



the **gaia** project
realistic environmentalism

Project Guide: Calculating Savings

The Gaia Project

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Calculating Savings

A guide to calculating savings, performing cost / benefit analyses and calculating payback periods to be applied to projects in your classroom.

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The Gaia Project is a charitable organization dedicated to providing project based learning opportunities in the areas of energy, environment and sustainable engineering.

We develop projects, provide professional development, technical support and ongoing project support for teachers and students. Our projects aim to incorporate three key principles, which symbolise our focus on realistic environmentalism.

1. **Data Informed Decisions** – We want students to be able to explain why, and quantify the effect of each decision they made along the way to their final solution.
2. **Economic Assessments** – We expect students to be able to assess the cost effectiveness of their solutions, and be able to optimize their projects with limited budgets.
3. **Environmental Impact and Lifecycle Assessments** – We need students to take a holistic view to their projects. This means looking at their projects from cradle to grave, as opposed to just examining the use phase, and acknowledging that greenhouse gas reduction is not the only environmental issue at stake.

For more information, please visit www.thegaiaproject.ca

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Introduction

While there is an environmental benefit to reducing energy consumption, we live in a world that is focused on economics. For this reason, for the time being, we still need to justify environmental action by the amount of money that it will save the bill payer.

For behavioural changes, people want to see that that by changing their actions there is actually a significant benefit.

For structural changes, people want to see that by spending some money up front to save energy, they will actually save money in the long run.

This document will cover how to calculate savings and perform a cost/benefit analysis.

While the financial aspect is still the most important influence for decision makers, we'll also cover the environmental savings.

Calculating Savings

Before and After

The most important thing to remember when calculating savings is that for every change made, we need to have a **'Before'** scenario and an **'After'** scenario. We can't calculate how much is saved by only looking at the result. Instead:

$$\text{Amount Saved} = \text{Amount Used Before} - \text{Amount Used After}$$

$$\text{Cost Saving} = \text{Cost Before} - \text{Cost After}$$

The first step in a sustainability plan is

establishing the baseline inventory, which covers the amounts currently being used or produced. This inventory can be updated using the exact same methods every time a change is made.

Example: Energy Savings

For example, if after completing the inventory we implement a policy that has custodial staff turn off all of the computers at 5pm, we can then reanalyze the energy use of the computers using the same methods, and determine if any energy has been saved.

Suppose Table 1 [see end of document] is from the original energy inventory, and suppose Table 2 [see end of document] is the energy inventory after the above policy was implemented.

Adding up the last column, we can see that the four computers used 5.80kWh in the original energy inventory, and only 3.67kWh after the change was made.

$$\text{Energy Saved} = 5.80 \frac{\text{kWh}}{\text{day}} - 3.67 \frac{\text{kWh}}{\text{day}} = 2.13 \frac{\text{kWh}}{\text{day}}$$

$$\text{Energy Saved} = \text{Energy Used Before} - \text{Energy Used After}$$

We can change this to whatever time period we want, such as a year. This might be by multiplying by 365 days if we think that these savings occur every day, but it might also be by multiply by 195 days if we think that these savings will only occur on days when school is in session.

$$\text{Energy Saved} = 2.13 \frac{\text{kWh}}{\text{day}} \times 195 \frac{\text{days}}{\text{year}} = 415 \frac{\text{kWh}}{\text{year}}$$

Example: Cost Savings

Once we know energy savings, calculating cost

savings is straightforward. We can simply use the rate at which we are billed for energy. For electricity this is roughly around \$0.10 / kWh for schools in New Brunswick.

$$\text{Cost Saving} = 415 \frac{\text{kWh}}{\text{year}} \times 0.095 \frac{\$}{\text{kWh}} = \$39.43$$

So by turning these four computers off at night instead of leaving them in standby mode, we can save almost \$50 per year.

Example: Carbon Dioxide Savings

Once we know energy savings, calculating the amount of carbon dioxide that was saved from being emitted to the atmosphere is also straightforward. Different sources of energy have different carbon dioxide emissions factors.

- **Heating Oil:** 235 g of carbon dioxide / kWh
- **Natural Gas:** 194g of carbon dioxide / kWh
- **Electricity:** 500g of carbon dioxide / kWh (this is the New Brunswick average for all the generating stations combined)

So in this case, where we have saved:

$$\text{Carbon Dioxide Saved} = 415 \frac{\text{kWh}}{\text{year}} \times 0.5 \frac{\text{kg}}{\text{kWh}}$$

Carbon Dioxide Saved = 207.5 kg of carbon dioxide

from only four computers.

Cost/Benefit Analysis

Calculating savings for behavioural changes is pretty straightforward – it's a little more

complicated when we need to spend some money in order to save energy. For example, if you have to spend \$100 up front to save \$100 a year, most people would probably think that is a reasonable investment. What if it was \$1,000 up front, or even \$10,000?

A cost/benefit analysis helps in making that decision, by showing how much of a benefit we can gain from the initial cost, and determining the number of years required to pay back on the initial investment.

Suppose there is a device that costs \$100, has an expected lifetime of five years, and can save us \$35 a year in energy (as calculated above).

We can construct a simple spreadsheet showing year-by-year the costs and the savings. In Table 3 [see end of document] we can see that the cost of \$100 is only applicable in the first year (2010), while the saving of \$35 is applied for each of the five years that we expect the energy saving device to last.

So, although in 2010 we are actually going to lose \$65, we will save \$35 for each of the next four years. The result is that over the five year period, we will have saved \$75 after accounting for the initial cost. We can also see that in the last row (Cumulative Cost/Saving) that the energy saving device pays back on its original investment sometime year three (2012).

In this case, the energy saving device provides a positive return on investment, since we save more money than the original cost. If the energy saving device had instead cost \$200, then we would have the table shown in Table 4 [see end of document], where we can see that over the five year period we would actually have lost \$25.

Net Present Value

The above scenario is a very simple cost/benefit analysis, and can be useful for simple cases; however, it falls short in one crucial area – we don't value money consistently over time.

This method is fairly advanced and should only be used where students are very comfortable with the basic concepts first.

Discount Rate

Generally, we consider that a sum of money is more valuable today than the same sum of money in the future. So \$10 today is more valuable and useful to you than \$10 ten years from now.

We call the rate at which we devalue money in the future the **Discount Rate**. There is no fixed discount rate – it's different for everyone depending on their specific situation. You can quickly determine your discount rate though by going through the following exercise.

If I were to offer you \$10 today, or a sum of money a year from now, what would the sum of money need to be for you to wait a year?

For example, if the sum a year from now was \$10.01, then you would probably take the \$10 today; however, if it was \$1000 a year from now, you would probably wait. There is a number at which you would switch from taking it today to waiting until next year. Let's say it's \$12.

$$\text{Discount Rate} = \frac{\$12}{\$10} - 1 = 0.2 = 20\%$$

So if that transition point was at \$12, then your discount rate would be 20%. Money today is worth 20% more than it is a year from now to you.

In general, most businesses will operate with a discount rate around 10%. This becomes very important when doing a cost/benefit analysis, because future savings aren't worth as much as the initial investment.

Net Present Value

We use the term **Net Present Value (NPV)** to determine what a future sum of money is worth today at a given discount rate. We can calculate it using the following formula:

$$\text{NPV} = \frac{\text{Future Sum of Money}}{(1 + \text{Discount Rate})^{\text{Number of Years in Future}}}$$

So if I had a discount rate of 10%, and someone offered me \$200 in five years, it would have a Net Present Value of:

$$\text{NPV} = \frac{\$200}{(1 + 0.1)^5} = \frac{\$200}{1.1^5} = \frac{\$200}{1.61} = \$124.18$$

Using NPV and Discount Rates in Cost/Benefit Analyses

Using the same energy saving device that cost \$100 example that we used previously, we can modify the table to the one shown in Table 5 [see end of document]. We can see that instead of the savings being worth \$35 a year, they steadily decrease from \$35 to \$23.91 by the fifth year.

So instead of cumulatively saving \$75, we actually only save \$45.95 over the five year period. Also instead of the payback period being in the third year, it has now shifted to the fourth year.

Using NPV and Discount Rates will generally weaken the case for making investments in energy saving infrastructure, but it is a much

more realistic analysis reflecting the fact that companies and organizations value money more highly today than they do in the future.

Glossary

Discount Rate

Rate at which devalued over time

Net Present Value

Used to determine what a future sum of money is worth today at a given discount rate.

Useful Values

Heating Oil

235 g of carbon dioxide / kWh

Natural Gas

194g of carbon dioxide / kWh

Electricity

500g of carbon dioxide / kWh (this is the New Brunswick average for all the generating stations combined)

Gasoline

248g of carbon dioxide / kWh

Diesel

252g of carbon dioxide / kWh

Table 1: Original Energy Inventory

Room	Device	Number	Mode	Average Power (Watts)	Time Used per Day (hours)	Energy Used per Day (Wh)	Energy Used per Day (kWh)
Classroom 1	Computer (HP1234)	4	Working	150	3	1,800	1.80
			Idle	80	4	1,280	1.28
			Standby	40	17	2,720	2.72
			Off	2	0	0	0.00

Table 2: Updated Energy Inventory

Room	Device	Number	Mode	Average Power (Watts)	Time Used per Day (hours)	Energy Used per Day (Wh)	Energy Used per Day (kWh)
Classroom 1	Computer (HP1234)	4	Working	150	3	1,800	1.80
			Idle	80	4	1,280	1.28
			Standby	40	3	480	0.48
			Off	2	14	112	0.11

Table 3: Saving \$75 over the life of a product

Year	2010	2011	2012	2013	2014	Total
Cost	-\$100					-\$100
Saving	\$35	\$35	\$35	\$35	\$35	\$175
Annual Cost / Saving	-\$65	\$35	\$35	\$35	\$35	\$75
Cumulative Cost / Saving	-\$65	-\$30	\$5	\$40	\$75	\$75

Table 4: Losing \$25 over the life of a product due to a higher upfront cost

Year	2010	2011	2012	2013	2014	Total
Cost	-\$200					-\$200
Saving	\$35	\$35	\$35	\$35	\$35	\$175
Annual Cost / Saving	-\$165	\$35	\$35	\$35	\$35	-\$25
Cumulative Cost / Saving	-\$165	-\$130	-\$95	-\$60	-\$25	-\$25

Table 5: Introducing Net Present Value and Discount Rates

Year	2010	2011	2012	2013	2014	Total
Cost	-\$100					-\$100
Saving	\$35	\$35	\$35	\$35	\$35	\$175
Discount Rate	10%					
Net Present Value of Cost	-\$100.0					
Net Present Value of Saving	\$35.00	\$31.82	\$28.93	\$26.30	\$23.91	\$145.95
Annual Cost / Saving	-\$65.00	\$31.82	\$28.93	\$26.30	\$23.91	\$45.95
Cumulative Cost / Saving	-\$65.00	-\$33.18	-\$4.26	\$22.04	\$45.95	\$45.95