></td>
<td>percent by weight</td>
<td></td>
</tr>
<tr>
<td>The volume of solid wastes resulting from the clearance of existing structures on the site that will not be sent to a solid waste facility.</td>
<td>0%</td>
<td>0%</td>
<td>ratio by weight</td>
<td></td>
</tr>
<tr>
<td>The volume of solid wastes resulting from the construction process that will not be sent to a solid waste facility.</td>
<td>30%</td>
<td>30%</td>
<td>ratio by weight</td>
<td></td>
</tr>
<tr>
<td>Outdoor air rate ventilation in primary areas of Local Retail occupancy</td>
<td>4.85</td>
<td>4.85</td>
<td>L/s per occupant</td>
<td>7.00</td>
</tr>
<tr>
<td>Outdoor air rate ventilation in primary areas of Office occupancy</td>
<td>0.07</td>
<td>0.11</td>
<td>L/s per occupant</td>
<td>1.00</td>
</tr>
<tr>
<td>Outdoor air rate ventilation in primary areas of Industrial occupancy</td>
<td>0.03</td>
<td>0.03</td>
<td>L/s per occupant</td>
<td>5.00</td>
</tr>
<tr>
<td>Annual consumption of delivered energy (presumed purchased)</td>
<td>2,424</td>
<td>1,672</td>
<td>MJ / m² * yr</td>
<td>22,168</td>
</tr>
<tr>
<td>Annualized embodied energy for above- and below-grade structure and building envelope</td>
<td>52</td>
<td>68</td>
<td>MJ / m² * yr</td>
<td>471</td>
</tr>
<tr>
<td>Total of annualized embodied energy and annual delivered energy</td>
<td>2,476</td>
<td>1,741</td>
<td>MJ / m² * yr</td>
<td>22,639</td>
</tr>
<tr>
<td>Total primary non-renewable fuels used on-site and for generation of electricity, annual basis</td>
<td>2,683</td>
<td>1,839</td>
<td>MJ / m² * yr</td>
<td>24,530</td>
</tr>
<tr>
<td>Predicted Greenhouse Gas Emissions from annual operations</td>
<td>212.0</td>
<td>156.3</td>
<td>Kg / m² * yr</td>
<td>1,938</td>
</tr>
<tr>
<td>Crude estimate of annualized embodied GHG emissions, Kg CO₂ equivalent (based on kg CO₂ equivalent per GJ)</td>
<td>111.8</td>
<td>115.5</td>
<td>Kg / m² * yr</td>
<td>1,056</td>
</tr>
<tr>
<td>Predicted total Greenhouse Gas Emissions from annual operations and annualized embodied emissions</td>
<td>323.8</td>
<td>271.8</td>
<td>Kg CO₂ / m²</td>
<td>2,485</td>
</tr>
</tbody>
</table>
### Case Study: Jackson Triggs Estate Winery

#### Greenhouse Gas Equivalent calculations for operations

<table>
<thead>
<tr>
<th></th>
<th>Bmark</th>
<th>Max</th>
<th>Bmark Best</th>
<th>Design</th>
<th>Incomplete because of missing data on emissions from nuclear, hydro reservoirs, geothermal, biomass etc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greenhouse Gas Equivalent, kg. per year CO₂ kg+CH₄g*21/1000</td>
<td>731,481</td>
<td>584,627</td>
<td>539,503</td>
<td>Kg. CO₂ equiv. per year</td>
<td></td>
</tr>
<tr>
<td>GGE per kg in per unit net area</td>
<td>212</td>
<td>169</td>
<td>156</td>
<td>Kg. Equiv / m² * yr</td>
<td></td>
</tr>
<tr>
<td>Ratio of Design to Benchmark GGE per year for net area</td>
<td>100%</td>
<td>80%</td>
<td>74%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Predicted annual GGE, normalized to area and occupancy</td>
<td>1938</td>
<td>1549</td>
<td>1429</td>
<td>(Kg. Equiv / m²) / (kaph / m²) * yr</td>
<td></td>
</tr>
<tr>
<td>Ratio of Design to Benchmark, for occupancy-adjusted GGE</td>
<td>100%</td>
<td>80%</td>
<td>74%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Ozone Depletion Calculations for operations

<table>
<thead>
<tr>
<th></th>
<th>Bmark</th>
<th>Design</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Ozone Depletion from leakage of CFC-11 equivalent, in gm per yr.</td>
<td>403</td>
<td>175</td>
<td>gm CFC-11 equiv. per year</td>
</tr>
<tr>
<td>Predicted CFC-11 leakage equivalent per year in gm. per unit net area</td>
<td>0.11666</td>
<td>0.05068</td>
<td>gm CFC-11 equiv / m² * year</td>
</tr>
<tr>
<td>Ratio of Design to Benchmark leakage of CFC-11 equivalent per year for net area</td>
<td>100%</td>
<td>43%</td>
<td></td>
</tr>
<tr>
<td>Predicted leakage of annual CFC-11 equivalent, normalized to area and occupancy</td>
<td>1.06670</td>
<td>0.46340</td>
<td>(gm CFC-11 equiv / m²) / (kaph * m²) * yr</td>
</tr>
<tr>
<td>Ratio of Design to Benchmark, for occupancy-adjusted net area of CFC-11 equivalent annual leakage</td>
<td>100%</td>
<td>43%</td>
<td></td>
</tr>
</tbody>
</table>

#### Acidification calculations for building operations

<table>
<thead>
<tr>
<th></th>
<th>Bmark</th>
<th>Design</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Acidification Equivalent, SO₂ kg. per year</td>
<td>2,655</td>
<td>2,172</td>
<td>Kg. SO₂ equiv. per year</td>
</tr>
<tr>
<td>SO₂ Equiv. per year in kg. per unit area net</td>
<td>0.77</td>
<td>0.63</td>
<td>Kg. SO₂ equiv / m² * year</td>
</tr>
<tr>
<td>Ratio of Design to Benchmark SO₂ Equiv. per year for net area</td>
<td>100%</td>
<td>82%</td>
<td></td>
</tr>
<tr>
<td>Predicted annual SO₂ Equiv., normalized to area and occupancy</td>
<td>7.04</td>
<td>5.75</td>
<td>(Kg. SO₂ equiv / m²) / (kaph / m²) * yr</td>
</tr>
<tr>
<td>Ratio of Design to Benchmark, for occupancy-adjusted net area SO₂ Equivalent</td>
<td>100%</td>
<td>82%</td>
<td></td>
</tr>
</tbody>
</table>

#### Photo-Oxidant calculations for building operations

<table>
<thead>
<tr>
<th></th>
<th>Bmark</th>
<th>Design</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Photo-oxidants, ethene-equivalent kg. per year (CH₄<em>0.007+VOC</em>0.337)</td>
<td>3.03</td>
<td>2.32</td>
<td>Kg. CFC-11 equiv. per year</td>
</tr>
<tr>
<td>Ethene equiv. per year in gm per net unit area</td>
<td>0.8770</td>
<td>0.6728</td>
<td>gm Ethene equiv / m² * year</td>
</tr>
<tr>
<td>Ratio of Design to Benchmark ethene equiv. per year for net area</td>
<td>100%</td>
<td>77%</td>
<td></td>
</tr>
<tr>
<td>Predicted annual ethene equiv., normalized to area and occupancy</td>
<td>8.0185</td>
<td>6.1522</td>
<td>(gm Ethene equiv / m²) / (kaph / m²) * year</td>
</tr>
<tr>
<td>Ratio of Design to Benchmark, for occupancy-adjusted net area ethene equivalent</td>
<td>100%</td>
<td>77%</td>
<td></td>
</tr>
</tbody>
</table>

#### Eutrophication calculations for building operations

<table>
<thead>
<tr>
<th></th>
<th>Bmark</th>
<th>Design</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Eutrophication , PO₄-equivalent kg. per year (NO₂<em>0.13+NO</em>0.2+NH₃*0.35)</td>
<td>662.02</td>
<td>528.22</td>
<td>Kg. PO₄-equiv. Per year</td>
</tr>
<tr>
<td>PO₄-equiv. per kg in per unit area net</td>
<td>0.1918</td>
<td>0.1531</td>
<td>Kg. PO₄-equiv / m² * year</td>
</tr>
<tr>
<td>Ratio of Design to Benchmark PO₄-equiv. per year for net area</td>
<td>100%</td>
<td>80%</td>
<td></td>
</tr>
<tr>
<td>Predicted annual PO₄-equiv., normalized to area and occupancy</td>
<td>1.7541</td>
<td>1.3896</td>
<td>(Kg. PO₄-equiv / m²) / (kaph / m²) * yr</td>
</tr>
<tr>
<td>Ratio of Design to Benchmark, for occupancy-adjusted net area PO₄-equivalent</td>
<td>100%</td>
<td>80%</td>
<td></td>
</tr>
</tbody>
</table>

Jackson Triggs Estate Winery, Rev. 01, Niagara-on-the-Lake, Canada, Summary Report

Partial because of missing COD, BOD, total nitrogen, orthophosphate and phosphorous data
### Annual Net Consumption of Delivered Energy by Fuel Type

<table>
<thead>
<tr>
<th>Bmark</th>
<th>Max</th>
<th>Bmark Best</th>
<th>Design</th>
<th>Bmark</th>
<th>Max</th>
<th>Bmark Best</th>
<th>Design</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MJ/m²</td>
<td>MJ/m²</td>
<td>MJ/m²</td>
<td></td>
<td>MJ/m²</td>
<td>MJ/m²</td>
<td>MJ/m²</td>
</tr>
<tr>
<td>Annual delivered fuel consumption</td>
<td>1,600</td>
<td>1,280</td>
<td>985</td>
<td>14,628</td>
<td>11,703</td>
<td>9,010</td>
<td></td>
</tr>
<tr>
<td>Annual delivered electrical consumption</td>
<td>825</td>
<td>680</td>
<td>687</td>
<td>7,540</td>
<td>6,032</td>
<td>6,279</td>
<td></td>
</tr>
<tr>
<td>Annual consumption of delivered energy per unit net area</td>
<td>2,424</td>
<td>1,940</td>
<td>1,672</td>
<td>22,168</td>
<td>17,735</td>
<td>15,290</td>
<td></td>
</tr>
</tbody>
</table>

### Annual Gross Consumption of Primary Energy by Fuel Type

<table>
<thead>
<tr>
<th>Bmark Standard</th>
<th>Bmark Best</th>
<th>Design</th>
<th>Bmark Standard</th>
<th>Bmark Best</th>
<th>Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>MJ/m²</td>
<td>MJ/m²</td>
<td>MJ/m²</td>
<td>MJ/m²</td>
<td>MJ/m²</td>
<td>MJ/m²</td>
</tr>
<tr>
<td>Annual delivered fuel consumption</td>
<td>1,600</td>
<td>1,290</td>
<td>985</td>
<td>14,628</td>
<td>11,703</td>
</tr>
<tr>
<td>Annual primary electrical consumption</td>
<td>1,091</td>
<td>873</td>
<td>908</td>
<td>9,974</td>
<td>7,979</td>
</tr>
<tr>
<td>Annual consumption of primary energy per unit net area</td>
<td>2,691</td>
<td>2,153</td>
<td>1,894</td>
<td>24,603</td>
<td>19,682</td>
</tr>
</tbody>
</table>

### Annual Consumption of Primary Non-Renewable Energy Sources

<table>
<thead>
<tr>
<th>Bmark Standard</th>
<th>Bmark Best</th>
<th>Design</th>
<th>Bmark Standard</th>
<th>Bmark Best</th>
<th>Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>MJ/m²</td>
<td>MJ/m²</td>
<td>MJ/m²</td>
<td>MJ/m²</td>
<td>MJ/m²</td>
<td>MJ/m²</td>
</tr>
<tr>
<td>Total primary non-renewable fuels used on-site and for generation of electricity, annual basis</td>
<td>2,683</td>
<td>2,146</td>
<td>1,839</td>
<td>24,530</td>
<td>19,624</td>
</tr>
</tbody>
</table>

### Total and Annualized Consumption of Primary Embodied Energy

<table>
<thead>
<tr>
<th>Bmark Standard</th>
<th>Bmark Best</th>
<th>Design</th>
<th>Bmark Standard</th>
<th>Bmark Best</th>
<th>Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>MJ/m²</td>
<td>MJ/m²</td>
<td>MJ/m²</td>
<td>MJ/m²</td>
<td>MJ/m²</td>
<td>MJ/m²</td>
</tr>
<tr>
<td>Primary embodied energy for above- and below-grade structure and building envelope, MJ/m²-year</td>
<td>13338</td>
<td>241570</td>
<td>17716</td>
<td>122</td>
<td>2209</td>
</tr>
<tr>
<td>Annualized primary embodied energy for above- and below-grade structure and building envelope, MJ/m²-year</td>
<td>3.9</td>
<td>70.0</td>
<td>5.1</td>
<td>35.3</td>
<td>640.0</td>
</tr>
</tbody>
</table>

### Annualized Consumption of Primary Embodied Energy plus Annual Primary Non-Renewable Operating Energy

<table>
<thead>
<tr>
<th>Bmark Standard</th>
<th>Bmark Best</th>
<th>Design</th>
<th>Bmark Standard</th>
<th>Bmark Best</th>
<th>Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>MJ/m²</td>
<td>MJ/m²</td>
<td>MJ/m²</td>
<td>MJ/m²</td>
<td>MJ/m²</td>
<td>MJ/m²</td>
</tr>
<tr>
<td>Annualized primary embodied energy for above- and below-grade structure and building envelope, plus annual primary non-renewable operating energy, MJ/m²-year</td>
<td>2,734</td>
<td>3,080</td>
<td>1,907</td>
<td>25,001</td>
<td>28,158</td>
</tr>
</tbody>
</table>
**GBTool Results worksheet**

**Environmental Sustainability Indicators**

<table>
<thead>
<tr>
<th>Selected Environmental Sustainability Indicators for the Design</th>
<th>per m² only</th>
<th>by area &amp; by occupancy</th>
</tr>
</thead>
<tbody>
<tr>
<td>ESI-1 Total net consumption of primary embodied energy, GJ</td>
<td>5.1</td>
<td>46.9 MJ/(m² yr) / (kaph/m²)</td>
</tr>
<tr>
<td>ESI-2 Net annualized consumption of primary embodied energy, MJ</td>
<td>68</td>
<td>626 MJ/(m² yr) / (kaph/m²)</td>
</tr>
<tr>
<td>ESI-3 Net annual consumption of primary energy for building operations, MJ</td>
<td>1894</td>
<td>17317 MJ/(m² yr) / (kaph/m²)</td>
</tr>
<tr>
<td>ESI-4 Net annual consumption of primary non-renewable energy for building operations, MJ</td>
<td>1839</td>
<td>16812 MJ/(m² yr) / (kaph/m²)</td>
</tr>
<tr>
<td>ESI-5 Net annualized primary embodied energy and annual operating primary energy, MJ</td>
<td>1907</td>
<td>17438 MJ/(m² yr) / (kaph/m²)</td>
</tr>
<tr>
<td>ESI-6 Net area of land consumed for building and related works, m²</td>
<td>4.6</td>
<td>147.8 m² / occupant</td>
</tr>
<tr>
<td>ESI-7 Net annual consumption of potable water for building operations, m³</td>
<td>113</td>
<td>110 m³ / (apsh/m²) * yr</td>
</tr>
<tr>
<td>ESI-8 Annual use of grey water and rainwater for building operations, m³</td>
<td>8</td>
<td>7 m³ / (apsh/m²) * yr</td>
</tr>
</tbody>
</table>
| ESI-9 Net annual GHG emissions from building operations, kg CO₂ equivalent | 156 | 1429 Kg CO₂/m² /
| ESI-10 Predicted CFC-11 equivalent leakage per year in gm. | 0.050681 | 0.463403 gm CFC-11 equiv / m² /
| ESI-11 Total weight of materials re-used in Design from on-site or off-site uses, kg. | 0 | 0 Kg / (apsh/m²) * yr |
| ESI-12 Total weight of new materials used in Design from off-site uses, kg. | 469 | 4292 Kg / (apsh/m²) * yr |

**Total and Performance Issues**

- **Total Score for Resources, Loadings and IEQ**
  - 2.3

- **Bar chart showing scores**:
  - Resources: 3.3
  - Loadings: 2.7
  - IEQ: 0.9
  - Service Quality: 2.1
  - Economics: 3.3
  - Management: 2.0
  - Transport: 0.0
Levels of Performance for Design at Category Levels

**Resource Consumption**

- Energy: 4.9
- Land: 2.0
- Water: 4.6
- Building reuse: 0.0
- New materials: 0.0

**Environmental Loadings**

- GHG: 4.9
- ODS: 2.8
- Acidification: 0.9
- Solid waste: 1.2
- Effluent: 1.9
- Site impacts: 4.3
**Indoor Environment Quality**

![Indoor Environment Quality Chart]

**Service Quality**

![Service Quality Chart]

**Economics and Pre-operations Management**

![Economics and Pre-operations Management Chart]
Appendix 1 Summary of Embodied Energy Assessment of Case Studies

The table below provides a brief overview of our assessment results to-date for the three Canadian projects. I am providing these results at this juncture in an effort not to be the bottleneck in the assessment process.

Alex also asked me to think about and make a recommendation concerning the assessment scoring for embodied energy and greenhouse gases for use by the assessment team in their deliberations. Essentially, it is impossible to come up with the “Best Design” embodied energy and greenhouses gas for all buildings, because each project building situation poses its own unique objectives and constraints. In the spirit of the Green Building Challenge, however, I have taken the approach of comparing the three building’s embodied energy results in an effort to arrive at a “Best Design” value for embodied effects. Here is my logic, for what it is worth….

1. Keeping in mind that the minimum embodied energy doesn’t necessarily mean the best design – that is, a higher embodied energy may mean a better overall performing structure and envelope, which can translate into a higher operating energy efficiency. In the case of the three GBC buildings, only the Mayo School actually incorporated a higher performing envelope, the other two projects rely more on technology oriented improvements to lower operating energy effects. Further the Mayo School project uses a wood frame (a lower embodied energy frame compared to steel and concrete alternatives), it also substituted cellulose for fiberglass insulation (again employing a lower embodied energy product), which has about the same R-value per inch as fiberglass.

2. A longer building life suggests greater durability and perhaps, improved flexibility in use over the projected life of the building. All three GBC projects have a similar life expectancy and mixed-use design element so no real indication of which is better is readily evident.

While each project has its particular merits, overall I believe the Mayo school incorporates and demonstrates a better design philosophy for maximizing the embodied effect trade-offs across material choice and the prevailing design constraints. Hence the Mayo school’s actual design Primary Energy and GWP should be the “Best design” values for inclusion in the Technical worksheet portion of the GBTool.

<table>
<thead>
<tr>
<th>GBC Project</th>
<th>Benchmark Design</th>
<th>Actual Design</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Primary</td>
<td>GWP</td>
</tr>
<tr>
<td></td>
<td>Primary</td>
<td>GWP</td>
</tr>
</tbody>
</table>
Appendix 1 – Summary of Embodied Energy Assessment of Case Studies

<table>
<thead>
<tr>
<th></th>
<th>Embodied Energy Gj/m²</th>
<th>kg/m²</th>
<th>Embodied Energy Gj/m²</th>
<th>kg/m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mayo School</td>
<td>2.45</td>
<td>129</td>
<td>2.74</td>
<td>134</td>
</tr>
<tr>
<td>JT Winery</td>
<td>4.02</td>
<td>242</td>
<td>7.16</td>
<td>381</td>
</tr>
<tr>
<td>RRC</td>
<td>3.47</td>
<td>130</td>
<td>3.88</td>
<td>142</td>
</tr>
</tbody>
</table>

Notes:
- GWP is global warming potential (greenhouse gases) on an equivalent CO2 basis.
- JT Winery difference attributed to benchmark design having only a 40 yr life vs. an 80 yr life for the actual design. Results for the actual design on a 40 yr life are 5.34 Gj/m² and 301kg/m².
- Red River College emphasized numerous reuse elements in their design and should be congratulated for these efforts. The higher design results really reflect the fact that RRC represents a four building complex with an atrium suspended between them relative to a single building benchmark providing the same functional area. That is, the surface area for the actual design is almost 4 times that of the single benchmark building and only the significant reuse elements of the actual design made the comparison close.

The following Table contrasts life cycle embodied and operating primary energy effects across the three project buildings and their respective benchmarks. Generally, embodied energy as a percent of total life cycle energy is higher for the actual designs than their respective benchmarks and varies between 1 and 13%. The arbitrarily long life of the buildings studied tended to skew the results towards operating energy being the more significant contributor to total life cycle energy. And while operating energy would likely be the major contributor to life cycle energy use in any case, a shorter life cycle would tend to shift more importance to embodied energy considerations.

### Primary Embodied to Primary Operating Energy Ratio Table

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mayo Bnmark</td>
<td>7883</td>
<td>5486</td>
<td>1.4 yrs</td>
<td>80</td>
<td>2%</td>
</tr>
<tr>
<td>Mayo Actual</td>
<td>8816</td>
<td>759</td>
<td>11.6 yrs</td>
<td>80</td>
<td>13%</td>
</tr>
<tr>
<td>RRC</td>
<td>69666</td>
<td>29747</td>
<td>2.3 yrs</td>
<td>75</td>
<td>3%</td>
</tr>
</tbody>
</table>
In fact it is apparent that three parameters drive this ratio – building type, location and how the electricity used by the building is generated. Obviously, building type plays a significant role in determining overall embodied and operating effects – who or what is the building used for, to what extent is comfort a consideration, what is its envelope surface area to floor space ratio, etc… A buildings location; i.e., its proximity to manufactured materials and products as well as fuels can greatly effect the outcome of the embodied energy side of the ratio. Similarly, a very cold or very warm climate location will greatly affect operating energy demand. The electricity generation method also plays a role in both the embodied and operating energy results, but the longer the building life the more significant will the electricity generation effect be on operating energy. For example, both the Mayo School and the Winery projects came up with operating energy scenarios for the actual buildings which reduced their immediate fossil fuel (space heating) requirements but increased their electricity demand, relative to their benchmark simulations. For the Mayo school the fuel switching in favour of electricity made sense, given that the electricity in the Yukon is almost all hydro based and doesn’t increase primary energy. In the case of the Winery project, however, the greater use of electricity didn’t have the same effect because Ontario’s electricity grid is considerably more dependent on nuclear and hydrocarbon fossil fuels, which tend to increase not only primary energy but greenhouse gas releases as well. In all the primary operating energy for the Winery project was the smallest of the three projects studied.

<table>
<thead>
<tr>
<th>Bnmark</th>
<th>RRC Actual</th>
<th>JTW Bnmark</th>
<th>JTW Actual</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>89053</td>
<td>13338</td>
<td>17718</td>
</tr>
<tr>
<td></td>
<td>14011</td>
<td>14398</td>
<td>14488</td>
</tr>
<tr>
<td></td>
<td>6.4 yrs</td>
<td>11 months</td>
<td>1.2 yrs</td>
</tr>
<tr>
<td></td>
<td>75</td>
<td>75</td>
<td>75</td>
</tr>
<tr>
<td></td>
<td>8%</td>
<td>1%</td>
<td>2%</td>
</tr>
</tbody>
</table>