InLCA: Selected Papers

Using BEES to Select Cost-Effective Green Products *

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Abstract. The BEES (**B**uilding for **E**nvironmental and **E**conomic **S**ustainability) software brings to your fingertips a powerful technique for balancing the environmental and economic performance of building products. The tool is based on consensus standards and designed to be practical, flexible, and transparent. Version 2.0 of the Windows™-based decision support software, aimed at designers, builders, and product manufacturers, includes actual environmental and economic performance data for 65 building products. The purpose is to support purchasing decisions by providing key science-based information often lacking in 'green' product selection. The intended result is a cost-effective reduction in building-related contributions to environmental problems.

Keywords: BEES; building for environmental and economic sustainability (BEES); building product performance; environmentally preferable purchasing; environmental decision support software; green buildings; InLCA; LCA; Life Cycle Assessment (LCA); life-cycle costing; measuring economic performance; measuring environmental performance; multiattribute decision analysis; software products; sustainable development

1 Introduction

How do *you* select environmentally preferable products? Designers and builders are increasingly asked to address the issue of 'green' building materials. Is a product environmentally preferable if it has recycled content? Is it not preferable if it offgasses during use? Are mainstream products always less preferable than products marketed and perceived as 'environmentally friendly'? Do environmentally preferable products always cost more? The BEES software says, 'not necessarily'.

A new version of the BEES software is now available for downloading at no charge (www.bfrl.nist.gov/oae/bees.html) [1]. BEES (**B**uilding for **E**nvironmental and **E**conomic **S**ustainability) brings to your fingertips a powerful technique for selecting cost-effective, 'green' building products. The tool is based on consensus standards and designed to be practical, flexible, and transparent. Version 2.0 of the Windows™-based decision-support software – aimed at designers, builders, and product manufacturers – includes actual environmental and economic performance data for over 65 generic building products.

BEES is developed in the United States by the NIST (National Institute of Standards and Technology) Building and Fire Research Laboratory with support from the U.S. EPA Environmentally Preferable Purchasing (EPP) Program and the White House-sponsored Partnership for Advancing Technology in Housing (PATH). The EPP Program is charged with carrying out Executive Order 13101, 'Greening the Government Through Waste Prevention, Recycling, and Federal Acquisition', which encourages Executive agencies to reduce the environmental burdens associated with the $200 billion in products and services they buy each year, including building products. BEES is being further developed as a tool to assist the Federal procurement community in carrying out Executive Order 13101.

2 Methodology

BEES measures the environmental performance of building products using the internationally-standardized and science-based life-cycle assessment approach [2,3,4]. All stages in the life of a product are analyzed: raw material acquisition, manufacture, transportation, installation, use, and recycling and waste management. Up to ten environmental impacts are measured across these life-cycle stages: global warming, acid rain, resource depletion, indoor air quality, solid waste, eutrophication (the unwanted addition of mineral nutrients to the soil and water), ecological toxicity, human toxicity, ozone depletion, and smog. Due to its comprehensive, multi-dimensional scope, life-cycle assessment accounts for shifts of environmental problems from one life-cycle stage to another, or one environmental medium (land, air, or water) to another. The approach highlights the tradeoffs that must be made to genuinely reduce overall environmental impacts.

BEES measures economic performance using similar life-cycle thinking. Economic performance is measured using the ASTM standard life-cycle cost method, which covers the costs of initial investment, replacement, operation, maintenance and repair, and disposal [5]. The life-cycle cost method sums these costs over a fixed period of time, known as the study period. Alternative products for the same function, say floor covering, can then be compared on the basis of their life-cycle costs to determine which is the least-cost means of covering the floor over the study period.

To combine environmental and economic performance into an overall performance measure, BEES uses the ASTM standard for Multiattribute Decision Analysis [6]. The BEES user specifies the relative importance weights used to combine environmental and economic performance scores and may

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test the sensitivity of the overall scores to different sets of relative importance weights. Supporting data and computations are documented.

3 Case Example

So how can *you* use BEES to compare the environmental and economic performance of competing products? Let's run through an example. Suppose we're considering two floor coverings: (1) a broadloom nylon carpet installed using a conventional glue, a mainstream alternative, and (2) a broadloom carpet made from PET (recycled soft drink bottles) and installed using a low-VOC glue (a glue emitting relatively low levels of volatile organic compounds), a product promoted as an environmentally friendly alternative.

The first step is to set our analysis parameters using the BEES window shown in **Fig. 1**. If we do not wish to combine environmental and economic performance measures into a single score, we can select the 'No Weighting' option and still compute disaggregated BEES results. Otherwise, we need to set importance weights. In this example, environmental performance and economic performance are of equal importance so both are set to 50 %. Next, we need to set relative importance weights for the environmental impact categories included in the BEES environmental performance score. We select the 'Equal Weights' set, assigning equal importance to all impacts. Our last parameter is the real discount rate used to convert future building product costs to their equivalent present value. Here, we accept the default rate of 4.2 %, the rate mandated by the U.S. Office of Management and Budget for most Federal projects [7,8].

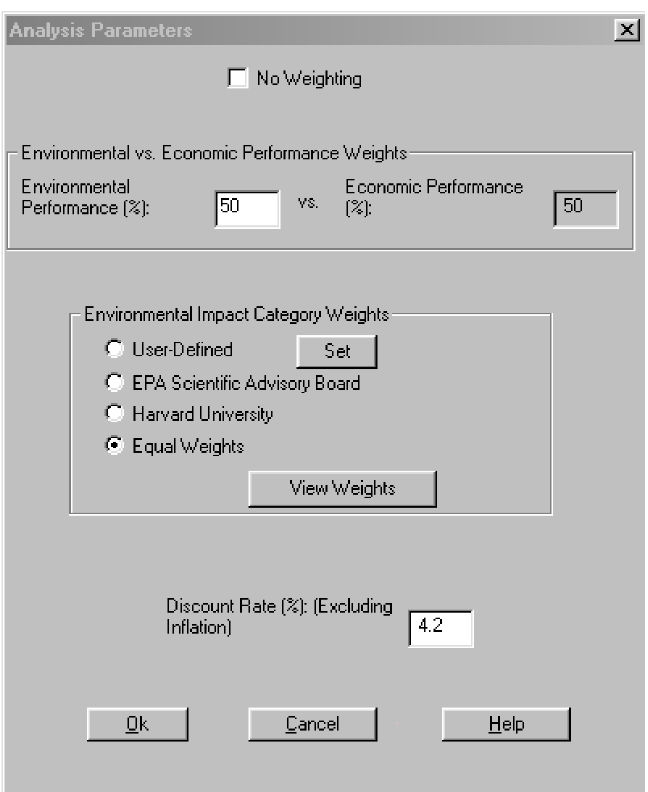


Fig. 1: Setting BEES analysis parameters

Next, we need to set one last parameter for each of our floor covering alternatives – the transportation distance from the manufacturing facility to the building in which the product will be installed. This parameter lets BEES compute an environmental performance score accounting for the significance of using locally-produced products. As illustrated in **Fig. 2**, we have selected a transportation distance of 805 km (500 mi) for our nylon carpet alternative.

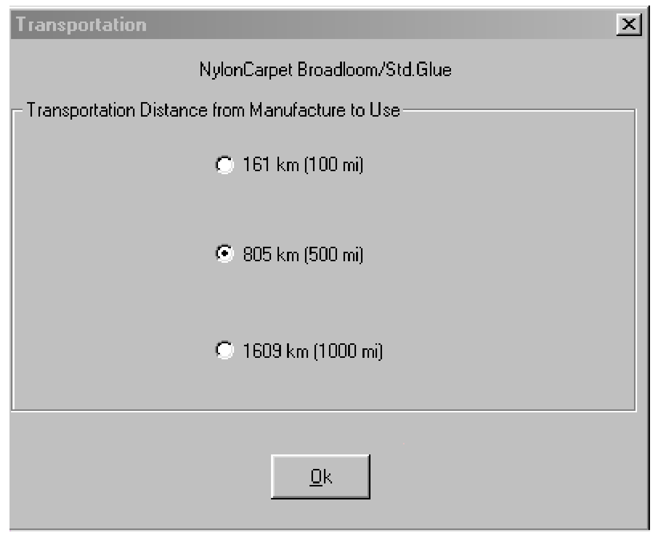
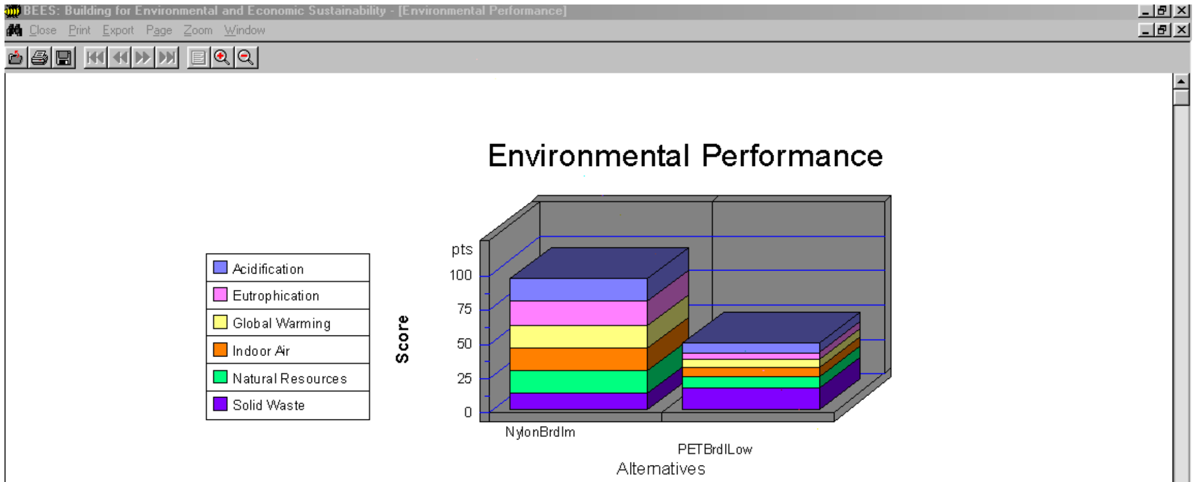


Fig. 2: Setting transportation parameters

Now we are ready to compute and view BEES results. **Fig. 3** shows the BEES Environmental Performance Results displaying the weighted environmental performance scores for our example in both graphical and tabular form. Lower values are better; if a product performs worse with respect to all environmental impacts, it receives the worst possible score of 100 points. In our example, the nylon broadloom carpet receives a total score of 96 points and the PET broadloom carpet a total score of 49 points. The figure breaks down the weighted environmental score by its six contributing, weighted scores for acidification, eutrophication, global warming, indoor air, natural resource depletion, and solid waste. As shown, PET carpet performs better on all impact categories except solid waste. Displayed on the table, next to each impact category, is its assigned relative importance weight.

Fig. 4 shows the BEES Economic Performance Results for our example, which gives first costs, discounted future costs, and their sum, the life-cycle cost. The figure shows that PET broadloom carpet has a higher life-cycle cost ($10.21 in present value dollars per 0.09 m^2 of installed carpet, or $10.21 per ft^2, compared with $4.57 for nylon), with both a higher first cost and higher future costs (due to a higher and more frequently-occurring replacement cost). Thus, based on our assigned discount rate of 4.2 % (displayed in the table next to the future cost category), PET broadloom carpet scores better environmentally, while nylon broadloom carpet scores better economically.

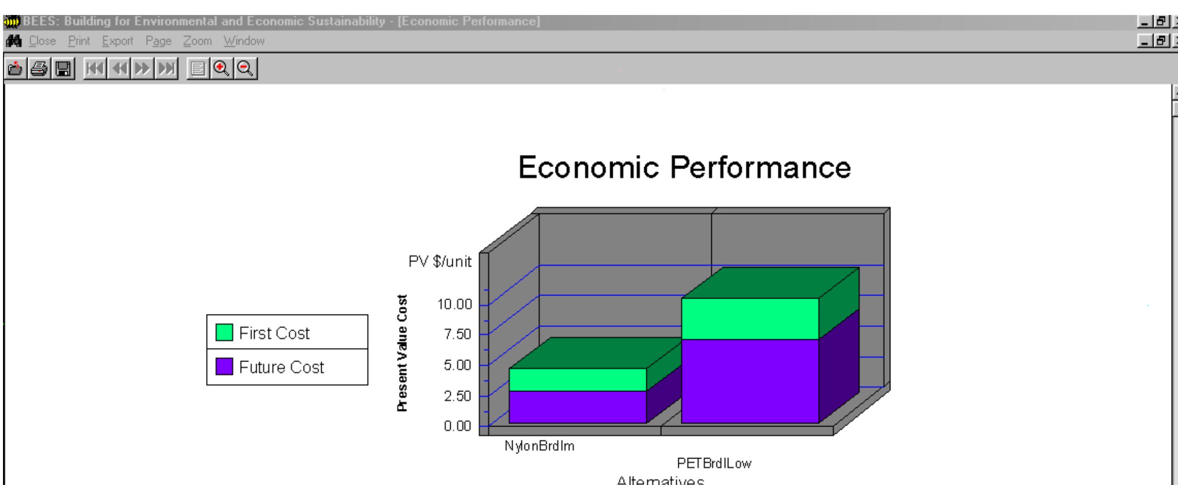
The overall performance score gives us a way to combine and balance the environmental and economic performance



Note: Lower values are better

Category	NylonBrdlm	PETBrdlLow
Acidification–17%	17	7
Eutrophication–17%	17	5
Global Warming–17%	17	6
Indoor Air–16%	16	7
Natural Resources--17%	17	8
Solid Waste–16%	12	16
Sum	96	49

Fig. 3: Viewing BEES environmental performance results



Category	NylonBrdlm	PETBrdlLow
First Cost	1.90	3.28
Future Cost– 4.2%	2.67	6.93
Sum	4.57	10.21

Fig. 4: Viewing BEES economic performance results

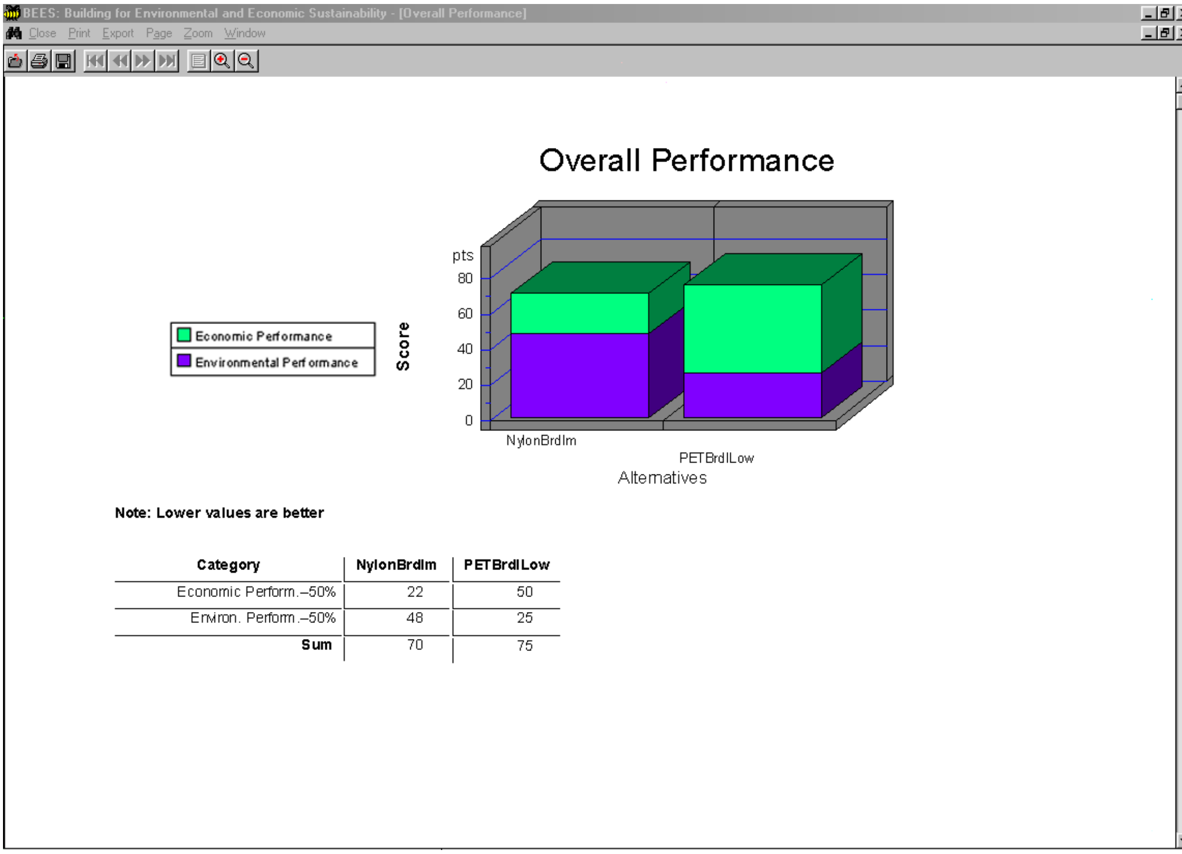


Fig. 5: Viewing BEES overall performance results

scores. **Fig. 5** shows the BEES Overall Performance Results based on our equal weighting of environmental and economic performance. It displays the overall performance score for each product alternative, which is the sum of its weighted environmental and economic performance scores. Displayed in the table, next to each performance category, is its assigned relative importance weight. We can see from this figure that nylon broadloom carpet receives a score of 70 points and PET broadloom carpet a score of 75 points. Thus, based on our analysis parameters, nylon broadloom carpet installed with conventional glue is slightly preferable overall to PET broadloom carpet installed with low-VOC glue. Note that besides the summary graphs shown here, BEES also offers detailed graphs for each environmental impact (e.g., reporting grams of carbon dioxide each product contributes to the global warming impact), which help pinpoint the 'weak links' in a product's environmental life cycle.

4 Conclusion and Future Outlook

Applying the BEES approach to the scores of other products included in BEES 2.0 (including framing, exterior and interior wall finishes, wall and roof sheathing, ceiling and wall insulation, roof and floor coverings, slabs, basement walls, beams, columns, parking lot paving and driveways) leads to several general conclusions. First, environmental claims based on single impacts, such as reduced global warming alone, should be viewed with skepticism. These claims do not account for the fact that one impact may have been improved at the expense of others. Second, assessments must always be quantified on a *functional unit* basis as they are in BEES, so that the products being compared are true substitutes for one another. One roof covering product may be environmentally superior to another on a kilogram-for-kilogram basis, but if that product requires twice the mass as the other to cover one square meter of roof, the results may reverse. Third, a product may contain a high-impact constituent, but if that constituent is a small portion of an otherwise relatively benign product, its significance decreases dramatically. Finally, a short-lived, low first-cost product is often not the cost-effective alternative. A higher first cost may be justified many times over for a durable, maintenance-free product. In sum, the answers lie in the tradeoffs.

BEES will be expanded and refined over the next several years. First, many more products will be added to the system so that entire building components and systems can be compared. To that end, manufacturers are encouraged to submit brand-specific performance data through the new *BEES Please* program (contact: blippiatt@nist.gov). Second, more environmental impacts, such as habitat alteration, are under development for incorporation into future versions of BEES. Finally, U.S. region specificity and greater flexibility in product specifications (e.g., useful lives) are being incorporated. The intended result is a cost-effective reduction in building-related contributions to environmental problems.

References

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Note Added in Proof

Who is Using BEES?

Since it was published in June 2000, over 3600 individuals from 60 countries have requested copies of BEES 2.0. The table below shows the distribution of these users by business type. Designers represent the largest interest group, followed by construction professionals. Individuals representing consulting, education, other (e.g., industry association), research, government, manufacturing, and military interests round out the BEES 2.0 user group.

BEES 2.0 Users		
Business Type	**Number**	**%**
Design	849	23%
Construction	567	15%
Consulting	419	11%
Education	375	10%
Other	378	10%
Research	312	8%
State/Local Gov't	273	7%
Federal Gov't	259	7%
Manufacturing	215	6%
Military	36	1%
Total	**3683**	**100%**