Environmental Science and Technology
Secondary Cycle II Year II
(Course code: 558404)

Evaluation Task for Competency 2 & Competency 3:
ENVIRONMENTAL ENERGY IN CANADA

Administered on:
June 5th 2009
9am -12pm

Student Booklet

Background Information

1. What is the Greenhouse Effect

The Greenhouse effect is what makes our planet habitable. The Earth is surrounded by a cloud of gases approximately 560 km thick, which we call the atmosphere. These gases reflect one third of the solar radiation directed toward Earth. The remaining rays pass through the atmosphere and are absorbed by the Earth's surface. To balance the incoming energy, the Earth also radiates energy back to space. However, due to the temperature difference between the Earth and the Sun, the Earth's radiation, called thermal radiation, is different from solar radiation in that it cannot pass through the Earth's atmosphere. Thus the thermal rays bounce back toward the Earth surface, trapping the energy between the Earth's surface and the upper atmosphere. This phenomenon is called the Greenhouse effect, because the atmosphere acts like the glass wall of a greenhouse trapping the heat and warming the planet. Without the natural Greenhouse effect, the average temperature at the Earth's surface would be below the freezing point of water.

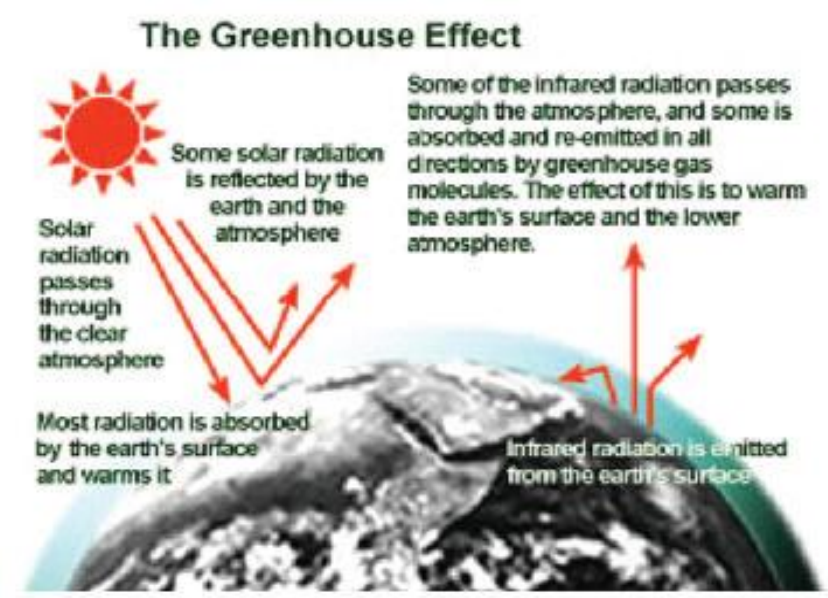


Figure 1: The greenhouse effect illustrated

Table 1:
Composition of the Atmosphere

Gas	Percentage
Nitrogen	78%
Oxygen	21%
Argon	1%
Ozone, methane, carbon dioxide & water vapour	Less than 1%

2. What is Global Warming?

Global warming refers to an average increase in the Earth's temperature, which in turn causes changes in climate. A warmer Earth may lead to changes in rainfall patterns, a rise in sea level, and a wide range of impacts on plants, wildlife, and humans. It is widely believed that the observed increase in the global temperature since the mid-1900s is very likely due to the observed increase in greenhouse gas concentrations, such as carbon dioxide or methane, resulting from human activities. By increasing the amount of these gases, humankind has enhanced the warming capability of the natural Greenhouse effect. Increasing temperatures will lead to changes in many aspects of weather, such as wind patterns, the amount and type of precipitation, and the types and frequency of severe weather events that may be expected to occur. Such climate change could have far-reaching and/or unpredictable environmental, social and economic consequences.

3. Canada's power

Canada generated 631 billion k•Wh of power in 2007, and has a high per capita use of this power, about 15,300 k•Wh/yr. In 2007, nuclear power contributed about 14.7% to this power, hydro power contributed 58% and fossil fuels contribute 23% (17% from coal and 6% from natural gas).

4. The combustion of fossil fuels

Coal, oil and gas are called "fossil fuels" because they have been formed from the organic remains of prehistoric plants and animals. Fossil fuels are made up of hydrogen and carbon. When fossil fuels are burned, the hydrocarbon (fuel) combines with oxygen to yield carbon dioxide, water and energy. The amount of carbon dioxide produced depends on the carbon content of the fuel; for example, for each unit of energy produced, natural gas emits about half and petroleum emits about three-quarters of the carbon dioxide produced by coal.

Table 2:
Energy Output by Fossil Fuels

Type of Fossil Fuel	Energy Content
Natural Gas CH_4	51.6 KJ per 1g
Petroleum/Crude Oil C_8H_{18}	43.6 KJ per 1g
Coal: A complex mixture of carbon, hydrocarbons, nitrogen and sulfur	39.3 KJ per 1g
Ethanol **(Biofuel)** C_2H_5OH	27.3 KJ per 1g

Fossil fuels are classified as a non-renewable energy. Renewable energies are energies whose source materials can be replaced within 50 years. Since fossil fuels are produced by the decomposition of fossilized plants and animals it is safe to say that this process takes more than 50 years.

5. Nuclear Energy

Changes can occur in the structure of the nuclei of atoms. These changes are called nuclear reactions. There is a substantial amount of energy created in a nuclear reaction, called nuclear energy or atomic energy. Nuclear energy is produced in two different ways; in the first, large nuclei are split to release energy (fission). In the second method, small nuclei are combined to release energy (fusion).

The “fuel” most widely used by nuclear plants is uranium (U-235) because its atoms are easily split apart. During the nuclear process a small particle, called a neutron, hits the uranium atom and splits it, releasing a great amount of energy as heat and radiation. More neutrons are also released. These neutrons go on to bombard other uranium atoms, and the process repeats itself over and over again. This process produces 2×10^{10} kJ/mol of energy.

As Uranium is a naturally-occurring ore it is non-renewable. It is composed of 3 major isotopes, U-238 (natural abundance 99.27%), U-235 (natural abundance 0.72%), and U-234 (natural abundance 0.01%)

6. Hydroelectricity

Most hydroelectric stations use either the natural drop of a river, such as a waterfall or rapids, or a dam is built across a river to raise the water level, to provide the drop needed to create a driving force. Water at the higher level is collected in the forebay. It flows through the station's intake into a pipe, called a penstock, which carries it down to a turbine. The turbine is a type of water wheel that is connected to a generator. As the water flows down the penstock the water pressure increases. It is this pressure and flow that causes the turbine to revolve, which in turn spins a generator. Inside the generator are large electromagnets attached to a rotor, which is located within a coil of copper wires. As the generator rotor spins the magnets, a flow of electrons is created in the coils of copper wire.

When hydroelectric reservoirs are created a flooding of land occurs. For example, the ***La Grande complex*** located in northern Quebec, on the James Bay territory, covers a 350,000 km^2 area, which is about eight times the size of Switzerland. It is one of the world's major hydroelectric developments with an annual output of some 81.2 billion k●Wh.

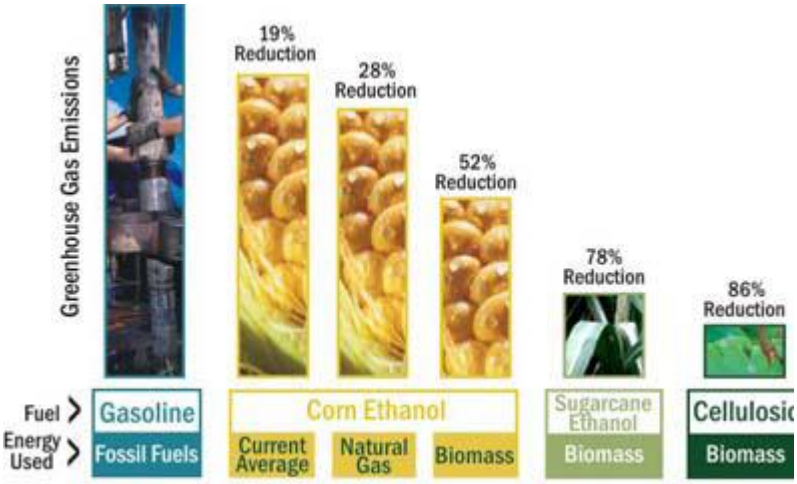
The creation of the reservoirs causes decomposition of a small fraction of the flooded biomass (forests, peatlands and other soil types) and an increase in the aquatic wildlife and vegetation in the reservoir. The result is higher Greenhouse gas (GHG) emissions, mainly CO_2 (carbon dioxide) and a small amount of CH_4 (methane). However, these emissions are temporary and peak two to four years after the reservoir is filled.

The flooding also leads to the conversion of mercury already present in plants and flooded soil, and its circulation in the aquatic environment. The result is an increase in fish mercury levels for a period ranging from 10 to 30 years, depending upon the fish species and reservoir characteristics.

7. Biofuels and Biomass Energy

Interest in biofuel production is growing. Biofuels (short for "biomass fuels") are liquid transportation fuels that substitute for petroleum products, such as gasoline or diesel. They include ethanol and biodiesel (a vegetable oil product) made from agricultural crops and residues, forest residues, or other kinds of plant-based "biomass feedstocks". When used appropriately in motor vehicles, biofuels have been shown to have a net positive effect in reducing harmful air emissions. Furthermore, biodiesel is biodegradable and has an absence of sulfur, which is present in trace amount in many fossil fuels.

Current global biofuel development, supported by governments around the world, is justified in part by the idea that biofuels are carbon-neutral—i.e., that they emit as much carbon dioxide as they absorb during plant growth, while emitting less carbon dioxide than comparable fossil fuels. One source claims that using 3.8 liters of biofuel instead of fossil fuels saves 9kg of CO_2 from being released into the atmosphere. This is a simplified perception that fails to take into account both the whole life-cycle of biofuels and carbon dioxide emissions due to land-use change. Well-managed biofuel production, incorporated into current agricultural production systems, can reduce Greenhouse gas emissions. However, if biofuel production encroaches on native vegetation, it is unlikely that even the most energy-efficient cropping system could offset the load of greenhouse gases emitted during the clearing of land. Land-use change, such as deforestation to provide more agricultural land also contributes significant CO_2 emissions. Biofuel activists, however, argue that in the future ethanol will be produced increasingly from cellulose found in crop residues (e.g., stalks, hulls), forestry residues (e.g., forest thinning, wood byproducts), energy crops (e.g., switchgrass), and sorted municipal wastes. Also, that some promising energy crops can grow on marginal soils *not suited* for traditional agriculture, thus not adding to their carbon footprint.



Source: Wang et al. *Environmental Research Letters*, Vol. 2, 024001, May 22, 200

Nitrogen also plays a role in accelerating global warming. Some of the fertilizer, in the form of nitrogen, will eventually be released into the atmosphere as nitrous oxide (N_2O), a Greenhouse gas 296 times more potent than CO_2. Excess nitrogen also has direct negative impacts on the biodiversity of terrestrial, marine and freshwater ecosystems.

Exam Questions

Question 1: Nuclear Energy

A) Briefly explain the concept of radioactivity. How is atomic structure linked to radioactivity & nuclear stability? How is radioactivity linked to the production of nuclear energy?
B) Explain which nuclear process, fission or fusion, is used in the production of nuclear energy using U-235?
C) Calculate the average atomic mass of uranium.

Question 2: Energy Choice

In your opinion, which source of energy production contributes the least to the ecological footprint of Canadians? Your answer should consider some of the following issues:

- ☐ Soil depletion
- ☐ Greenhouse gas contribution
- ☐ Water or soil contamination
- ☐ Geological timeline /Sustainability/ Biodegradation
- ☐ Ecological disturbances
- ☐ Biodiversity
- ☐ Amount of energy produced

Question 3: Carbon Dioxide Production

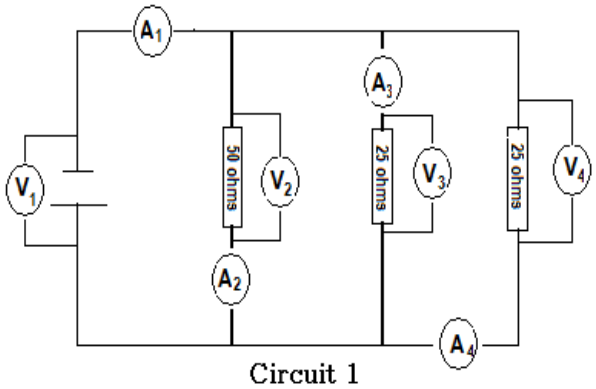
Describe quantitatively (in grams) how much more carbon dioxide is released by a Honda Civic, with a motor of 105 KW that travelled for 1 hour, that burns Petroleum than one that burns Bioethanol.

Hints:

- P•t =E (Joules)
- Table 2 provides the ratio to convert kJ to grams
- The chemical reactions are described in section 4: Combustion of fossil fuels
- Both chemical equations must be balanced before further calculations are made

Question 4: Energy and Power

Circuit 1 burned 5.0 kg of natural gas (see table 2) for 43 minutes in order to power the circuit. The reading on ammeter 1 is $1X10^2$ A. Circuit 2 was powered by 11.75 mg of uranium-235 (see nuclear energy) for 500 seconds and its power source has a potential difference 20 times greater than the potential difference of the power source of circuit 1. Find all the missing information. (**Hint:** P • t =E and P= I• V)



Circuit 1