

Chapter 12: Balance of the Planet I

Goals of Period 12

Section 12.1: To introduce computer simulations

Section 12.2: To provide easy instructions for the simulation

Section 12.3: To give information on the simulation's taxation and subsidy categories.

During our study of the World of Energy, we have examined forms of energy and how energy is used in our lives. Next, we consider the effect that energy use has on our planet. To introduce the interactive nature of this effect, we will use a computer simulation, called Balance of the Planet. This computer program simulates *one way* that the effect of energy use on the planet could occur.

12.1 Computer Simulations

A computer simulation is any program that simulates some event using a computer. A simulator is an apparatus that generates test conditions approximating actual or operational conditions. For instance, driving schools use a driving simulator to help students learn to drive. The computer responds to the steering wheel, accelerator and brake. It shows on the screen the windshield, side-view mirror, and rear-view mirror. A student can learn about good driving techniques without the danger of actual driving.

The Air Force uses flight simulator computers to test their pilots before they fly. The computer creates on the screen images that the pilot might actually see when flying. Simulators such as these can be very complex. A pilot practicing on a simulator would be able to use every instrument in the cockpit exactly as in a real plane. The simulator could feedback with visual images, the sounds, and even the changes in cockpit pressure the pilot experiences. The simulator can tilt the cockpit to simulate bank turns.

In principle, there is no limit to how real a simulator could be; however, in practice any simulator has limitations. Simulations can only reflect reality to the extent that it is understood or that the simulator is programmed to emulate. Many simulations model very complex situations that are often simplified in the program.

Background on Balance of the Planet

The simulation we will use is called Balance of the Planet. This computer program was developed in the mid 1980's when environmental concerns were becoming of far-reaching importance. The program is designed to show the effects of various environmental policies to the year 2035. The purpose of the program is to allow you to become acquainted with world energy questions and environmental consequences. Balance of the Planet is a simulation program – it in no way pretends to be able to predict the future. The program has related some basic facts about the environment

and, through many simplifications, has reduced the world's energy parameters and consequences to 150 variables. These 150 factors are related through simplified mathematical equations. The 150 equations are solved self-consistently each time the program advances the world 5 years. The program ends in the year 2035.

Playing the Game

When playing Balance of the Planet, you will have an opportunity to implement policies to try to improve the condition of the Earth's environment and inhabitants. You can discourage practices, such as the use of toxic heavy metals, by raising the heavy metal tax. Likewise you can encourage practices by reducing their tax rate. With the money raised from taxes, you can subsidize issues you think beneficial to the planet, such as recycling centers or solar energy research. After making changes to tax rates and subsidies, you execute your changes and the game advances five years into the future, showing you the effect of your policies. The simulation also provides factual information on environmental issues and the interactive nature of our environmental challenges – how one environmental issue may impact a related issue.

There are only two basic screens you need to operate the program: the Policy screen and the Results screen.

Policy Screen The Policy screen allows you to quickly access a tax or subsidy screen, where you can change the tax and subsidy rates. The Policy screen also summarizes all the current tax and subsidy rates. The Policy screen can be called up at any time during the game by typing the letter P.

Results Screen The Results screen shows the results of your tax and subsidy policies. This screen can be called up at any time during the game by pressing the letter R. The Results screen acts as a home base – if you get lost in the program, type R to find your way back.

Execute function In either the Results or Policy screens, you may press E for Execute Policies. Most of the game involves browsing through screens to see which environmental issues are getting worse and how to improve them. Only when you press E does anything actually happen, and the game advances five years into the future. Any changes in taxes or subsidies will not have any effect until the policies are executed.

Easy Instructions

1. Determine which issues you want to improve, for example, lung disease.
2. Find the lung disease category by pressing R to get the Results screen. Put the cursor on Lung Disease and hit Return.
3. The Lung Disease screen lists factors that influence the incidence of lung disease. Find the causes of lung disease by highlighting the factors in the upper right hand corner of the screen and hitting Return.

4. Once you have identified the causes of lung disease, find which tax categories are related to the causes.
5. Hit P to bring up the Policy screen. On the left side of the screen, select the tax you want to change, for example, the Coal tax. Use the arrow keys to adjust the tax to the level you want it to be for the next five years.
6. You may also want to adjust the rate of subsidies on the right side of the screen by highlighting a subsidy and using your arrow keys to adjust the rate.
7. Repeat steps 1 through 6 for the other issues you wish to address.
8. When all of your taxes and subsidies are at desired levels, press R to return to the Results screen. To execute your policies, press E for execute and wait a few seconds. The screen will show the results of your policies five years in the future.
9. To see information on your successes and failures, select Feedback on the Results screen and press Return. (Don't be discouraged if your changes do not have the desired result. Remember, the world is in bad shape. You can't turn it around in five years. Even successful policies may not show large improvements in just one five-year period.)
10. Repeat steps 1 through 9 to advance the simulation another five years.

Summary

Press

- | | |
|----------|--|
| P | To go to the Policy screen (adjust taxes and subsidies) |
| E | To execute your taxes and subsidies and advance the simulation five years into the future. |
| R | To go to the Results screen (shown point scores)
Select Feedback for more information on your results |

Hints

The game is not easy to win, so don't be discouraged. See the good things you've done by going to the Results screen to see how your taxes discouraged bad things and your subsidies encouraged good ones. Don't increase taxes too fast or the economy will suffer and your score will PLUMMET! Don't be afraid to hit them hard enough though. Pick a set of policies and stick with them unless you see them not having the effect you want. A decreasing score may not mean you aren't doing what you wanted to do. Perhaps you just don't agree with the program on what is important. That's okay.

12.3 Balance of the Planet Tax and Subsidy Categories

Results screen The Results screen looks like the following:

Positive Points:

Biodiversity Points

Forest Life Points

Lake Life Points

Marine Life Points

Quality Points

Sustainability Points

Negative Points:

Fall Points

Flood Death Points

Heavy Metal Points

Inundation Points

Land Abuse Points

Lung Disease Points

Pesticide Points

Radioactive Waste Points

Radiation Points

Skin Cancer Points

Starvation Points

The Results screen is how the program categorizes the good things and bad things in the world. A large score in a category in the left hand column is good, but a large score in a category in the right hand column is bad.

Explanation of Points Categories

POSITIVE POINTS (HIGH SCORES ARE GOOD)

1. **Biodiversity Points** You get points for having living species on the Earth. The more species in existence, the more points you get.
2. **Forest Life Points** You get points for species that live in forests.
3. **Lake Life Points** You get points for species that live in lakes.
4. **Marine Life Points** You get points for species that live in the water. This is hurt by oil spills, pesticide use, and eating seafood. Points increase in this category for more phytoplankton.
5. **Quality Points** You get points for a better quality of life. This is hard to define, but, in general, this means having more things under better living conditions. Northern (Industrial lifestyle) inhabitants have a different quality of life standard than do their Southern (Third World lifestyle) counterparts. Northern inhabitants benefit from such advances as new medicines, beef production, consumer goods, and more energy. This game weights the Northern and Southern lifestyles equally, which means that the importance per person is larger in the North. Third World peoples benefit from more basic things such as housing, food and clean water.
6. **Sustainability Points** You get points for operating the Earth in such a way that it will be livable even after the year 2035. This means you get points for lower population and more renewable energy such as solar and hydropower.

NEGATIVE POINTS (HIGH SCORES ARE BAD)

1. **Fall Points** You lose points when people fall to their deaths servicing their solar apparatus on their rooftops.
2. **Heavy Metal Points** You lose points for infiltration of heavy metals into water and food supplies. Heavy metals are highly toxic.
3. **Inundation Points** Most of the people in the world live on a coast. Global warming, caused by the greenhouse effect, will increase the world's water level. The result is a devastation of the fertile, populated coastal areas. You will be penalized for allowing this to happen.
4. **Flood Death Points** Soil erosion cause flood deaths. Many people in the world must deal with yearly flood catastrophe during the rainy season. If the country is not wealthy enough to build flood-controlling dams, they are helpless to do much about it. You lose points for flood deaths.
5. **Land Abuse Points** Activities such as deforestation (and subsequent soil erosion) and strip mining (to get coal) destroy fertile land areas and render them sterile for decades. Landfills also waste land. Landfill volume increases with population. You are penalized for this land abuse.
6. **Lung Disease Points** Many pollutants cause lung disease. The list includes sulfur dioxide, nitrous oxides, carbon monoxide, hydrocarbons, ozone, and particulates. You are penalized for allowing people to die from lung disease.
7. **Pesticide Points** Pesticide is poisonous to humans. Allowing pesticides to seep into ground water supplies will cost you points.
8. **Radioactive Waste Points** Radioactive waste is very dangerous. People exposed to the radioactivity from it will develop cancers at an abnormally high rate. Spent fuel from nuclear reactors will have to be stored away from people for hundreds of years at great cost and waste of valuable resources. No safe radioactive waste sites are in operation yet. You will be penalized for creating radioactive waste.
9. **Radiation Points** Exposure to radiation is damaging to people. Most large-scale radiation exposure comes from nuclear wars and nuclear plant accidents. Since wars are not accounted for in the game (they have too drastic an effect on the world's condition), nuclear plant accidents are the principle source of this. You will be penalized for any damaging radiation in the environment.
10. **Skin Cancer Points** A major effect of ozone depletion will be the increase of skin cancers. Skin cancer is usually treatable, but it can be fatal. You will be penalized for skin cancer occurrence.
11. **Starvation Points** Often the most difficult part of running the world is figuring out how to feed everyone. Even if your food supply is adequate to feed the world, you must be able to distribute the food where it is needed. You will be penalized for allowing people to starve. Starvation decreases as the food supply increases and the population decreases.

Policy screen The Policy screen looks like the following:

Source:	Tax Rate		
Beef Tax	6.00	Property Damage \$	
CFC Tax	40.0	Basic Research \$	8%
Coal Tax	250 million	BioResearch \$	8%
Fertilizer Tax	10.0	Coal Research \$	8%
Heavy Metal Tax	8.00	Dam Use \$	8%
Logging Tax	0.40	Debt for Nature \$	8%
Natural Gas Tax	250 million	Family Planning \$	8%
Nuclear Tax	250 million	Nuclear Research \$	8%
Oil Tax	250 million	Oil Research \$	8%
Pesticide Tax	10.0	Recycling Center \$	8%
		Solar Energy \$	8%
		Solar Research \$	8%
		Wood Stove \$	8%
Treasury: \$1.60 billion		total = 96%	

These are the sources of money and the places where money can be spent.

Effects of Taxation

- 1) **Beef (Livestock) Tax** Beef feeds people, but not very efficiently. It takes ten calories of food to produce one calorie of beef. Grazing beef can destroy grasses. Once the grass is killed, rain erodes the soil, making it useless for growing crops.
 - raising beef wastes grain
 - raising beef increases desertification
 - raising beef is a major source of food supply

- 2) **CFC's Tax** CFC's are chlorofluorocarbons. The most common formulas are CCl_3F (known as F11) and CCl_2F_2 (known as F12). CFC's don't burn and they don't make it easier for other things to burn. They aren't poisonous or carcinogenic. They don't crystallize, form salts, mix with water, oxidize, or do anything else.

CFC's (as Freon) are used in air conditioners and refrigerators. CFC molecules don't break down over years of use and they don't corrode delicate pipes. If they leak out, they won't poison anyone or catch fire. They are thought, however, to cause a destruction of ozone in the stratosphere. They are very stable anywhere in the atmosphere until they find themselves up in the stratosphere. In the stratosphere, ultraviolet radiation breaks apart the CFC's releasing chlorine atoms. These chlorine atoms bond with ozone and trap it forever. Ozone in this trapped form will not absorb ultraviolet radiation.

- production of CFC's leads to release of CFC's
- release of CFC's lead to destruction of ozone in the stratosphere

- ozone protects people and crops from harmful ultraviolet rays
- ultraviolet radiation causes skin cancers
- tropospheric CFC's contribute to greenhouse effect

- 3) **Coal Tax** Coal is a fuel. It can be used to produce electricity, the primary use of energy in industrialized nations. It cannot, however, be used to fuel automobiles, the second largest use of energy in industrialized nations.

Coal is composed mainly of carbon. When burned, carbon is released into the air as carbon dioxide, a greenhouse gas. Nitrogen, another component, can create nitrous dioxide, which combines with water in the atmosphere to make nitric acid (and acid rain). Nitrous dioxide production can be reduced by lowering the temperature of combustion of the coal, but this increases the production of hydrocarbons. Hydrocarbons are carcinogenic.

Often coal has impurities in it which are released into the air when it is burned. One impurity is sulfur. The sulfur released into the atmosphere combines with water to make sulfuric acid (and acid rain).

- coal is a cheap fuel
- burning coal causes sulfuric and nitric acid rain
- burning coal releases greenhouse gases
- burning coal releases hydrocarbons, causing lung cancer
- mining coal often requires strip-mining, wasting resources
- burning coal releases pollutants which cause lung disease

- 4) **Fertilizer Tax** Fertilizer supplies elements that plants need to grow. The three main components of fertilizer are nitrogen, phosphorous, and potassium. Using more fertilizer means better crops and lower food prices. Runoff from highly fertilized fields, however, is rich in nitrates. The nitrates collect in ponds and lakes, killing plant life in them, and thus killing animal life in the water.

Plants need more than just the elements supplied in fertilizer to grow. These other elements are not replenished by fertilizing, and, eventually, the soil is rendered infertile.

- using fertilizer increases food supply by increasing crop yields
- using fertilizer kills lake life
- eventually, soil becomes infertile even if fertilized

- 5) **Heavy Metals Tax** Heavy metals are essential to industry. Most toxic and common heavy metals are chromium, vanadium, lead, and mercury. Heavy metals are known to be highly toxic to animals and people.

- heavy metals are highly toxic and poison the water supply
- taxing heavy metals strains industry, hurts the economy and quality of life

- 6) **Logging Tax** Logging provides raw material essential for our civilization. But logging can destroy land. It is possible to log softwood trees (pine and fir) while replanting and caring for the ecosystem. It can be replenished in 20 to 30 years. The hardwood trees are logged using heavy equipment, cutting all the trees in a region. This destroys the trees and the soil, which isn't too fertile in the first place. The soil, eroded easily now, washes away and the land becomes desert.
- logging is essential for industry
 - logging desertifies land
 - logging erodes soil
- 7) **Natural Gas Tax** Natural gas is a non-renewable fossil fuel. It burns relatively cleanly, emitting only water vapor, carbon dioxide, and some nitrous oxides. Natural gas is very scarce. It will become expensive very quickly if relied upon.
- natural gas burns relatively cleanly
 - natural gas is scarce and therefore will become expensive fast
- 8) **Nuclear Energy Tax** Nuclear energy is clean. It does not release greenhouse gases. It also is a non-renewable, expensive source of energy. Nuclear power plants use uranium. Uranium is rare and expensive to mine. After using the fuel, radioactive waste is dangerous for decades at least. This causes serious disposal problems. Nuclear accidents also happen, such as Three Mile Island in Pennsylvania and in Chernobyl, Russia. Nuclear plants often release radioactive gases. These factors lead to cancers.
- nuclear energy does not pollute the air (or emit greenhouse gases)
 - nuclear energy is expensive
 - nuclear energy increases radiation deaths
- 9) **Oil Tax** Oil is our primary source of energy. Over one half of all energy used is in the form of oil. Oil is dirty to burn (but not as dirty as coal). Most of our oil is used in transportation (such as cars). Oil produces the same pollutants as coal, except in lower amounts in some cases.
- oil is a difficult to replace fuel
 - burning oil causes sulfuric and nitric acid rain
 - burning oil releases greenhouse gases
 - burning oil releases hydrocarbons, causing lung cancer
 - oil spills cause damage to ocean life
 - burning oil releases pollutants which cause lung disease
- 10) **Insecticides Tax** Insecticides kill pests, thus increasing crops and, thereby, the food supply. Insecticides are poisonous to insects. They are also poisonous to animals and humans. Insecticides find their way into the ground water and poison water supplies, hurting crops and water life. It also decreases the drinking water supply.
- using insecticides increases the food supply
 - using insecticides kills animals and people
 - using insecticides poisons water supplies

Effects of Subsidies

- 1 **Property Damage** In this simulation, the government must pay for all damages due to acid rain. Damage mainly comes in the form of buildings and roads that are eroded.
- 2 **Basic Research** Basic research funds all kinds of scientific research. It improves technology of all kinds and, therefore, the quality of life.
 - basic research improves the quality of life
 - basic research improves efficiency of energy use
- 3 **BioResearch** BioResearch refers to any research into living organisms. This improves the way we use living organisms and the way we improve our medical technology.
 - bioresearch improves the food supply through crop yields
 - bioresearch improves medicines, and, therefore, the quality of life
- 4 **Coal Research \$** Coal research money is used to improve coal technology. This improves the efficiency of coal burning, reduces pollutants, and locates more sources of coal deposits to keep the price down.
 - coal research \$ reduces coal pollutants
 - coal research \$ improves energy output from reserves
- 5 **Dam Use \$** Dam use \$ subsidizes the use of hydropower. Dams, however, require a suitable site. Even if all dams possible were built, there are not enough sites to supply more than about 10% of the world's energy. It is, however, an important part of the world's energy supply. Dams also erode soil and kill riparian and lake life. This water, being controlled, is able to be used for irrigation, drinking, or wherever needed.
 - dam use \$ increases hydropower
 - dam use \$ increases reservoir size and water supply for irrigation
 - dam use is limited
 - dams erode soil and kill lake life
- 6 **Debt For Nature \$** Debt for nature \$ pays money to poor nations to stop cutting down their trees. Cutting down trees leads to soil erosion, and forest life destruction. It also, maybe most importantly, contributes to the greenhouse effect. All the CO₂ the trees took in while growing is released when cut down and decay.
 - increasing debt for nature \$ decreases deforestation
 - increasing debt for nature \$ slows the greenhouse effect
 - increasing debt for nature \$ helps poor nations get out of debt
- 7 **Family Planning \$** Family planning money refers to a program which actively pursues a goal of population control. The most important way to have enough resources to feed the world is to decrease the number of mouths to feed (or at least reduce the increase of mouths to feed).

- increasing family planning \$ slows population growth
 - slowing population growth reduces the pollution rate
 - slowing population growth reduces the need for material supplies
 - slowing population growth reduces the consumption of energy (and its problems)
- 8 **Nuclear Research \$** Nuclear research money refers to money spent to improve nuclear technology. This may mean anything from better ways to build power plants, to better ways of mining uranium, to better ways of storing radioactive waste.
- increasing nuclear research \$ improves the efficiency of nuclear power
 - increasing nuclear research \$ improves the safety of nuclear power
- 9 **Oil Research \$** Oil Research money refers to money spent to improve oil technology. It can refer to any kind of improvement from efficiency of car engines to the building of better tankers that don't rinse their storage tanks into the ocean periodically to clean themselves. Since natural gas is very similar to oil as an energy source, the oil research goes also to pay for natural gas research.
- increasing oil research \$ improves efficiency of oil and natural gas use
 - increasing oil research \$ reduces pollution from oil and natural gas use
- 10 **Recycling Center \$** Recycling center money refers to the money spent to encourage recycling of materials.
- increasing recycling \$ reduces use of materials
 - increasing recycling \$ reduces amount of logging
 - increasing recycling \$ increases quality of life
- 11 **Solar Energy \$** Solar energy refers to photovoltaic and other direct solar power, and wind power, biomass and other alternative energy sources. Solar energy money refers to money spent to subsidize the actual use of solar energy. Initially, it is expensive to implement solar energy equipment. Solar energy, however, uses only the energy from the sun. The sun is a virtually inexhaustible source of energy. Solar energy releases no pollutants when used. Greenhouse gases are released, however, when producing solvents to make solar panels
- increasing solar energy \$ increases the use of solar energy
 - increasing the use of solar energy decreases the use of other fuels
 - increasing the use of solar energy increases the quality of life if it is inexpensive to use
- 12 **Solar Research \$** Solar research money refers to the money spent in improving solar technology. This research may increase the efficiency of solar energy or find less harmful ways to produce solar cells. Efficiency is the most important purpose of research, since solar energy must be inexpensive in order that people use it.
- increasing solar research \$ decreases the cost of solar energy
 - increasing solar research \$ increases the supply of solar energy

13 **Wood Stove \$** Wood stove money refers to the money spent in improving wood burning technology. Industrialized nations do not burn much wood, but Third World nations do. These nations are very poor and must cut down their best fuel resource, trees, for fuel. If they have more efficient stoves, then they cut down fewer trees. Cutting down fewer trees means savings resources and less greenhouse gas contribution. It also improves the quality of life for those in the Third World.

- increasing wood stove \$ slows deforestation
- increasing wood stove \$ slows the greenhouse effect
- increasing wood stove \$ improves quality of life

Not included in the game:

- Wars: too unpredictable
- Fusion: not feasible in the near future as a fuel source
- Hydrogen Power (fuel cells): not considered a viable alternative.

12.3 Glossary of Terms Used in Balance of the Planet

ACID RAIN The phenomenon of a slight acidification of rainfall by the presence of nitric acid and sulfuric acid in the clouds. Acid rain erodes buildings and poisons lakes and rivers.

BIRTH RATE The rate of surviving children. If every couple has two surviving children, then the birth rate is 2:2 and the population remains constant. If every couple has one surviving child, the birth rate is 1:2, and the population is decreasing.

CARCINOGENIC Known to cause cancer.

EXAJoule 10^{18} J (one quintillion) joules. That's a lot.

GOODIES An imaginary unit used by the program to quantify the number of consumer goods available.

GREENHOUSE EFFECT The effect of trapping of solar energy in the atmosphere. The result is global warming and subsequent ocean level rise.

GREENHOUSE GAS Any gas which contributes to the greenhouse effect. Examples are carbon dioxide and CFC's.

HAPPIES An imaginary unit used by the program to quantify the amount of happiness.

HECTARE An area equal to 2.5 acres.

PERMANENCE An imaginary unit used by the program to quantify the condition of the Earth for the future.

PHYTOPLANKTON One celled animals which form the basis for the food chain.

RIPARIAN LIFE Life living alongside streams.

STRATOSPHERE The outer region of the atmosphere (the last air before the vacuum of space).

TROPOSPHERE The inner region of the atmosphere (the air close to the ground).

WHIZBANGS An imaginary unit used by the program to quantify the amount of scientific discoveries made in a given field.

Period 12 Summary

12.1 Computer simulations can be used to simulate an event that is dangerous, expensive, or very complicated involving many variables.

Balance of the Planet simulates the effects of various policies on the economic, social, and environmental welfare of the Earth. Practices can be discouraged by taxing them and encouraged by subsidizing them.

Period 12 Exercises

- E.1 Which of the following variables are NOT considered in "Balance of the Planet"?
- a) wars
 - b) nuclear fusion as a fuel source
 - c) hydrogen (fuel cells) as a power source.
 - d) ALL of the above variables are considered.
 - e) NONE of the above variables are considered.
- E.2 In the computer game "Balance of the Planet," what is likely to happen if the beef tax is decreased?
- a) more beef is consumed
 - b) world starvation decreases
 - c) world starvation increases
 - d) Both a) and b) are correct.
 - e) Both a) and c) are correct.
- E.3 In the computer game "Balance of the Planet," which of the following is **NOT** a result of increasing the pesticide tax?
- a) the use of pesticides decreases
 - b) water quality improves
 - c) flood deaths increase
 - d) crop yields decrease
 - e) world starvation increases