the gaia project
realistic environmentalism

Project Guide: Transportation Audit

The Gaia Project
53 Shore Street
Fredericton, NB
E3B 1R3

1 (877) 442-4136
www.thegaiaproject.ca
contact@thegaiaproject.ca

Transportation Audit

A guide to delivering a transportation auditing and reduction project in your classroom

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

The Gaia Project
53 Shore Street
Fredericton, NB
E3B 1R3
Canada
1 (877) 442-4136
contact@thegaiaproject.ca

This project guide has been produced with the support of:

- New Brunswick Department of Environment
- The McCain Foundation
- Irving Oil
- The R. Howard Webster Foundation
- Dillon Consulting
- Airfire Telephone and Data
- Stantec
- TD Waterhouse

Front Cover Credits
Wheelie Bins—Caledonia Lane photo by Rupert Ganzer under a Creative Commons BY-ND 2.0 Licence

Transportation Audit

We all use some method of transportation to arrive at our daily destinations, whether that be walking, driving, cycling or taking public transportation. We all know that driving produces greenhouse gas emissions, but often we still drive because it's the most convenient option available to us, especially on a busy schedule. In many communities, public transportation, aside from school buses, may not exist and carpooling might be difficult.

Discussing with your class

Ask students how each of them arrived at school that morning. Is that how they always arrive? Where do they go after school? How do they get there? Have a student do a quick survey of how many people take the bus, walk, drive or cycle.

The aim of the transportation audit is to produce an inventory of the current transportation methods to and from your site, assess their environmental, economic and social impact, and find ways to reduce and measure those impacts.

This guide should always be used in conjunction with our Sustainability Plan guide, which provides the overarching framework for conducting this sort of inventory and improvement process. It is not necessary to complete the entire sustainability plan.

Essential Resources

Sustainability Plan: The Gaia Project
http://www.thegaiaproject.ca/projects/sustainability-planning

Additional Resources

Statistics Canada: Annual Canadian Vehicle Survey
http://www.statcan.gc.ca/bsolc/olc-cel/olc-cel?catno=53-223-X&CHROPG=1&lang=eng

Creating an Inventory

The first step in any managed reduction strategy is to find out where you are today. The most effective way to do this is to assemble an inventory of all the contributors, and set about measuring and/or estimating the impact of each one.

For transportation, this means vehicles and the amount of fuel being used to drive those vehicles.

The only way to measure the exact impact of transportation to and from a site over the course of a year would be to install each and every vehicle with a fuel consumption sensor, and collect the data for every trip for twelve months.

This, of course, is not a feasible option. Nor is it a good use of resources, since there are many strategies you can pursue that will provide fairly accurate results, for a fraction of the cost and minimizing the amount of time required.

Measuring the precise amount of fuel consumption either requires the previously mentioned sensor, or requires us to top up gas tanks after each journey to record the amount use. These methods are not practical, so instead we can use something that is much easier to measure—distance.

Fuel Efficiency

We can use vehicle **fuel efficiencies** which are available for all vehicle makes and models from Natural Resources Canada to convert distance into fuel consumption.

If a car has a fuel efficiency of 10 litres per 100km, that means it can drive 100km using 10 litres of gas. So a journey of 20km, will use approximately 2 litres of gas.

Three numbers are usually given in the Fuel Consumption Guide: highway, city/urban, and combined. Highway represents fuel efficiency while driving in **highway** conditions (fast, steady speed), while **city/urban** represents fuel efficiency under standard city driving conditions (slow, stopping and starting). The **combined** number is an average fuel efficiency that takes into account how much the average Canadian driver spends on highways and in cities.

Which value you use will depend on the trip you are analyzing. You may know the drive consisted primarily of city or highway driving, you may know that there was an 80/20 split between city and highway driving (in which case you can calculate your own fuel efficiency), or you may not know anything about the trip at all and have to use the combined value.

These values are also ideal values, meaning they come from perfectly tuned, brand new cars, being tested indoors at the speed limit under controlled conditions. It is unlikely that many cars actually meet the fuel efficiencies specified in the guide; however, as long as you use a consistent data source, the fuel efficiencies relative to each other are probably fairly close. So a result indicating a 20% saving in gas is probably accurate, even if the amount of gas used isn't exactly accurate.

The alternative would be to increase all of the numbers in the book by a fixed percentage to account for non-ideal conditions, adequately maintained vehicles. Some cars actually record their fuel efficiency, so you could compare these values to the design values.

Beware: driving style can greatly impact fuel efficiency. Someone who consistently drives 40km/h over the speed limit is likely to use considerably more fuel than the design value.

Essential Resources

Fuel Consumption Guide: Natural Resources Canada

http://oee.nrcan.gc.ca/transportation/tools/fuel-consumption-guide/fuel-consumption-guide.cfm

Year-by-year fuel efficiencies of all vehicles sold in Canada since 1995.

Fuel Types

So far we've talked about fuel as if there was only one type, but that isn't the case.

For most vehicles, there will be an option between gas and diesel. These are both derived from oil, but are different fuels. It's important to separate vehicles based on the fuel they use, because gas and diesel have different amounts of energy, release different amounts of emissions, and are priced differently.

Besides gas and diesel, you may find some other alternative fuel sources. Keep track of all of these different fuel types separately.

- **Biofuels**—on rare occasions, people may be producing their own fuels from organic plant matter
- **Electricity**—vehicles are beginning to hit the market that get their fuel from a traditional wall outlet. These may not release any emissions directly, but we must think about where the electricity comes from.
- **Natural Gas / Propane**—natural gas is used by some vehicles (particularly in Europe) as a cleaner source of fuel for vehicles.
- **Hydrogen** — rare in Canada, but some vehicles use hydrogen to drive the vehicle forward. These vehicles burn hydrogen which produces only water as an exhaust, but think about where the hydrogen comes from in the first place.
- **People—**not everyone drives a motorized vehicle. Some people actually walk, skateboard, or bike!

Distance Travelled

Individual Journeys

The most accurate estimate of fuel used at your site is going to come from inputting each individual journey to and from your site into your inventory.

This can be done by asking each driver how far they had just travelled to reach the site as they arrived, and how far they were going to drive as they left the site. The resulting table would look something like that shown in Table 1 [see end of document].

This is an incredibly time consuming process, and unrealistic to maintain on an ongoing basis. So while it may provide the most accurate results, we are probably going to have to look for solutions that make the process more efficient but do not sacrifice huge amounts of accuracy.

The following are some potential methods to do this. These are not the only methods, nor do they have be used independently. You may combine more than one of these approaches to best suit your needs.

Weekly basis

Instead of inventorying every single journey made by each car, we could record the values on a weekly basis. The resulting table would look identical to Table 1, except that the distances travelled would be per week instead of daily. You are likely to lose a little bit in accuracy, since people may not be as accurate with their driving distance estimates for the previous week compared to a daily survey

We could also create an inventory based on average weeks, in which drivers were asked about how many times they drive to the site each week and how far they drive. In that case, we could amend the table to look something like Table 2 [see end of document].

Average Distance

Instead of determining the distance driven by each driver individually, a survey could be conducted to find the average distance driven by all drivers. In that case, we could amend the table to look like Table 3 [see end of document], where all vehicles are assumed to have driven the same distance.

Grouping Vehicles

It may not be necessary to inventory every vehicle individually, but classify them according vehicles classified by year as the fuel efficiency can vary quite dramatically from year to year. Where this is not the case – for example when the fuel efficiency is the same over a number of years, or even relatively close – it is probably acceptable to group them.

Energy Use

Once the amount of fuel used has been calculated, it is a simple step to calculate the amount of energy used. Remember that diesel and gas have different energy contents, so this calculation has to be performed for each of the fuels.

The energy content of gas and diesel are:

- Gas: 34.8 MJ / L = 9.67 kWh / L
- Diesel: 38.6 MJ / L = 10.72 kWh / L

Using our inventory, we can now calculate the total amount of energy used in transportation to and from the site, as shown in Table 5 [see end of document]

Emissions

Once the amount of fuel used has been calculated, it is a simple step to calculate the amount of carbon dioxide that is emitted to atmosphere when burning that fuel. Remember that diesel and gas have different emission factors, so this calculation has to be performed for each of the fuels.

The carbon dioxide emission factor of gas and diesel are:

Gas: 2.4 kg of CO_2 / L
Diesel: 2.7 kg of CO_2 / L

Using our inventory, we can now calculate the total emissions released from transportation to and from the site, as shown in Table 6 [see end of document]

Implementing Improvements

Now that we have estimated the distance, energy use and emissions associated with travel to and from the site, we can start to identify some ways that we can reduce.

If we have audited transportation to and from the school, a major portion of this will likely come from buses. We can analyze each route to ensure that it is picking up the most students per run and look to see if there are alternate routes (perhaps with less traffic or to pick up more students per bus). This will be unique to each school, and will be hard to enact any changes.

However, we can look at implementing anti-idling policies at the school. This could be accomplished through signage or letter/e-mails to students and parents/guardians.

We can also encourage more people to walk or bike to school—perhaps no one bikes to school because there is nowhere to secure them on the premises. If this is the case, we could conduct a cost/benefit analysis for installing more bike racks at the school or by creating bike lanes.

Positive peer pressure can work to help implement improvements—you are less likely to drive a short distance to get to school if all of your friends are walking, biking or skateboarding to school. This could be made into a school wide challenge by having people track the distance they walk, bike or board to school.

Calculating Savings

Once you have implemented changes, you'll want to redo your transportation audit. Your Generally, it will still be important to keep

process should be identical to your first audit to ensure that the only changes are due to the changes you implemented.

To be able to calculate reductions, it is important to remember that you need to know what the situation was like before a change was made and after a change was made [see Table 7 at end of document].

The audit shown in Table 7 indicates that diesel use dropped 10%, gasoline use dropped 6%, and total fuel consumption dropped 7%.

Per Student

When comparing numbers from two different inventories, it may not be fair to compare the total amount of fuel used at the site directly. For example, a school could see an increase in enrolment from one year to the next, so more transportation may be required even though each student has reduced the amount of fuel they are responsible for,

For this reason, it can be useful to calculate the amount of fuel used per student for use as a comparison tool.

Glossary

Fuel Efficiency

The effectiveness of the vehicle at burning fuel to cover distance. Usually measured in L / 100km which represents the amount of fuel required to travel 100km, or in MPG in which we look at the distance the vehicle can travel on a single gallon of gas

Useful Values

Gasoline

Energy Content: 34.8 MJ / L = 9.67 kWh / L

Carbon Dioxide Emissions: 2.4 kg CO_2 / L

Diesel

Energy Content: 38.6 MJ / L = 10.72 kWh / L

Carbon Dioxide Emissions: 2.7 kg CO_2 / L

Table 1: Individual Journey Inventory

Make	Model	Year	Fuel	Fuel Efficiency (L / 100km)	Licence	Distance Travelled (km)	Fuel Used (L)
Toyota	Prius	2006	Gas	4.1	GOP 203	20	0.82
Volkswagen	Jetta TDI	2004	Diesel	5.4	GAA 123	10	0.54

Table 2: Creating Average Weeks

Make	Model	Year	Fuel	Fuel Efficiency (L / 100km)	Licence	Days per Week	Distance Each Way (km)	Distance per Week (km)	Fuel Used (L)
Toyota	Prius	2006	Gas	4.1	GOP 203	4	8	64	2.62
Volkswagen	Jetta TDI	2004	Diesel	5.4	GAA 123	5	6	60	3.24

Table 3: Using Average Driver Distance

Make	Model	Year	Fuel	Fuel Efficiency (L / 100km)	Licence	Distance Trav-elled (km)	Fuel Used (L)
Toyota	Prius	2006	Gas	4.1	GOP 203	15	0.62
Volkswagen	Jetta TDI	2004	Diesel	5.4	GAA 123	15	0.81

Table 4: Grouping Vehicles

Make	Model	Year	Num-ber	Fuel	Fuel Efficiency (L / 100km)	Licence	Distance Travelled (km)	Fuel Used (L)
Toyota	Prius	2006	3	Gas	4.1	GOP 203	20	2.46
Volkswagen	Jetta TDI	2004	2	Diesel	5.4	GAA 123	10	1.08

Table 5: Energy Use Associated with Fuel Use

Fuel	Fuel Used (L)	Energy in Fuel (MJ / L)	Energy Used (MJ)	Energy Used (kWh)
Diesel	800	34.8	27,840	7,733
Gas	4000	38.6	154,400	42,889
Total			182,240	50,622

Table 6: Carbon Dioxide Emissions Associated with Fuel Use

Fuel	Fuel Used (L)	Carbon Dioxide Emission Factor (kg / L)	Carbon Dioxide Emitted (kg)
Diesel	800	2.4	1,920
Gas	4,000	2.7	10,800
Total			12,720

Table 7: Calculating Savings Attained

Fuel	Fuel Used Before (L)	Energy Used Before (kWh)	Carbon Dioxide Emitted Before (kg)	Fuel Used After (L)	Energy Used After (kWh)	Carbon Dioxide Emitted After (kg)	Percentage Reduction
Diesel	800	7,733	1,920	720	6,960	1,728	10%
Gas	4000	42,889	10,800	3760	40,316	10,152	6%
Total		50,622	12,720		47,276	11,880	7%