The Science of Climate Change presentation notes

Slide #	Slide Text	Slide Notes
1	The Science of Climate Change	
2	Ontario EcoSchools Partners	
3	The Science of Climate Change	
4	Wake Up video clip	• We hear a lot in the media, schools etc. about environmental problems caused by human activities • Many people choose to ignore them – go about everyday life, don't see or believe how they might be affected; others are sounding the alarm, and doing what they can to steer us toward living in better harmony with earth

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5	Environmental problems interrelated	Climate change is one such environmental issue – often covered in media, ignored by many Environmental problems are all interrelated Climate change is connected to every other environmental issue in the news – habitat loss, pollution of air, water and land, overuse of natural resources, species extinction, garbage, dwindling water supplies. Presentation will provide overview of science behind climate change, and some of the impacts it is expected to have on the planet Also review some of the promising contributions science is making toward our ability to reduce the risks of climate change

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6	Earth's climate system	Review of climate system Earth's climate system includes 5 major interactive components: atmosphere (air), hydrosphere (water), cryosphere (ice/snow), land surface, biosphere (living things) • Climate determined by atmospheric circulation, and its' interaction with ocean currents, and land (albedo (albedo is the fraction of light that is reflected by the surface of the earth), vegetation, soil moisture): global distribution of heat & moisture • Overall earth's climate depends on factors that influence the balance of energy entering and leaving the atmosphere, such as the composition of the atmosphere, solar radiation, volcanic eruptions, etc. • Climate is influenced by external forcing mechanisms – the SUN is the most important

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7	The greenhouse effect	• The greenhouse effect is normal process within the climate system that helps regulate energy flow in and out of the system.
		• Gases of the atmosphere trap the sun's heat (infrared radiation) near the earth's surface – the greenhouse effect
		• Without greenhouse effect, earth too cold for many life forms – average 34°C colder.
		• Main greenhouse gases in the atmosphere:
		  • carbon dioxide (CO2),
		  • methane (CH4),
		  • nitrous oxide (N2O),
		  • and ozone (O3); also tiny particles in the earth's atmosphere (aerosols) and water or ice particles also trap radiation from the sun.

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8	Earth vs Venus	• Venus is a great extreme example of the greenhouse effect: • Compare Earth to Venus - very similar planets if you compare size, density and composition • Venus atmosphere is composed mostly of carbon dioxide. • several layers of clouds many kilometers thick composed of sulfuric acid – completely obstruct our view of the surface. • dense atmosphere produces run-away greenhouse effect that raises Venus' surface temperature by about 400 degrees to over 468 oC (hot enough to melt lead). • Venus thought to have once been covered in oceans, but these would have boiled away. • If the Earth had been a little closer to the sun, this may have happened to us!
9	Climate has always changed	• The earth's climate has changed many times in the past • Past million years, glacial and interglacial periods have alternated due to variations in the earth's orbit, solar radiation • Past 1000 years have been relatively stable • Natural climate changes can take place quite quickly
10	Energy Balance	• ***The balance of energy influences the climate of our planet***

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11	Climate global	Climate, in the context of "climate change" refers to the climate system of the earth as a whole, with all of its interactive components: • atmosphere (air), • hydrosphere (water), • cryosphere (ice/snow), • land surface, • biosphere (living things) Climate of earth on the whole is mostly determined by factors that affect the energy equilibrium of the planet.
12	Energy balance	• The sun provides the energy that drives the earth's climate system. • For a stable climate: need a balance between *incoming solar radiation,* and the *outgoing infrared (heat) radiation* emitted by the climate system.

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	Diagram link notes	• Of the incoming solar radiation, 49% (168 W/m2) is absorbed by the surface. • That heat is returned to the atmosphere as sensible heat, as evapo-transpiration (latent heat) and as thermal infrared radiation. Most of this radiation is absorbed by the atmosphere, which in turn emits radiation both up and down. • The radiation lost to space comes from cloud tops and atmospheric regions much colder than the surface. • Heat being absorbed by the atmosphere is trapped and as a results the average temperature of the planet increases. This is know as the greenhouse effect. • When the amount of energy coming into the system changes or the amount of energy leaving the systems changes there is a change in the energy balance which over time results in a climate change.

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13	Energy out of balance	• Changes in energy entering or leaving the earths system affect the energy balance of the plane's climate systems.
		• The climate system reacts to restore the energy equilibrium between its parts.
		• As the climate changes to achieve energy equilibrium the parts of the earths climate system react and change: atmosphere (air), hydrosphere (water), cryosphere (ice/snow), land surface, biosphere (living things)
		•
		• Different parts of the climate system react on different timescales, eg. Troposphere (layer of atmosphere close to the earth) comes into equilibrium within days or weeks, stratosphere takes a few months.
		  ○ Oceans take a long time to respond to imbalance, and influence the land.
		  ○ Biosphere can react quickly e.g. to drought

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14	The enhanced greenhouse effect	• Over the past 250 year the climate system has been re-balancing itself because of the enhanced greenhouse effect. • What is the enhanced greenhouse effect: • *Increased concentrations* of greenhouse gases are absorbing more infrared radiation (heat) than in past, and preventing the infrared – heat-energy from leaving the planet. • The atmosphere therefore contains more heat energy • The global climate system adjusts to *bring the energy into equilibrium across the system.*

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15	Global climate moving to equilibrium	Lets step back: • Globally what parts of the climate system have changed since the Industrial Revolution? • Scientists from all over the world have been studying climate change for several decades, and sharing their findings through the Intergovernmental Panel on Climate Change (IPCC) • The third IPCC report, released in 2001 concluded the earth's climate was changing because of human activities are affecting the energy balance of the climate system. • Over thirty Canadian scientists were involved in the writing and review of this major international work. Main IPCC scientific findings: • The global average surface temperature has increased over the 20th century by about .6°C (1°C in the Arctic) • Snow cover and ice extent have decreased in the northern hemisphere: mountain glaciers are retreating, Arctic sea ice thickness is declining and snow and ice cover have decreased. • global average sea level has risen and ocean heat content has increased: sea level has risen 10-20cm during the 20th century and ocean heat content has increased since the late 1950's

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16	Climate change human influence	How have people affected the balance of the climate system and enhanced the greenhouse effect. • 100 years before the industrial revolution started (around 1750), greenhouse gases remained relatively constant. The earths climate system was in equilibrium with a balanced energy system. • Since the Industrial Revolution, there has been and increased concentration of various greenhouse gases in the atmosphere • Sources include: • agriculture • industry • energy generation from burning fossil fuels (coal fired electricity generation) • transportation • CO2 has increased by more than 30% • CO2 still increasing by 0.4% per year _____ Click on the “graph icon” to see the changes in CO2 concentrations over the last 1000

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17	Carbon is crucial	*What has happened to create the enhanced greenhouse effect and change the climate systems balance?* • Carbon cycling throughout the parts of the climate system have changed the balance of energy within the system. _____ Carbon atom icon connects the next 3 slides.
18	Carbon key to recent climate change	• Humans are changing the carbon cycle, affecting the global climate
19	Carbon the building block of life	• Carbon is the basic building block of all living things • Our own bodies are made of carbon based molecules, as are those of other animals and plants. • A finite amount of carbon exists in the earth's systems. • Carbon is constantly cycled from one state to another through the atmosphere and biosphere.

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20	The carbon cycle balanced budget	• Carbon is constantly cycled from one state to another through the atmosphere and biosphere • The numbers on the diagram represent the amount of carbon stored in areas or transported by a particular process *(measured in billions of tons of carbon).* • Note: plant material store only 0.3 % of the carbon. • *Burning fossil fuels releases 6.3 billion tonnes* of carbon into the atmosphere each year. • CO2 is an important greenhouse gas, and component of the atmosphere.
21	Carbon sources	Natural sources of CO2 and other greenhouse gases: • Respiration - process whereby living things take in oxygen and release CO2 • Decomposition - major natural source of CO2 as well as methane (CH4) as well – another greenhouse gas • Forests can be sources of carbon and other greenhouse gases if burning, beset by disease or decomposing • Volcanoes release CO2 and water vapour when they erupt (small effect on climate change)

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22	Carbon sinks	Sinks *absorb* CO2 from the atmosphere: • Vegetation absorbs CO2 during the process of photosynthesis • Forests contain huge amounts of biomass • In temperate zones such as Canada, healthy growing forests sequester (hold) large amounts of CO2 • Other types of vegetation also fix CO2: algae, wetlands • Calcite formation (limestone) major C sink over geological time Oceans also a sink for CO2: • Complex biogeochemical process governed by ocean circulation and carbonate chemistry • When atmospheric CO2 concentration is increasing, partial pressure drives ocean to absorb more CO2 • CO2 uptake by oceans limited by rate of mixing between deep water and surface water, and this rate of mixing decreases as the oceans warm • Mixing process called *thermohaline circulation* – a giant ocean conveyor belt mixing warm surface water with saltier, cooler deep water – strongly influences climate

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23	Source - Sinks balance	• Sources and sinks of greenhouse gases have remained in balance. Generally what was released was absorbed. Very little increase in the amount CO2 in the atmosphere. • Natural changes to the earth's climate appear linked to fluctuations in earth's orbit or solar radiation • For thousands of years, the earth's atmosphere has changed very little. *Note that forests can naturally be both sources and sinks:* In Canada, fast growing young forests tend to be sinks, while older forests become sources as they start producing CO2 through forest fires and decomposition. _____ Click on the "diagram icon" to for a more detail explanation of the balance of carbon in the atmosphere and the biosphere.

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	Carbon cycle diagram link notes	• If you ignore the use of fossil fuels, the carbon released in the natural systems by vegetation and oceans (red) is approximately equal to the carbon taken up by photosynthesis and being dissolved in the oceans. • The net carbon entering the atmosphere is zero. • The numbers on the diagram represent the amount of carbon stored in areas or transported by a particular process (measured in billions of tons of carbon).
24	How do we know?	*How do we know all of this?* – scientists weren't around back then measuring CO2 • Thermometers came into use mid 19th century • Scientists reconstruct temperature based on information from other sources: ice cores, tree rings and sediment cores – not precise, but provide approximate trends • Ancient California bristlecone pines preserved in dry climate provide records 10,000 years old • Antarctic ice core samples go back 500,000 years, giving clues to temperature and CO2 levels from air bubbles trapped in ice

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25	Carbon sources human influence	• Carbon deposits from ancient buried organisms were transformed over millions of years into coal and oil. (these are known as fossil fuels) • Thus, huge carbon reserves were sequestered away in the earth's crust as fossil fuels. • Removing fossil fuels from earth's crust, and burning them, produces CO2 • CO2 is added to earth's atmosphere, increasing CO2 concentrations • Present concentrations around 379 ppm, an increase of 80 ppm (29%) since 1750 (beginning of the Industrial Revolution)

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26	Carbon sinks human influence	• Clearing forests – not only do trees take in CO2 but forest soils hold huge amounts of carbon • Disturbing forest soils and burning stumps release carbon to atmosphere; the carbon sinks become carbon sources • Destruction of wetlands and other green spaces removes these carbon sinks from the system • Wetlands are under stress from development - over time many wetlands have been converted to agricultural land • Now many in populated areas are drained / filled for industrial land, parking lots, housing developments • As the climate warms, so will the oceans. As they warm, they will absorb less CO2
27	Source - Sinks imbalance	• At the same time as we contribute to increasing CO2 sources, we are reducing the sinks which absorb CO2 • The enhanced green house effect traps more energy and the climate system changes to re-balance the system. _____ Click on the “diagram icon” to for a more detail explanation of the imbalance of carbon in the atmosphere and the biosphere.

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	Carbon cycle diagram link notes	• The natural system does not have the capacity to absorb the additional carbon produced by the burning of fossil fuels. • The natural systems that act as sinks (forest, wetlands) have been reduced through habitat destruction. • The numbers on the diagram represent the amount of carbon stored in areas or transported by a particular process (measured in billions of tons of carbon).
28	Source and sinks not all are equal	• Various carbon sources release carbon at different rates • Some sinks absorb carbon more quickly than others For detailed information about carbon and climate change go to: http://www.grida.no/climate/ipcc_tar/wg1/095.htm _____ Click on the “diagram icon” to for a more detail diagram about rates of carbon movement in the atmosphere and the biosphere.
	Diagram link notes	For more information about the carbon cycle visit IPPC website: http://www.grida.no/climate/ipcc_tar/wg1/095.htm

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29	Greenhouse gases increasing	Other greenhouse gases are also increasing • Methane CH4 increasing from landfills; rice paddies; cows and other ruminants mass farmed; increased decomposition as forests cleared etc. • Aerosols also increasing – dust, sulphates, nitrates, soot • Aerosols also act as counterbalance to global warming by reflecting incoming solar radiation back to space • Increase in greenhouse gases and aerosols result in an increase to the amount of energy in the earth's climate system, creating instability

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30	Graph	Generally earth's atmosphere has been stable for the last 1000 years • 1750: CO2 concentration around 280 ppm – earth's atmosphere relatively stable at that level for millennia • present CO2 levels are at around 3779 ppm • Climate generally on a slow cooling trend during past 2000 years, then a sharp increase in 20th century • Direct relationship between increasing CO2 levels and temperature levels since the Industrial Revolution _____ Click on the "film icon" for a video clip that shows predicted temperatures changes across the globe over the next 100 years (present - 2100).
	Video link notes	Click on the map to stop the model every 25 yrs.
31	Weathering the storm	

Slide #	Slide Text	Slide Notes
32	Climate regional	• Climate refers to average weather over a certain time span, and over a certain area: • Can refer to various regions of the earth, eg. temperate, tropical • Climate varies from place to place and influenced by: 1. latitude 2. proximity to the ocean 3. vegetation 4. geographical features e.g. mountains • Natural and human communities are adapted to climate conditions • Generally climate is quite predictable

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33	Weather	Weather is the fluctuating state of the atmosphere around us (time scale of days to months) Studies the variables that affect our daily life: 1. precipitation 2. wind 3. humidity 4. cloud type 5. solar radiation • Growth, movement, structure and decay of weather systems are influenced by atmospheric circulation, interactions with ocean currents and the land. Things we might not normally notice • Limited predictability

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34	Severe Weather	• Excess energy in atmosphere creates instabilities in weather patterns and global climate system • In Canada, an increase in the duration, severity and frequency of weather events has already been observed (no strong scientific proof at this time that this is connected to climate change) • Many changes to regional weather patterns have also been observed by scientists • Computer generated climate models indicate that severe weather events will increase in intensity and frequency • No significant trends in tropical storm intensity and frequency have been determined – variation in analyses makes it difficult for scientists to draw conclusions. _____ Click on the “graph icon” to see data about the frequency of weather disasters in Canada over the last 100 years.

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35	Severe Weather	What can we expect/predict for the weather and related issues: Precipitation - Increase in intense precipitation events observed in many areas of the world, both northern and southern hemispheres - Increase of 0.5% to 1% precipitation in much of northern hemisphere mid and high latitudes - Results suggest that regions where total precipitation has increased have also had pronounced increases in extreme heavy precipitation events - Heavy winter snowstorms and ice storms, as well as heavy rainfall events are all included under intense precipitation events Drought - Increased summer continental drying and risk of drought is predicted - Droughts increase risk of forest fire, adding more CO2 and aerosols to the atmosphere, disturbing soils, reducing sinks, etc Warming - Warm temperatures will result in more melting of icecaps with associated increases in sea level around the globe

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36	Thermohaline circulation changes?	• The density of sea water is controlled by its temperature (thermo) and salinity (haline). The circulation of ocean currents caused by differences in water density is therefore called thermohaline circulation. • Thermohaline circulation is known as the great ocean conveyor belt – it is a series of connected currents which move water and nutrients from pole to pole, and is one of the major global drivers of climate • Warm shallow water mixes with cold deep saltier water • One section, known as the Gulf Stream, moves warm water up to Europe, making the climate more temperate. • Some climate models suggest that if the climate warms, thermohaline circulation could stop altogether • Long term effects of this are unknown although if the Gulf Stream stops flowing, Europe will most likely cool • Changes to thermohaline circulation will likely have an impact on marine and coastal ecosystems and wildlife as well _____ Click on the “diagram link” to see a schematic of global ocean circulation. Click on the “film icon” for a video clip about the relationship between the thermohaline currents and climate.

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37	Ecosystems and wildlife	• Populations of wildlife affected directly due to temperature changes and severe weather, or indirectly through changes in vegetation and habitat • As climate warms, expected that some species will expand range northwards • Some species are not as mobile as others • Difficult for wildlife to migrate and shift its range as a result of fragmentation and loss of habitat • Scientific studies now suggest that climate change may drive up to 25% of land based animals and plants to extinction • Some cold-water fish species are expected to decline • Arctic animals such as polar bears affected by decrease in ice thickness and extent – affects their ability to hunt successfully • Hotter drier summers will shrink wetland ecosystems already under pressure from development

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38	Science & Technology Problem and solution	• Science holds promise for the future • Same curiosity led scientists to study paleo-climate (climates of the past) and atmospheric science • We learned about climate change, and became aware of problem of increasing CO2 levels in atmosphere
39	Technology pollution	• Science and technology could be said to have created the problem • Our natural human curiosity and creativity led us to discover and apply the energy contained in fossil fuels • We developed technology to extract and use these more efficiently
40	Science & Technology opportunity for change	

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41	Computer climate models	• Computer models developed to study climate change – trends of the past, predict future trends based on different scenarios • Early models not very accurate – didn't take into account all factors affecting climate, eg. feedbacks, water vapour etc. • Now models much better – can accurately reproduce trends of the past, and make reasonable future projections based on different scenarios. Scientists usually combine results from several models for better accuracy • Mainly limited now by the difficulty in predicting human factors influencing climate change: population, economic change, technological developments etc. • Canadians have made important contributions to climate change studies and modeling • Dr. Andrew Weaver, professor of Earth and Ocean Sciences from University of Victoria, focuses research on the ocean circulation and the role of oceans in climate, with emphasis on 3-D numerical modeling. • Canadians, including Dr. Weaver, played a large role in the Intergovernmental Panel on Climate Change (IPCC) third assessment report

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42	Satellite technology	• Models made possible because of information gathered by satellite technology • Gained a lot of information about trends in weather, cloud cover, ice and snow cover, land surface, albedo etc. • Gives us the ability to track changes.
43	Technology - Boon or Bust?	
44	Energy revolution	• Reducing our contribution to climate change means reducing our *society's dependence on fossil fuels.* • Science and technology have a huge role to play in helping us to research and design new technology that is more sustainable and less reliant on fossil fuels, and this helps us decrease our greenhouse gas emissions • *This is an energy revolution*, and it is already happening worldwide

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45	Energy revolution wind turbines	• There are other ways of generating electricity without producing emissions • In the Climate Change Plan for Canada, released in November, 2002, the Canadian government set a target of 10% of new electricity generating capacity from emerging renewable resources, such as wind. • Wind power – a technology dating back to 5000 BCE (before common era) • Wind energy is growing by 30% per year worldwide • Denmark generates 17% of its energy through windpower, and aims to provide 50% by 2030. Jobs associated with the manufacturing and exporting of this technology are predicted be a big part of the Danish economy. • European Union aims to generate 22% of electricity (12% of all energy) from renewable resources by 2010 • In 2003, Toronto erected North America's first wind turbine set in a downtown urban setting • Modern wind turbines have the potential to generate 3,000 mw of energy in Ontario • If developed – will produce thousands of jobs in construction and maintenance • As of 2003, Ontario had 9 turbines (Quebec – 133, Alberta – 157) _____ Click on the "film icon" for a video clip about the wind generated power in Denmark and other parts of Europe.

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46	Energy revolution solar	• Worldwide, solar power has huge potential • Photovoltaic cells (PV) enable us to capture the sun's energy and convert it to electricity, e.g. to power calculators, heat water for homes, swimming pools, etc. • Can store solar energy in batteries to use when sun not shining • Can use this PV system to provide energy for homes – lighting, appliances etc. and some businesses • In Canada – most potential for solar energy applications is in remote communities where it is too expensive to connect to the grid – can use solar power as alternative to noisy, smelly generators • No emissions • Same potential exists in many developing countries _____ Click on the "diagram link" to see a details of how a PV cell works

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	PV cell link notes	• Photovoltaic cells (PV) are made from semiconductors such as silicon. • When solar radiation hits the solar cell a certain portion of the energy is absorbed. • This absorbed energy “knocks” electrons loose from the silicon atoms allowing them to flow. • PV cells also contain electric fields which force the electrons to flow and create current. A more detailed explanation is available at http://library.thinkquest.org/27754/apphow.html
47	Low-tech solar	• Already people use solar energy to dry clothes, provide natural lighting, etc. • Water can be warmed by running it through dark pipes or similar system on the roof – can be used for heating pool water • Solar warmed water requires less energy to bring it up to hot temperatures for domestic use.

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48	Energy revolution micro hydro	Role of science besides increasing understanding of global environmental issues such as climate change, science is central to the development of new technologies to reduce our dependence on fossil fuels. • Hydropower is one form of alternative energy – not new – people have been tapping into power from running water for millennia. • More recently hydro used to generate electricity – either using the natural drop of a river, like Niagara Falls, or create that drop with the construction of a dam. • Large scale dams can have major environmental impacts – displacing human and natural communities, destroying large areas of habitat • Small hydro generating stations are good alternatives to coal powered generating stations – little environmental impact on their surroundings, and no greenhouse gas emissions • Really small micro-hydro units can provide energy for a house or small community from the natural drop of a small creek or river – especially good for remote locations near running water – the same basic process as huge dams • No greenhouse gas emissions _____ Click on the “diagram link” to see an explanation of hydro production of electricity.

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	Link to hydro-electricity generation notes	Here are the elements of a basic hydro dam: 1. Forebay 2. Intake 3. Transformer 4. Generator 5. Penstock 6. Turbine 7. Draft tube 8. Tailrace Water at the higher level (the forebay) goes through the intake into a pipe, called a penstock, which carries it down to the turbine. The turbine is a type of water wheel. The turbine is connected to a generator. When the turbine is set in motion, it causes the generator to rotate, and electricity is produced. The falling water then exits the generating station through the draft tube and the tailrace where it rejoins the main stream of the river (Image and explanation from www.opg.com).

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49	Energy revolution building design	• Other ways to reduce energy – design buildings to be energy efficient and use renewable energy sources. • Reduce energy required to heat, cool and light buildings • This house is completely off the electricity grid and uses passive solar, photovoltaic cells and wind power to provide the energy need to run the home. • Very low greenhouse gas emissions.

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50	Energy revolution transportation	• Much of our fossil fuel use is related to transportation – getting us and our consumer goods around the planet as quickly as possible • Cars, trucks and other gas-powered vehicles are one of the greatest sources of GHGs • Options: • People can help by buying smallest most fuel efficient model to suit needs • Hybrid Cars Companies like Honda and Toyota make hybrid cars that combine a gasoline engine with a battery-powered electric motor. • Hybrid cars use less gas, and therefore produce fewer greenhouse gas emissions. • prices will come down if more people buy them • Public Transit • public transit cuts down on number of vehicles on the road, produces less greenhouse gas per rider that single occupant vehicles.

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51	Energy revolution fuel cell	• More high tech contributions • Various sectors of Canadian industry are actively involved in research and the development of new technologies to reduce greenhouse gas emissions. • A Canadian company, Ballard, is considered a leader in fuel cell research: producing electricity by combining hydrogen fuel with oxygen from air, producing only water and heat as by-products. • Ballard's prototype fuel cell transit buses have been demonstrated in Vancouver, as well as the US and Europe. For more information about fuel cells and Ballard Technologies visit: http://www.ballard.com/ _____ Click on the "film icon" for a video clip about the fuel cell technology.

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52	Hydrogen power systems	• Another Canadian company, Globaltech, developed HPS (Hydrogen Power System) • HPS: combustion enhancement system (using hydrogen as a fuel) which can be retrofitted on transport trucks, making them more efficient, and thus reducing their greenhouse gas emissions. • Currently this technology is used mostly on heavy equipment: • Reduced emissions • Increased fuel efficiency – lower cost to operate large trucks and machinery.
53	Climate Change Challenge	
54	Kyoto protocol	Kyoto protocol: • December 1997, representatives of over 160 countries met in Kyoto, Japan • Kyoto is an an international agreement on climate change, that limits global Greenhouse Gas emissions to 5% below 1990 levels by the period 2008-2012 • To become legally binding the protocol required ratification by countries representing 55% of the global CO2 emissions – by September 2004, enough countries had ratified the protocol for it to come into effect.

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55	Aims of Kyoto	For details and full text of the Kyoto Protocol visit: http://unfccc.int/resource/convkp.html
56	People power	• As individuals we also have a lot to contribute to the battle against climate change • Need to look at our own every day lives and see where we can reduce our own CO2 emissions • Canadian writer Guy Dauncey encourages individuals to become carbon activists – he suggests 10 simple practical steps to help individuals to reduce their carbon emissions, starting with the calculation of your present emissions. Other steps include driving less, improving our home insulation, taking vacations close to home, eating less beef and more local foods, etc. • We can't afford to wait for governments or industry to act – individuals need to do what is within their power to reduce greenhouse gas emissions as well. • Take the One-Tonne Challenge www.climatechange.gc.ca/onetone/english/index.asp • Future career choices
57	The solution	• Don't need to resort to shipping everyone off the planet!