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ABSTRACT

This guide discusses the global warming issue and offers a plan to facilitate a decrease in the emissions of the major greenhouse gases in the United States, including those under the control of individual citizens. A letter from the organization's president describes its involvement with the global warming issue. A brief overview presented in the foreword includes comments on political, personal lifestyle choice, ecological, and international considerations. In the foreword, the connection between global warming and U.S. consumer decisions and actions is made and the greenhouse diet plan is introduced. In chapter one, a description of "greenhouse" includes the identification of greenhouse gases, and their relationship to climate disruption. Chapters two and three identify national (industrial, transportation, residential, commercial) and individual (air conditioners, solvent cleaners, refrigerators, etc.) greenhouse gas emissions and a method for estimating contributions of carbon dioxide as a result of each citizen's energy consumption is discussed (includes a worksheet). Chapter four offers suggestions on how to decrease household greenhouse gas emissions via the CO2 diet. In chapter five, an example is provided on how an Audubon staffer implemented the diet plan. A discussion of how individual and governmental action can curb greenhouse gas emissions through improved energy policies, technologies, and investment is presented in chapter six. Appendices present a global perspective of greenhouse gas emissions, carbon dioxide equivalences for other greenhouse gases, and the methodology for the carbon dioxide diet calculations. (Contains 51 references.) (MCO)

AUDUBON POLICY REPORTS

"Bringing Science To Life"

CO_2 DIET FOR A GREENHOUSE PLANET:

A Citizen's Guide For Slowing Global Warming

By John DeCicco, James Cook, Dorene Bolze, Jan Beyea

NATIONAL AUDUBON SOCIETY

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CO_2 DIET FOR A GREENHOUSE PLANET: A Guide to Slowing Global Warming

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FROM THE PRESIDENT

Global warming is an environmental issue that recognizes no boundaries. As such, it cuts across the borders of nations and continents, and across backyards and ecosystems everywhere. Our solutions must therefore also cut across the boundaries that separate individuals from their governments, and those that separate scientists and policy-makers in different disciplines.

At Audubon we are working to bring together the pieces of the global warming puzzle. Our 50-person science department and our 25-person lobbying and litigation department have been at the forefront of efforts to introduce more energy-efficient technologies and legislation across the country.

"Our solutions must cut across the boundaries that separate individuals from their governments."

In 1984 we launched the Audubon Energy Plan, which showed that the United States could meet its needs for goods and services without increasing energy consumption. And indeed the national increase in energy use has been less than predicted by government and industry.

We took a leadership role in getting states to implement appliance efficiency standards, an initiative that helped convince manufacturers to accept national legislation to improve efficiency.

We have also been active in exposing the hidden environmental costs of industrial and utility energy use, and are working to encourage all states to adopt legislation similar to that in New York, where utilities will soon be required to include estimates of the costs of environmental damage such as global warming in their cost-benefit analyses.

And our Washington, D.C., office is actively lobbying for legislation that will require the United States to reduce its CO_2 emissions 20 percent by the year 2000.

The *CO_2 Diet for a Greenhouse Planet* is Audubon's latest initiative in the fight to save our Earth from disaster. We hope that you will find it useful in your own efforts to make a difference for the environment. And if you'd like to take it one step further, join our Audubon Activist Network and learn about what you can do on other issues affecting our lives and our planet.

Peter A.A. Berle

National Audubon Society
New York, N.Y.
May 1990

FOREWORD

For as long as we know, the Earth has been a place of change. Geologic history confirms that our environment has changed—sometimes in brief spurts, sometimes in long, millenial shifts from hot to cold and from one atmospheric condition to another. Our understanding of these changes is developing, but remains limited.

On one point our knowledge is quite sound: environmental changes have been precipitated historically by natural forces. We now know that humankind, through growth and ingenuity, has developed the power to fundamentally alter the environment. Indeed, we are now powerful agents of change.

The environmental challenges we face, from groundwater pollution to global warming, from ocean dumping to ozone depletion, all derive from the cumulative effects of countless individual actions. These challenges appear daunting if not overwhelming. How much of a difference can we, as individuals make? Does using less energy in our homes, driving more efficient cars or using less packaging make a difference? Absolutely.

Audubon's *CO_2 Diet for a Greenhouse Planet* provides a framework for making a difference to protect the global environment. The Diet is a road map for individuals who want to help become better stewards of the world around us.

While individuals can make a difference in the fight to prevent global warming, our leaders must also develop national and international policies to meet the enormous challenge we face.

As we enter the 1990s, the Berlin Wall has been torn down and, with it, our definitions of national security. Increasingly, environmental considerations are replacing military confrontations as the primary indicator of our national and international security.

The unity of the global climate will be—indeed, must be—a strong inducer of interdependence. Our domestic and international policies must reflect these new conditions of life. Nowhere will this be more challenging than here in the United States. With only 5 percent of the world's people, we generate 20 percent of all the greenhouse gases emitted annually. Without U.S. leadership, efforts to address global warming will be impossible.

Our government must accept the goal established in 1988 by scientists at the World Conference on the Changing Atmosphere in Toronto, to limit carbon dioxide emissions dramatically.

"With only 5 percent of the world's people, we generate 20 percent of all the greenhouse gases emitted annually. Without U.S. leadership, efforts to address global warming will be impossible."

To reach this goal, the United States must embark on a national campaign to provide incentives for the production and use of energy-efficient goods and technologies. Energy efficiency is good energy policy, good economic policy, and good environmental policy, and must be the cornerstone of our response to the global warming threat.

We also must support legislation and technologies that encourage the complete phase-out of all ozone-depleting chemicals, such as chlorofluorocarbons. At the same time, the industrialized nations must do all that they can to help developing nations undertake a CFC diet such that these chemicals are eliminated completely by the year 2000.

Finally, the United States must once again develop its commitment to the issue of global population growth. By itself, population could overwhelm our best intentions to protect the environment. Unchecked, population could double, if not triple, late in the next century. At a minimum, we need to make voluntary family planning services available universally by the year 2000.

Several years ago, one of the witnesses who testified at hearings I held on global warming stated:

> "The inhabitants of the planet Earth are quietly conducting a gigantic experiment. So vast and so sweeping will be its impacts that were it brought before any responsible council for approval, it would be firmly rejected as having potentially dangerous consequences. Yet the experiment goes on with no significant interference from any jurisdiction or nation" (Wallace Broecker, Professor of Geology at Columbia University, November 9, 1987).

Working together, we can summon the individual and political will to halt the experiment we are conducting on the global environment—but we must act now. The suggestions in Audubon's CO_2 *Diet for a Greenhouse Planet* are important first steps in that process.

Timothy E. Wirth
U.S. Senate
May 1990

Introduction

Americans are responsible for much of the greenhouse gas emissions causing global warming. By cutting emissions 2 percent a year, we can make a dent in the problem.

The problem: global warming. The cause: our emissions of carbon dioxide and certain other gases. The Earth's natural greenhouse effect has been heightened due to current patterns of energy use and population growth. This is causing the atmosphere to trap more heat, which will increase the global temperature.

In the face of such a gigantic problem, many people feel powerless. They see global warming as beyond their control.

Nothing could be further from the truth. Acting as individuals, Americans can cut emissions at home and on the road, which combined account for one-third of the total national greenhouse gas emissions. And if we pull together, we can transform both industry and lifestyles so that our economy becomes environmentally sustainable for ourselves, our descendants, the Earth, and its wildlife.

GREENHOUSE GLUTTONY

The average American is responsible for the emission of 55,000 pounds of carbon dioxide and its equivalent in other greenhouse gases every year, mainly through the use of energy. These emissions are our global warming "calories." Altogether, we generate some 6 billion tons of greenhouse gases annually.[1] That is more than 20 percent of the world's total, even though the United States has just 5 percent of the world's population.[2]

Automobiles, furnaces, appliances, lights, newspapers, and foam party streamers: using any of these items contributes to our emissions of carbon dioxide or other greenhouse gases. We can easily cut our global warming calories by some commonsense measures that will in most cases also save us money. All we have to do is go on a diet—Audubon's CO_2 Diet for a Greenhouse Planet.

GOING ON THE CO_2 DIET

Regular diet books list the calories found in various foods and explain how to reduce calorie intake. In Audubon's CO_2 Diet we list the global warming "calories" associated with our activities and the products we use. As with a food diet, we set a goal of how many pounds of emissions we can sustain—in this case, for a healthy planet—and embark on a reduction plan.

"Our initial goal is quite modest: reducing at an average rate of 2 percent each year."

Our initial goal is quite modest: reducing at an average rate of 2 percent each year. This will add up to a 20 percent cut within 10 years, which will make a significant contribution toward slowing global warming. And we need to keep cutting at this rate every year until we don't have a problem (see Appendix A).

Because of the lag in the Earth's response to greenhouse gases and because a large fraction of these gases remain in the atmosphere, future generations will have no chance to solve the problem if we don't act now. *We are therefore a critical generation in the history of the world's climate.*

1 Our Greenhouse Planet

Population growth and the unwise use of energy will lead to an increased rate of climate change, adversely affecting wildlife, habitat, and people.

The Earth's atmosphere has been compared to the glass walls of a greenhouse: the presence of certain gases—termed greenhouse gases—causes the atmosphere to trap heat, like a greenhouse on a global scale. This planetary greenhouse effect maintains the temperature of the land and seas and influences climate.

The levels of greenhouse gases depend on natural cycles involving not only the atmosphere but also the oceans, soils, sediments, and the living world, especially plants. Because the natural cycles change slowly over thousands of years, the Earth's climate changes slowly as well. There is a close relationship between the climate and the natural world. Ecosystems can move and wildlife can evolve, but only slowly, at rates matched to the natural cycles of climate change. When changes are too quick or too dramatic, some species do not survive and entire ecosystems are transformed.

CLIMATE DISRUPTION

Because of uncontrolled population growth and a short-sighted choice of technologies, humankind is emitting enormous quantities of greenhouse gases. The amount of greenhouse pollution we spew has gotten so large that it is seriously disrupting the atmospheric processes that affect the Earth's climate. Although there are uncertainties about the magnitude and rate of the changes, many scientists agree that we are greatly speeding up the rate of climate change.[3]

According to scientific models, the changes are likely to be very uneven. While the tropics may be relatively unaffected, the existing ecosystems in the polar regions could be devastated. Changed patterns of rainfall could cause arid regions to be inundated, yet areas now important for growing food could become too dry for agriculture. And plant and animal populations throughout many regions will be thrown out of balance; some species may be driven to extinction.[4]

The burning of biomass such as trees also emits CO_2, but planting trees and plants can compensate for the loss. Unfortunately, however, forests worldwide are being cut down much faster than they can grow back.

GREENHOUSE GASES

The most important greenhouse gas is carbon dioxide (CO_2).[5] Carbon dioxide is emitted when fossil fuels (coal, oil, gas) are burned. Our energy system is now mainly based on burning fossil fuels for transportation, for generating electricity, and for heat. Most of the unnatural CO_2 buildup in the atmosphere causing

CO_2 Calories in Gasoline

When a fuel is burned, most of it becomes exhaust, which ends up in the air. A gallon of gasoline weighs almost 7 pounds, of which about 6 pounds are carbon. When burned, the carbon combines with oxygen to form carbon dioxide. Adding the weight of the oxygen to that of the carbon results in about 22 pounds of CO_2— more than the weight of the unburned gallon of gasoline. That's enough to double the CO_2 concentration in a volume of nearly one-half million cubic feet of air (about the space enclosed by a small shopping center).

global climate change has come from the use of fossil fuels.

Chemicals called halocarbons also have a significant impact on the global climate.[6] Halocarbons are mostly synthetically made and include such compounds as chlorofluorocarbons (CFCs) and halons. Although halocarbons are released in much smaller quantities than CO_2, the global warming impact of a halocarbon molecule can be thousands of times that of a CO_2 molecule. For the CO_2 Diet, we will count halocarbon emissions in pounds of CO_2 equivalence, i.e., the amount of CO_2 that would produce the same global warming effect (see Appendix B).

"If our greenhouse gluttony continues, CO_2 levels will double within the lifetime of our children."

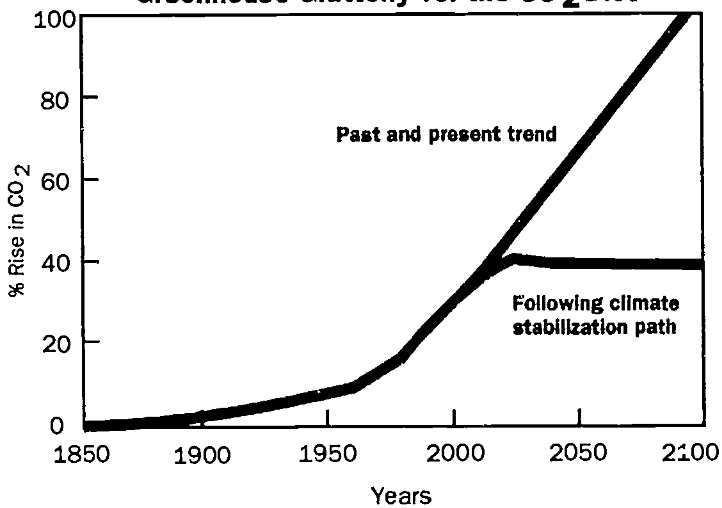
Other gases also contribute to global warming, of which methane (CH_4) and nitrous oxide (N_2O) are the most significant.[7] However, because scientists are currently uncertain about the impact of human activities on the natural atmospheric cycle of these gases, we do not include methane and nitrous oxide emissions in the CO_2 Diet.

Our past and current emissions of greenhouse gases are such that some degree of climate change is inevitable during the next century. But we can decrease the severity of the disruption and slow the rate at which it occurs by reducing greenhouse gas emissions. And if we act quickly, we may buy enough time to mitigate part of the environmental damage and help wildlife to migrate or otherwise adapt to the changes.

The choice we face is illustrated in Figure 1. The higher part of the curve shows the past and present trend of CO_2 levels in the Earth's atmosphere. The levels are climbing steeply, mostly because of our wasteful use of fossil fuels. If this "greenhouse gluttony" continues, CO_2 levels will double within the lifetime of our children, which may cause major climatic disruption, according to scientific models.

The lower part of the curve shows how we can hold down CO_2 levels by following the CO_2 Diet. We are currently approaching the fork on the graph, a critical point. The choice is ours. We can continue the "high calorie" diet that is so unhealthy for the planet or we can change our habits to follow a "low calorie" CO_2 diet that will stabilize our climate.

Figure 1. Atmospheric Carbon Dioxide Levels Greenhouse Gluttony vs. the CO_2 Diet



2

Who Emits What?

Industry is responsible for the lion's share of our greenhouse emissions, but the transportation and residential sectors are also major contributors.

Before we examine individual greenhouse gas emissions, we need to look at the big picture—the United States as a whole. The economy's emissions can be divided into four major sectors: industrial, commercial, residential, and transportation (see Table 1). We have included indirect emissions (e.g., losses at the well, emissions at the refinery, emissions embodied in the manufacturing process) as well as direct emissions (e.g., when fuel is burned).

Table 1. CO_2 emissions per person by sector in the U.S. economy

Sector	Annual CO_2 Emissions lb per person
Industrial	15,400 (35 %)
Transportation	14,500 (33 %)
Residential	7,900 (18 %)
Commercial	6,200 (14 %)
TOTAL	44,000 (100 %)

Note: The energy data for tables in this section are from EIA (1986). Values of carbon emitted per unit of fossil energy consumption are 26, 21, and 14 billion kilograms of carbon per quad (10^{15} Btu), for coal, oil, and natural gas, respectively (from SRI 1979). These values were multiplied by the ratio of molecular weights (44/12) to give CO_2 emissions per unit of energy use.

U.S. EMISSIONS OF CARBON DIOXIDE

U.S. emissions of CO_2 are dominated by industry, which emits the highest proportion of CO_2 (35 percent), primarily through manufacturing processes. Trucks, cars, and other types of transportation also make significant contributions (33 percent). Our homes are responsible for 18 percent of the total; our offices and shops for 14 percent (Table 1).

Figure 2 gives a detailed breakdown of the sources of CO_2 emissions among the sectors. Looking at the figure, we can see that:

In our homes: Most of the CO_2 we emit comes from the use of electricity, primarily appliances and lighting. This is because the generation of electricity currently relies heavily on fossil fuel combustion.[8] Space heating accounts for 37 percent of residential emissions. Water heating (15 percent) and air conditioning (9 percent) make up the remainder.

On the road: Nearly half of CO_2 emissions are from automobiles, while trucks aren't far behind. The "leanest" forms of transportation are, not surprisingly, also the cleanest—bicycling and walking.

In stores and offices, as well as other commercial buildings, most CO_2 emissions are associated with electricity use. Conservation measures targeted at heating, ventilating, air-conditioning, and lighting can greatly reduce commercial CO_2 emissions. Most of us interact with the commercial sector in the workplace and while shopping. However, unless we are managers, it is difficult for us to have a direct effect on the CO_2 emitted here. Indirectly, we can have some impact, for example, by encouraging business people to use energy-efficient products, educating store owners about energy use and its environmental impact, pressuring legislators to support policies that promote energy efficiency, or working with our own employers on energy conservation efforts in the workplace.

Among industries, chemical production, which includes plastics, is by far the most energy intensive, emitting 24 percent of total industrial CO_2. The production of primary metals (16 percent) and paper (11 percent) is also important.

Although it is difficult for the individual to reduce the amount of CO_2 emitted by the industrial sector, if our jobs involve energy-intensive production processes or the use of halocarbons, we should look for ways to reduce the associated greenhouse gas emissions.

U.S. EMISSIONS OF HALOCARBONS

Halocarbons are synthetic chemicals that have become commonplace in our lives. Nationwide halocarbon emissions are shown in Table 2 in terms of their CO_2 equivalent global warming impact. The largest source of emissions is automobile air conditioners. The aver-

Figure 2. Annual CO_2 Emissions in the United States

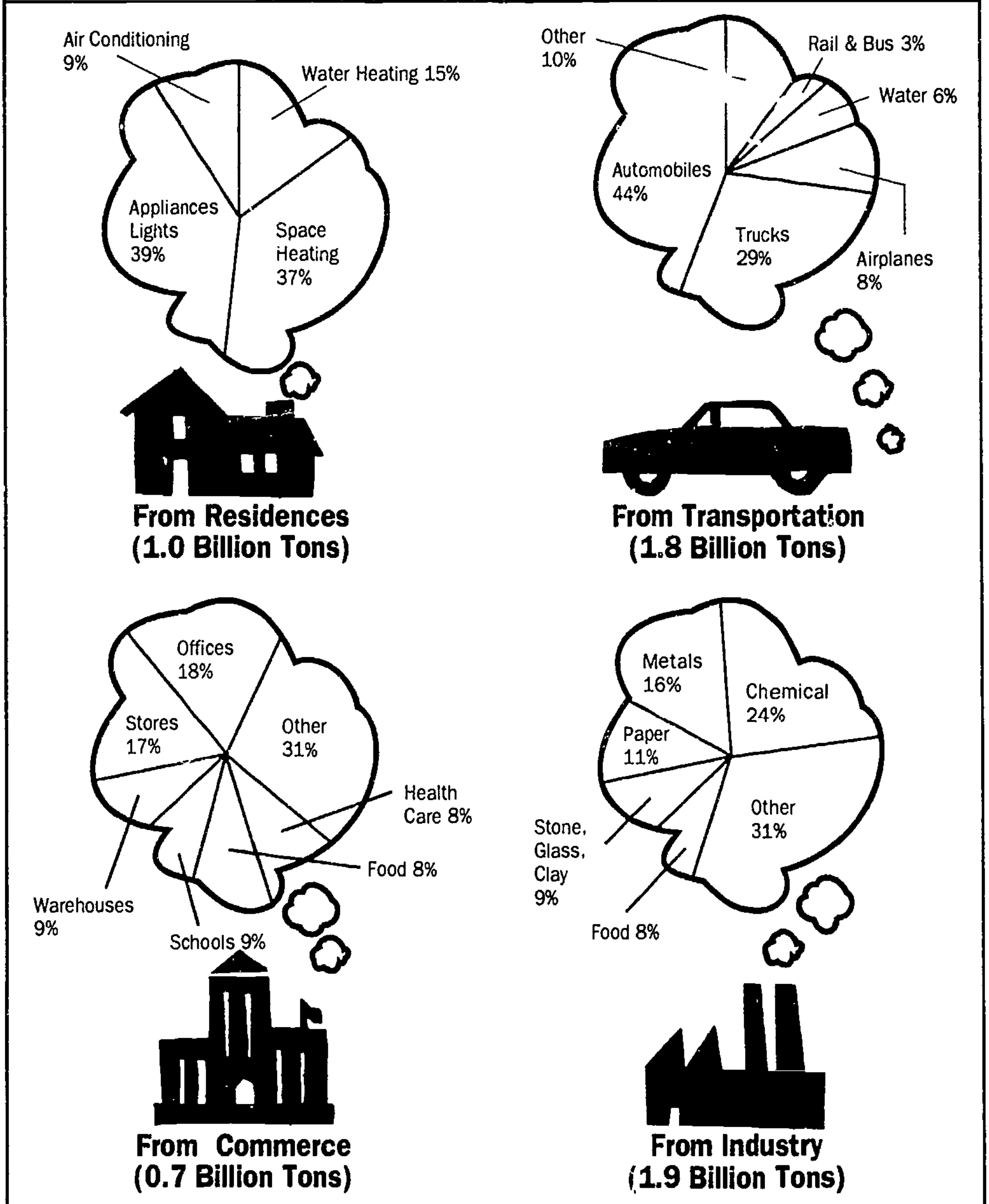


Table 2. Halocarbon emissions per person in the U.S. economy

Activity	**Annual Emissions (lb of CO_2 equivalence)**
Mobile air conditioners	2,640 (24 %)
Solvent cleaning	1,810 (16 %)
Rigid plastic foam insulation	1,760 (16 %)
Retail refrigeration	730 (7 %)
Flexible plastic foam	370 (3 %)
Air conditioning	330 ([illegible] %)
Residential refrigeration	110 (1 %)
Halon fire extinguishers	40 (< 1 %)
Other	3,200 (29 %)
TOTAL (rounded)	11,000 (100 %)

The CO_2 equivalent emissions listed here give the estimated global warming impacts of various halocarbon emission sources, as calculated using the procedures described in Cook (1990) and based on statistics from EPA (1987b,1988).

For mobile air conditioners, the 2,640 pounds of CO_2 equivalence shown in this table is based on nationwide emissions from leakage and servicing, averaged over the entire U.S. population. The 4,800 pounds mentioned in the text is the annual average for each unit, which is greater because not everyone in the U.S. has a mobile air conditioner.

age CFC emission from leakage and servicing of each mobile air conditioner is equivalent to 4,800 pounds of CO_2 per year (see box). Halocarbons are also found in refrigerators (both the cooling system and insulation) and in a number of consumer items.

The CFC-12 released from the average car air conditioner is comparable in its greenhouse impact to the CO_2 emitted in the car's exhaust. For example, driving 10,000 miles per year in a car that gets 25 mpg generates 8,800 pounds of CO_2 while the CO_2 equivalent emissions from the air conditioner add up to an additional 4,800 pounds a year. Having an air conditioner therefore increases a car's global warming impact by more than 50 percent.

Worksheet for helping you calculate what you emit			
Consumption or activity	**Your use (units per year)**	**CO_2 factor (lb CO_2/unit)**	**Annual emissions (lb CO_2 eq.)**
Residential Utilities			
Electricity	kWh	1.5 lb/kWh	
Oil	gallons	22 lb/gal	
Natural gas	therms	11 lb/therm	
Propane or bottled gas	gallons	20 lb/gal	
Transportation			
Automobiles	gallons	22 lb/gal	
Other motor fuel use	gallons	22 lb/gal	
Air travel	miles	0.9 lb/mile	
Bus, urban	miles	0.7 lb/mile	
Bus, intercity	miles	0.2 lb/mile	
Railway or subway	miles	0.6 lb/mile	
Taxi or limousine	miles	1.5 lb/mile	
Household Waste			
Trash (anything discarded)	pounds	3 lb/lb	
Recycled items	pounds	2 lb/lb	
Halocarbon Products			
Refrigerators and freezers	(number)	830 lb each	
Car air conditioners	(number)	4,800 lb each	
Other halocarbon products (see Table 4 for equivalences)			
TOTAL ANNUAL GREENHOUSE GAS EMISSIONS (pounds CO_2 equivalent)			

This worksheet accompanies Chapter 3; see page 75 for an extra copy that you can cut out and fill in.

3

What Do You Emit?

A little arithmetic is all that is needed to estimate personal contributions of CO_2 "calories" from transportation, utilities, halocarbons, and waste.

We have seen the extent of CO_2 and halocarbon emissions in the United States. Now we'll look at how you can estimate your own contribution to global warming so that you can more easily target areas for reduction. If, however, the calculations appear too daunting, you may skip to the next chapter, which explains how to reduce your energy calories.

We've prepared a CO_2 Diet worksheet that will help you calculate your emissions (see facing page). There

Table 3. Estimating your annual carbon dioxide emissions from automobile use

Method A:

Step 1: Divide the number of miles you drive each year by the gas mileage of your vehicle. This gives you the number of gallons of motor fuel you burn each year.

Step 2: Multiply the number of gallons by 22 (pounds of CO_2 per gallon), the emissions factor for gasoline or diesel fuel. The result is your annual emissions, to be entered on the Worksheet.

Method B:

Pick the row of the table that most closely matches the fuel mileage (mpg) for your vehicle and then look in the column that is closest to the number of miles you typically drive each year. The number you arrive at (pounds of CO_2 per year) is to be entered directly on the CO_2 Diet Worksheet.

Mileage	Number of miles driven per year						
(mpg)	5000	7500	10000	12500	15000	17500	20000
10	11000	16500	22000	27500	33000	38500	44000
15	7300	11000	14700	18300	22000	25700	29300
20	5500	8200	11000	13800	16500	19200	22000
25	4400	6600	8800	11000	13200	15400	17600
30	3700	5500	7300	9200	11000	12800	14700
35	3100	4700	6300	7900	9400	11000	12600
40	2800	4100	5500	6900	8200	9600	11000
45	2400	3700	4900	6100	7300	8600	9800
50	2200	3300	4400	5500	6600	7700	8800

are three steps to filling it out. First, you estimate your consumption of fuels and other products that contribute to greenhouse gas emissions (first column). Then you multiply the number of units (kilowatt-hours, gallons, or whatever) of the item you use by its CO_2 emissions factor (second column). This provides the CO_2 emissions for each product or activity, which you fill into the third column. Finally, you add the numbers in the third column to estimate your total annual emissions. Following are more specific explanations of each heading in the worksheet (see Appendix C for technical discussion).

You may be unsure of some of your numbers. Don't give up. It's better to make a rough estimate or even guess at something than to leave it out altogether, or not to do the accounting at all.

Residential Utilities

Divide the dollar amount of your yearly payments for electricity, oil, natural gas, or propane by the unit price. You can find the unit price on a recent bill or receipt, or call your utility company or supplier. If you keep particularly good records, you can also estimate the total by tallying the amounts shown on your bills from the past year. If you buy bottled gas by the cylinder rather than by the gallon, there are about 24 gallons in a standard 100-pound cylinder, so it might be easiest for you to multiply the number of cylinders you use by 24 in order to estimate the number of gallons. Smaller bottles, like those used for portable grills, hold 20 pounds, or about 5 gallons of propane.

If you do not get utility bills because you live in an apartment building that is master-metered, you can ask the superintendent for information on utilities. Even though consumption may vary among apartments, you can make a rough guess at your share by dividing the building's total utility consumption by the number of apartments.

Transportation

For each motorized vehicle you use (car, truck, motorcycle, boat, snowmobile, etc.), divide the number of miles you drive by the average miles per gallon of the vehicle to estimate the number of gallons of gasoline you use in a year (see Table 3 on previous page). Treat diesel fuel just like gasoline. Multiply by the CO_2 factor of 22 to get the total yearly emissions. For example, if your car gets 20 miles per gallon and you drive 10,000 miles a year, your annual use of gasoline is 500 gallons and your CO_2 calories amount to 11,000 pounds. Table 3 includes a tabulation for estimating your CO_2 emissions directly from your car's mileage per gallon and the number of miles you drive each year.

Be sure to include distance traveled in rental cars. In addition, if you are filling out the worksheet for only yourself, rather than for your household, but often travel with others in the car, you can reduce your mileage according to the average ridership of the car. For example, if you drive 10,000 miles with one other person on average, charge yourself for 5,000 miles of emissions.

Also make rough estimates of how far you travel each year by air and other means of transportation. If you belong to a frequent flyer program, you can use the statements to estimate the number of miles traveled (be sure to deduct bonus miles that don't reflect actual travel).

"Make rough estimates of how far you travel each year by air and other means of transportation."

If you commute by public transportation, tally your annual mileage by multiplying the number of trips made by the average distance traveled each trip. For example, suppose your commute involves a 12-mile bus ride followed by a 3-mile metro rail ride, twice a day on 240 workdays a year, for a total of 480 trips per year. The distances would then total 12 x 480 = 5,760 urban bus miles and 3 x 480 = 1,440 rail miles.

Because the energy efficiency and therefore the CO_2 emissions from public transportation varies, the factors we give in the worksheet are based on national averages.

When you take a taxi ride, you will have to make very rough estimates of the distances involved. If you are sharing the taxi, divide the per-trip mileage by the number of passengers.

Household Waste

Estimating the quantity of CO_2 that is emitted in the production and disposal of household waste may be rather tricky, since we're not used to thinking of such things as paper or plastic in pounds. It's better, however, to take a guess at how much you discard than to ignore your CO_2 emissions from trash. The emissions factor we give for garbage is based on national averages of the composition of the waste stream and does not include the contribution from halocarbons.

Recycled goods generally involve less greenhouse gas emissions than goods produced from raw materials. Since the amount saved by recycling varies (see Appendix C), we have provided an approximate emissions factor on the worksheet to reflect lower CO_2 calories for items you recycle.

Here are some hints for estimating the quantity of garbage you generate: For trash that is squashed down by hand, a full 30-gallon garbage bag (large size) holds about 40 pounds, a 10-gallon bag about 13 pounds, and a 5-gallon bag (about the same as a standard paper grocery bag) holds about 7 pounds. Estimate how many bags you generate each week and multiply by 52 weeks per year. If you have a trash compactor, a standard size bag holds about 22 pounds of compressed trash when full. [9]

"Recycled goods generally involve less greenhouse gas emissions than goods produced from raw materials."

For newspapers, a rule of thumb is that a one-foot-high stack of newspaper (about a cubic foot) weighs about 40 pounds. If you get the paper every day, the stack might reach 6 feet in a year, amounting to 240 pounds. (Double this for *The New York Times*!)

Magazines and other paper products are usually heavier, at about 60 pounds per cubic foot. You can also estimate them on a per issue basis: A standard magazine weighs between 6 and 14 ounces. A lightweight magazine (such as *Time* or *Newsweek*) averages about 8 ounces, so a weekly subscription (52 issues a year) adds up to 26 pounds. Heavier magazines (such as *Scientific American* or *National Geographic*) weigh about 14 ounces each, so a monthly subscription to one of these works out to about 10 pounds per year.

Halocarbons

Estimating the primary source of your halocarbon emissions is easy: for every car air conditioner you own, you emit the equivalent of 4,800 pounds of CO_2. Remember that these emissions occur regardless of whether or not you use the air conditioner.

Similarly, note the number of refrigerators or freezers you have—each contributes an average of 830 pounds of CO_2 equivalent emissions each year (this is in addition to the emissions from the electricity they use, which is counted under utility use).

"For every car air conditioner you own, you emit the equivalent of 4,800 pounds of CO_2."

For other products that contain halocarbons, you can use the CO_2 equivalence factors given in Table 4 to estimate your emissions. In the case of major appliances (such as air conditioners), get an annual emission figure by dividing the total greenhouse gas content (in CO_2 equivalents) by the number of years you keep the item.[10]

YOUR TOTAL GREENHOUSE CALORIES

Now you are ready to add up all the emissions numbers in the last column of the worksheet and enter the sum on the bottom line. This is the total number of greenhouse calories emitted by you or your household. The worksheet covers only emissions associated with residential activities and personal transportation. The United States average for this portion of overall

Table 4. CO_2 equivalences of halocarbons in consumer items

Item	Halocarbon content	Pounds of CO_2 equivalent
Air conditioners		
Automobile	3.3 lbs CFC-12	17,500
Central	4.4 lbs CFC-22	6,200
Room	0.9 lbs CFC-22	1,200
Refrigerators or freezers		8,300
In insulation	2.2 lbs CFC-11	
In cooling system	0.4 lbs CFC-12	
Portable halon fire extinguisher	1.6 lbs Halon-1211	2,700
Foam insulation (4'x 8'x 1" sheet)	0.9 lbs CFC-11	2,400
CFCs in cans		
"Air" horn	1.0 lbs CFC-12	5,300
Dust remover	0.7 lbs CFC-12	4,000
Foam party streamers	0.3 lbs CFC-12	1,800
"Air" brush cartridge	0.2 lbs CFC-12	1,200
Spray spot remover or electronic parts cleaner	0.3 lbs CFC-113	1,000

Note: For some of these items, the halocarbon content may not be completely released for some time. That is why different values, representing typical release rates, are used for auto air conditioners and refrigerators on the CO_2 Diet worksheet. Other items may have larger releases depending on use. For instance, if you use "air" brush cartridges containing CFC-12 as propellant at a rate of two a month, that's 24 cartridges a year, resulting in a whopping emission of 28,800 pounds per year of CO_2 equivalence.

annual emissions is about 18,000 pounds of CO_2 equivalence per person,[11] which is one-third of the overall annual average of 55,000 pounds per person discussed in the introduction. For a four-person household, then, the worksheet total would average 72,000 pounds of CO_2 greenhouse calories per year.

Keep in mind that the emission factors listed in this report are based on national averages. They do not take into account regional differences, such as the different sources used for electricity generation (hydroelectric power plants do not emit CO_2, while coal-fired plants do). Similarly, our tips on CO_2 calorie cutting are also based on average statistics.

4

Going on the CO_2 Diet

Going on the CO_2 Diet saves energy and money. Audubon's tips target home heating and cooling, appliances, lighting, motor vehicles, halocarbons, and waste.

Now that you know how to count your CO_2 "calories," it's time to figure out a personal reduction plan. As in a food diet, the best way to reduce is to look at the items that have the most calories. For most people, the "fat" in greenhouse emissions is found in transportation, home heating, and cooling.

Let's suppose your household adds up greenhouse gas emissions and they total 40,000 pounds of CO_2 equivalence per year. Following the CO_2 Diet guideline of a

2 percent reduction each year, you need to find a way to cut an average of 800 pounds of emissions yearly.

To go on the CO_2 Diet, all you have to do is turn to the "calorie cutters" listed here and figure out the most painless way of reducing your total emissions by that amount. If you can cut more, even better. You can get a head start on reaching the ten-year goal of decreasing your greenhouse gas emissions 20 percent, to 32,000 pounds per year.

On the other hand, if you live in a superinsulated house with efficient appliances and fluorescent lighting, recycle most of your garbage, and drive very little in a 50-miles-per-gallon non-air-conditioned vehicle, you are already well below average in CO_2 emissions—keep up the good work!

GREENHOUSE CALORIE CUTTERS

Home Heating and Cooling

Have your furnace or boiler tuned up. Each percentage gain in combustion efficiency from a tune-up will cut your heating system's CO_2 emissions by at least the same percentage. Furnace efficiency varies greatly. Your serviceman should be able to give you the efficiencies before and after a tune-up; multiply the increase in efficiency by your heating fuel CO_2 emissions to estimate the greenhouse emissions reduction from the tune-up.

If you need to replace your furnace or boiler, buy a new high-efficiency model. You can expect a gain of 10 percent or more in heating efficiency. Improving the efficiency of an oil- or gas-fired system from 65 percent to 85 percent will reduce fuel use and CO_2 emissions by 24 percent over one heating season. If your current greenhouse calories for heating are 15,000 pounds of CO_2 per year (the national average for households with oil heat), an efficiency improvement like this would cut 3,600 pounds of CO_2 emissions.

Lower your thermostat by 2°F in winter. In a typical house, this would reduce heating-fuel-related CO_2 emissions by 6 percent. (In mild climates the percent reduction can be much greater.) For example, if your worksheet now shows emissions of 7,000 pounds of CO_2 per year for your heating fuel, this measure could trim your greenhouse emissions by 420 pounds.

Turn your thermostat down 10°F *at night for eight hours* (an automatic thermostat setback prevents you from forgetting). The general rule of thumb is that for every 1°F reduction over an eight-hour period, CO_2 emissions are reduced 1 percent.

Apply "superinsulation" principles to your home. Increase insulation in walls, ceilings, floors; add layers of window glazing; and control ventilation. The emissions reduction you'll obtain from insulation and weatherization measures depends on the kind of shape your house is in and the extent of the measures you take. We can't predict how much your emissions will be reduced, but for many people, the cuts will be substantial; you'll know the results when you get your lower energy bills.

"For every 1°F reduction on your thermostat over an eight-hour period, CO_2 emissions are reduced 1 percent."

Set your air conditioner thermostat higher. If you have central air conditioning, raising the setting from 75°F to 78°F can reduce your electricity bill by about 8 percent, with a corresponding reduction in electricity-related CO_2 emissions.

Water Heating

Insulate your water heater. For gas heaters, this can save 20 therms and 220 pounds of CO_2 a year; for electric, 700 kilowatt-hours and 1,100 pounds of CO_2.[12]

If you need a new water heater, buy a more efficient and less polluting model. If you use electricity for water heating, consider a heat-pump water heater, which can greatly reduce electricity consumption compared to conventional electric water heaters. In many areas, solar water heating is cost effective and can result in greatly lowered CO_2 emissions.

Install low-flow showerheads. If you heat water with gas, you can save 8 therms and 80 pounds of CO_2; with electricity, you can save 200 kilowatt-hours and 300 pounds of CO_2. You can cut additional greenhouse calories by installing aerators on kitchen and bathroom faucets that don't have them.

Also, don't leave the water running unnecessarily—fill the sink or a basin instead. Little measures like this can really add up. Suppose you now leave the hot water running continuously while you are showering, shaving, and doing dishes. Using a basin or filling the sink and running the water just for the actual washing and rinsing can easily save 30 to 40 gallons of hot water a day. Do this every day, and your greenhouse calories can be cut by 1,200 (gas water heater) to 3,800 (electric) pounds of CO_2 per year.[13]

"When showering, shaving or washing dishes, running the water only when actually washing and rinsing can save 30 to 40 gallons of hot water a day and between 1,200 and 3,800 pounds of CO_2 a year."

Wash clothes in cold water when possible. If you do four out of five washes in cold water, you can cut out as much as 350 pounds of CO_2 emissions if you use gas and 1,000 pounds if you use electricity. Also, remember always to do full loads—that saves water as well as cuts greenhouse calories.

Appliances

On average, the use of electricity translates into the emission of 1.5 pounds of CO_2 per kilowat-hour, so *select an efficient model when you buy a new appliance.* Be particularly careful in choosing a refrigerator, which is a major electricity user. Other major appliances for which you should be sure to buy efficient models are air conditioners, clothes washers, and dishwashers. For example, a front-loading clothes washer uses less hot water than a top-loader to wash the same amount of clothes and so cuts emissions.

Refrigerator efficiency has improved over the last 15 years. Labels on new refrigerators show their expected yearly use of electricity in kilowatt-hours; select a model that has a low rating for its size group. It may be difficult to know exactly how much energy your old refrigerator used, but replacing it with a more efficient model will certainly help your CO_2 Diet.

For example, replacing a 12-year-old model that might use 1,500 kWh/yr, with a new model of the same size rated at 850 kWh/yr would reduce your electricity use by 650 kilowatt-hours and your CO_2 emissions by 1,000 pounds a year.

Refrigerators contain halocarbons (CFCs), mostly in the foam insulation, which will eventually be released into the air when the refrigerator is discarded. That's why we don't recommend replacing an old refrigerator solely to decrease emissions of greenhouse gases. In fact, if you have extra space you might consider storing an old refrigerator until CFC recovery methods become available.

"Replacing a 100-watt incandescent bulb used six hours a day with a compact fluorescent can save 260 pounds of CO_2 annually."

Lighting

Use compact fluorescent bulbs. These use only 20 to 40 percent of the electricity of incandescent bulbs. Replacing a 100-watt incandescent bulb used six hours a day with a compact fluorescent can cut out 260 pounds of CO_2 a year as well as pay for itself in about a year through the electricity savings. Compact fluorescents are most cost-effective when they are used in light fixtures that get the most hours of use, as, for example, lights that stay on all night or most of the day.

Other energy-saving bulbs are available for use in lighting fixtures that compact fluorescents can't fit. These include tungsten-halogen incandescents, which can cut power use by half. The "energy-saver" variety of ordinary light bulbs do cut electricity use and the CO_2 emissions that go along with it by 5 to 10 percent; these are worthwhile, but go for fluorescents to get larger savings in energy use.

Turn off lights and appliances when they are not needed. Don't forget this old-fashioned, commonsense measure!

Motor Vehicles

You can reduce CO_2 emissions from your car by conserving gasoline. So, when possible, minimize driving by combining trips, car pooling, using public transportation, and walking or bicycling. If you have a 25-miles-per-gallon car and reduce your annual driving from 12,000 to 10,000 miles, your annual CO_2 emissions will drop by 1,800 pounds. Keep your car well tuned-up, the tires properly inflated, and hold your highway driving speed to 55 miles per hour. The average efficiency improvement from a tune-up is 9 percent. The difference between driving 10,000 miles a year in a poorly tuned versus a well tuned car that gets 20 miles per gallon (the national average) is about 1,100 pounds of CO_2—to say nothing of the added benefit of reducing the air pollution in the exhaust.

"If you have a 25-mpg car and reduce your annual driving from 12,000 to 10,000 miles, your annual CO_2 emissions will drop by 1,800 pounds."

Avoid auto air conditioners. Remember that just having one results in CFC emissions equivalent to 4,800 pounds of carbon dioxide a year—whether or not you use it. If, however, you live in a warm climate, and can't do without an air conditioner, there are ways to lessen its impact. Leakage accounts for over half of CFC emissions, so make sure that the hoses and connections are in good condition. As old hoses break, replace them with new models that have a barrier layer of nylon that reduces leakage by 90 percent. Make sure to patronize service shops that have CFC recycling equipment.

Alternative refrigerants (such as HFC-134a) that have less of an impact on global warming are being tested for use in mobile air conditioners. These are expected to become available in the mid-1990s, so if you can, put off buying a car with an air conditioner until then.

Halocarbon Products

Avoid non-essential uses of CFCs and halons, such as spray foam party streamers, bike horns, and spray spot removers. In items such as these, CFC-12 is merely used as a source of pressure. In many cases, compressed air would work just as well. (Some manufacturers came out with replacement sprays containing a flammable propellant instead of CFCs; these pose a fire hazard and some of them have since been recalled.)

The CFCs in the cooling systems of home air conditioners, refrigerators, and freezers are generally released only during servicing and upon disposal. Venting during servicing can be avoided by patronizing shops that use CFC recovery equipment. Some repair shops may soon begin using plastic bags to capture CFCs during servicing. Call your local government and electrical utility to see if a recovery program exists in your area. Even if it doesn't, your call will help put pressure on organizations to introduce one.

"If everyone recycled paper products, we would reduce related CO_2 emissions by 30 percent."

Waste

Cut down on waste at home by avoiding products that are over-packaged, recycling as many items as possible, and buying recycled products. If everyone recycled just paper products (such as magazines and newspapers), we'd not only have less of a garbage crisis, but we'd also reduce paper-related CO_2 emissions by 30 percent. Recycling aluminum cans will cut associated emissions by 85 percent—that's over half a pound of CO_2 saved for each can. Recycling glass can cut emissions by about 30 percent. Also, use utensils, cups, containers, etc., that are reuseable.

Tree Planting

Just as you can improve your nutrition by adding lots of greens, so you can improve your CO_2 Diet by planting trees. Trees remove carbon dioxide from the air and use it to grow. One tree can absorb an average of 26 pounds of CO_2 a year. Depending on the tree's size and placement, the CO_2 calorie reduction from a tree can be as much as 300 pounds a year because of the cooling and heating energy savings from using the tree to shelter your house from direct summer sunlight and chilling winter winds.[14]

CALORIE CUTTING IN THE FUTURE

"We need to work together to pressure government and industry to improve technologies and provide incentives for an environmentally sustainable lifestyle."

Don't become disheartened if you have gone through the diet tips and found it difficult to attain your 20 percent goal. In some cases people have already made most of the improvements possible today, given current fossil-fuel based technologies and the cost of new products. Therefore, we also need to work together to pressure government and industry to improve technologies and provide incentives for an environmentally sustainable lifestyle.

The political will mustered to address the energy crisis in the 1970s has already resulted in significant improvements in energy efficiency. CO_2 emissions would be even greater today if it weren't for automobile fuel efficiency standards, which have saved energy nationwide, as well as kept oil prices down. New products that reduce our CO_2 calories roll off the assembly lines every year. For example, a whole array of new lighting products, both fluorescent and improved incandescents, is in the stores. [15] Heat pump clothes dryers are being developed that not only save energy and reduce CO_2 emissions but also get rid of the need for a dryer exhaust vent (having a drain pipe instead). The efficiency of most major appliances, such as refrigerators, freezers, ranges, ovens, and air conditioners will also improve continually in the years ahead.

We need to keep the pressure on government and industry. First, we need t[illegible]rm ourselves about the technological choice[illegible]o us. Then we need to work with our sta[illegible]ederal governments to require industry to sup[illegible] products and services that are low on CO_2 calories. It is possible for cars to more than double their fuel efficiency, for example, but we must first require industry to produce them. Super-insulated homes use far less energy than others; we need standards that will bring all homes up to that level.

FOR MORE INFORMATION

A good source of information on efficient appliances, including furnaces, boilers, water heaters, and air conditioners, is The Most Energy-Efficient Appliances, *a booklet updated annually by the American Council for an Energy-Efficient Economy (ACEEE), 1001 Connecticut Avenue NW, Suite 535, Washington, DC 20036 (available for $3).*

An excellent series of booklets on energy saving, covering the topics of Home Appliances, Weatherization, Insulation, *and* Heating Systems, *can be purchased from the Massachusetts Audubon Society, S. Great Rd., Lincoln, MA 01773 (617-259-9500).*

State-of-the-art information on home insulation is given in The Superinsulated Home Book *by Nisson and Dutt (published by Wiley, 1985). This book explains how to apply energy efficiency in new construction and provides guidelines for existing homes.*

For warmer climates, a guide for energy-efficient home building and many fact sheets on appropriate conservation measures and solar water heating are available from the Florida Solar Energy Center (300 State Road 401, Cape Canaveral, FL 32920).

Many of the tips given in the book 50 Simple Things You Can Do to Save the Earth *(EarthWorks Group, 1989) apply to cutting* CO_2 *emissions and can be used to supplement the measures we have suggested here.*

Most states have offices that provide information on energy efficiency particular to their region. Utility companies are also a source of information, and some of them may offer audits that can help you identify the best ways to save energy in your own situation.

5

An Audubon Staffer Goes On a CO_2 Diet

CO_2 "calories" can be cut through a combination of informed choices and wise investments. An Audubon staffer shows how it is done.

As authors of the *CO_2 Diet for a Greenhouse Planet*, we have practiced the diet ourselves—and lost "weight." Following is a personal account of how the two-person household of one of our authors measured up.

COUNTING OUR CALORIES

The two of us rent rather than own our house and have two small cars and an old truck. We both work for environmental organizations, which involves a lot of

Worksheet for sample household			
Consumption or activity	**Your use (units per year)**	**CO_2 factor (lb CO_2/unit)**	**Annual emissions (lb CO_2 eq.)**
Residential Utilities			
Electricity	7,200 kWh	1.5 lb/kWh	10,800
Oil	625 gallons	22 lb/gal	13,800
Natural gas	0 therms	11 lb/therm	0
Propane or bottled gas	70 gallons	20 lb/gal	1,400
Transportation			
Automobiles	550 gallons	22 lb/gal	12,100
Other motor fuel use	0 gallons	22 lb/gal	0
Air travel	23,000 miles	0.9 lb/mile	20,700
Bus, urban	0 miles	0.7 lb/mile	0
Bus, intercity	0 miles	0.2 lb/mile	0
Railway or subway	1,500 miles	0.6 lb/mile	900
Taxi or limousine	400 miles	1.5 lb/mile	600
Household Waste			
Trash (anything discarded)	2,200 pounds	3 lb/lb	6,600
Recycled items	320 pounds	2 lb/lb	640
Halocarbon Products			
Refrigerators and freezers	1 (number)	830 lb each	830
Car air conditioners	0 (number)	4,800 lb each	0
Other halocarbon products (see Table 4 for equivalences)			240
TOTAL ANNUAL GREENHOUSE GAS EMISSIONS (pounds CO_2 equivalent)			68,600

business travel, so airplane travel is a large source of our CO_2 emissions. Our CO_2 Diet worksheet is shown on the facing page. Here is how we filled it out.

Our last electric bill was $52. We didn't save all of our electric bills, but glancing through the checkbook shows that a monthly bill is usually in the low $50s but sometimes higher in mid-summer. We took $54 as an average and then multiplied by 12 months to get $648. The price on the bill was $.09 per kWh, so dividing the $648 by this gives an estimate of 7,200 kWh yearly.

Oil use was easier to determine since we had a record of our deliveries. We added up the total number of gallons (625) and filled in this number on line 2 of the worksheet.

We do 't have natural gas, but us(ıbout 3 cylinders of propane a year for the kitchen stove; at 23.5 gallons for a 100 pound cylinder, this totals 70 gallons a year.

Of our two cars, the larger one gets used more than the smaller one (it's more comfortable!). Even our larger car is a compact model, however, and it averages 33 miles per gallon. It was driven about 12,000 miles last year. We divided that figure by 33 mpg for an estimate of 360 gallons of gasoline. A similar calculation for the smaller, 36-mpg car gave us an estimate of 140 gallons. We also have an old panel truck; we only drove it about 500 miles last year, but at 10 mpg, it burned 50 gallons of gasoline. Our total gasoline use therefore totals 550 gallons for the year.

Most of our public transportation mileage is by air. We figured round-trip mileages for two cross-country trips at 12,000 miles, one overseas trip at 8,000 miles, and 6 shorter trips of 500 miles each. These total 23,000 miles. We came up with estimates for rail miles in a similar fashion, by counting trips and making a rough guess of the distance per trip.

By taxi or limo, we took 3 round trips of 50 miles each (150 miles), about a dozen 10-mile trips (120 miles), 20 short, 5-mile trips taken alone (100 miles); and another 10 short trips shared with another passenger (25 miles); these add up to 395 miles (which we rounded to 400 miles).

We throw away about 6 brown bags full of garbage each week. Using the rule of thumb that each bag weighs 7 pounds, that amounts to 42 pounds per week. Multiplying by 52 weeks gave us a total of about 2,200 pounds per year, which we filled in on the garbage and discarded paper line on the worksheet. We recycle our newspaper, which weighs about 6 pounds per week, totaling about 320 pounds per year. [16]

As for the items we own that contain halocarbons, we have one refrigerator and two window air conditioners. We don't have air conditioners in our cars. The one refrigerator accounts for 830 pounds per year of CO_2 equivalent emissions.

"Our household waste was responsible for about 2,520 pounds of CO_2 emissions a year."

Looking at Table 4, we see that an average room air conditioner contains 1,200 pounds of CO_2 equivalence. Assuming that the air conditioner lasts for 10 years, we divided by 10. This yields 120 pounds for each room air conditioner, or a total of 240 pounds of CO_2 equivalence a year.

To complete our worksheet, we multiplied the numbers under the "your use" column by the corresponding CO_2 emissions factors in the middle column, writing the resulting emissions estimates in the last column (under "CO_2 emissions") of the worksheet. Adding up these figures resulted in a grand total of 68,600 pounds of CO_2 equivalence for our two-person household.

OUR CO_2 REDUCTION PLAN

To meet Audubon's 2 percent annual reduction goal, we have to start cutting our emissions by 1,370 pounds per year, or a total of about 13,700 pounds over the next ten years (see Table 5). We figured a good way to begin was to examine the items causing the greatest CO_2 emissions and identify what we could do now, and then look at areas we could improve over the long term.

WHAT WE ARE DOING NOW

Heating

Our largest emissions at home come from oil used for heating. Our oil burner hadn't been serviced in a while and it turned out that it needed a tune-up. The serviceman measured the efficiency before and after the tune-up, and identified an efficiency gain of 9 percent. That will cut our oil-related emissions by at least 9 percent, for a reduction of 1,200 pounds of CO_2 a year. If we keep the burner in tune, this will cover nearly a year of our CO_2 Diet goal.

"Tuning up our oil burner saved us 1,200 pounds of greenhouse gas emissions—nearly a year of our CO_2 Diet goal."

We already use a night setback and can't reduce our thermostat setting further without sacrificing comfort.

Transportation

Our largest source of emissions is air travel. We don't have much discretion over this, so we're stuck with this portion of our greenhouse gas emissions for right now. Hopefully, improved fuel efficiency by commercial airlines will help us to decrease our emissions in the future—airline fuel efficiency has already increased by over 20 percent since 1980 and has doubled since 1970. [17]

Filling out our worksheet made us notice how much more often we use the larger car compared to the

Table 5. CO_2 Diet reducing plan for our sample household

Worksheet findings	**CO_2 calories (in lb)**
Our current annual emissions	68,600
Annual average reduction needed (2%)	1,370
Our ten-year reduction goal	13,700
What we are doing now	**CO_2 calories cut (in lb)**
Boiler tune-up	1,200
Fluorescent lighting	1,030
Using smaller car more often	880
Subtotal (rounded)	3,100
What we can do in the next ten years	
Storm windows	3,200
More efficient refrigerator	1,500
Replace 33-mpg car with 40-mpg car	900
Bicycling for errands	600
Subtotal	6,200
What we can do if we work together	
40% community recycling	900
Getting a 50-mpg car instead of a 40-mpg car	900
Further lighting efficiency	500
Improved airline fuel efficiency	2,100
High-efficiency furnace	1,000
Elimination of global impact CFCs	1,070
Subtotal (rounded)	6,500
Total reduction over ten years (rounded)	**15,800**

smaller one. If we save the larger car for two-person, long trips, cutting its annual miles from 12,000 to 8,000 (it gets about 33 mpg), and use the smaller car for 8,000 miles (it gets about 36 mpg), we'll save 40 gallons per year, a reduction of 880 pounds of CO_2 a year—another 6 months of the CO_2 Diet goal.

Lighting and Appliances

To reduce electricity-related emissions, we used three 13-watt compact fluorescent bulbs (replacing 60-watt bulbs) in a fixture that is on 8 hours a day—cutting 630 pounds of CO_2 a year. We put one 22-watt bulb (100 watt replacement) in a 12-hour-per-day lamp and another in a 4-hour-a-day-lamp to save another 400 pounds of CO_2 a year.

We didn't include such common measures in our plan as low-flow showerheads, faucet aerators, water heater insulation, and cold water washing because we were already doing them to save energy.

Adding up our CO_2 calorie reductions in these three areas gives us a total of 3,100 pounds, which is a two-year head start toward our ten-year goal.

"Replacing incandescent bulbs with fluorescents saved us 1,000 pounds of CO_2."

WHAT WE CAN DO IN THE NEXT TEN YEARS

Some of our biggest potential calorie cutters will require monetary investments, which means we will not be able to take action on all of them right away.

Heating

We can improve the energy efficiency of our home by adding storm windows and we are fortunate enough to have a landlord who is willing to make this improvement. Since most of our windows have a single pane, adding storm windows will lower our oil bill as well as cut our global warming calories about 3,200 pounds. [18]

Transportation

Automobile fuel efficiency is gradually improving, and when the time comes to replace one of our cars, we will buy a model that gets at least 40 mpg. Even if we drive the same number of miles each year, this will cut our CO_2 calories by 900 pounds. But we really don't have to drive so much. Because we live within just a few miles of where we run most of our errands, we can probably cut 1,000 miles per year by bicycle use, even if we bike only in decent weather. This will cut another 600 pounds of CO_2 calories as well as help burn off food calories!

Electricity

Our big CO_2 emitter related to electricity is the refrigerator, since we use the air conditioner only a few weeks in mid-summer and our hot water is heated by oil. Our current refrigerator is a second-hand behemoth, complete with poor door seals, thin walls, and heater strips. We're not quite ready to replace our refrigerator yet; however, when we have the money, buying a newer, more efficient refrigerator should easily save us 1,000 kWh of electricity per year.

"We can realistically expect to achieve a 14 percent cut in CO_2 calories over 10 years, but need improved technologies and financial incentives if we are to attain the remaining 6 percent of our goal."

As summarized in Table 5, these measures, which we can implement ourselves over the next several years, total 6,200 pounds. Adding these to the 3,100 pounds by which we've already cut our CO_2 calories brings the total up to 9,300 pounds. Comparing this to our 10-year goal of 13,700 pounds, we see that our emissions are still 4,400 pounds too high. Consequently, we can realistically expect to achieve only a 14 percent cut in our CO_2 calories by ourselves, rather than the 20 percent that is needed.

WHAT WE CAN DO IF WE WORK TOGETHER

Further CO_2 calorie cutting is technically possible, but truly "lo-cal" technologies and products have not yet been made available. We need to work together to place pressure on government and industry to provide us with the tools we need to lead a CO_2-lean life. Just as industry has developed many products using low-calorie sugar replacements and low-fat substitutes, so it should develop products that are low on greenhouse gas emissions. Similarly, we need to require government and business to work out ways to favor investment in efficiency improvement that are socially beneficial. Some examples particular to our household follow:

Heating

It is not likely that our furnace will wear out in the next 10 years, but even now oil burners are available that have efficiencies as high as 90 percent. However, since we currently rent our house, it would be financially heroic for us to spend money on a new furnace for a house in which we may stay only a few years. If we were to buy the house, such an investment might be more worthwhile. Moreover, most landlords are not likely to replace the furnace since they don't pay the heating bill. So right now neither we nor our landlord have the financial incentive to replace our furnace with a better model. If business and government were to provide incentives (such as a way of sharing the fuel savings), we could cut another 1,000 pounds of CO_2 a year by installing a high-efficiency furnace.

"Just as industry has developed many products using low-calorie sugar replacements and low-fat substitutes, so it should develop products that are low on greenhouse gas emissions."

Lighting

We can also make further improvements in our lighting efficiency if new lamps and fixtures become available. We expect that improvements in our household lighting efficiency could result in cutting another 500 pounds of CO_2 calories.

Transportation

If improved fuel-efficiency standards are legislated, we should be able to replace our 36-mpg car with a 50-mpg model, rather than a 40-mpg model as we assumed earlier. This would cut an additional 900 pounds of CO_2 calories. In addition, if airline fuel efficiency improves by about 10 percent over the next ten years (this is about half the rate of improvement over the past ten years), our air-related travel emissions can be cut by 2,100 pounds.

Those of us who live in urban areas should also press for improved mass transit and ways to encourage bicycle use. Such measures, if widely implemented, would provide significant cuts in greenhouse gas emissions as well as reduce urban air pollution.

Waste

Our garbage-related emissions are sizable as well. We are already recycling what we can, given the recycling options available in our community. To reduce garbage-related emissions further, we need to push for policies that reduce the sources of waste and provide for more comprehensive recycling programs. It is very likely that with good programs our community will achieve a 40 percent recycling rate. Even without the likely improvements in processing energy efficiency, this will result in a one-third cut in that portion of our trash-related CO_2 emissions. That's 40 percent x 33 percent x 6,600 pounds, a cut of about 900 pounds.

"With continued political pressure it is likely that safe replacements will be found for the halocarbons and other chemicals that now cause global warming."

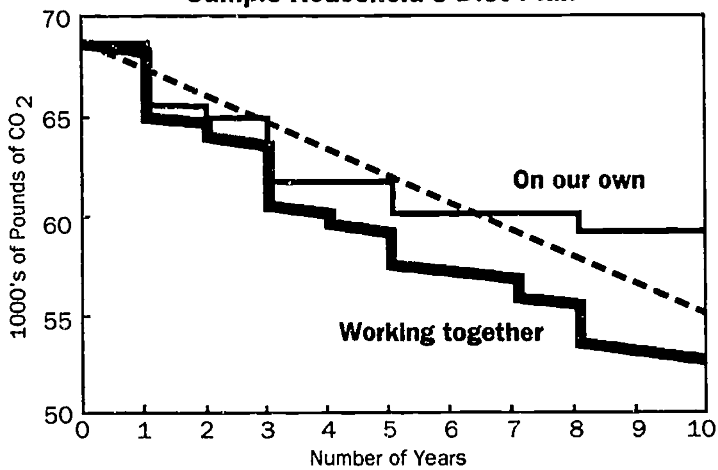
Halocarbons

International agreements are already in place to phase out halocarbons that damage the ozone layer. With continued political pressure, it is likely that safe replacements will be found for the halocarbons and other chemicals that now cause global warming. Our refrigerator and air conditioning-related CFC emissions can therefore be cut out entirely, for a savings of 1,070 pounds.

CHARTING OUR DIET PROGRESS

Figure 3 illustrates our sample household's CO_2 diet possibilities. The graph shows annual greenhouse gas emissions (as thousands of pounds of CO_2 equivalence per year) plotted over the next ten years. The dotted line is our CO_2 Diet target—an average calorie cutting rate of 2 percent per year, decreasing our emissions level by 20 percent, to 54,900 pounds in 10 years. The upper line shows the step-by-step reductions we can make with our individual efforts. In the first year, we reduce emissions by 3,100 pounds, based on the actions we've already taken (see Table 5). Over the following 10 years, we can cut by another 6,200 pounds. However, as the figure shows, if we only act by ourselves, we'll fall short of our ten-year goal.

Figure 3. CO_2 Emission Reductions
Sample Household's Diet Plan



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The lower line shows the calorie-cutting path we can take if government and industry commit themselves to reducing greenhouse gas emissions. With this sort of national commitment, we can expect to reach our emissions reduction goal. The steady decrease of emissions every year is partially due to increasing community recycling rates, a phase-out of harmful halocarbons, and other gains, such as airline fuel efficiency improvements. A national effort to remove disincentives to investing in improved technologies, such as better lighting and high-efficiency furnaces, will also play a role. Finally, some of the actions we take on our own can result in bigger cuts with national support. For example, if better automobile mileage standards are enacted, we will be able to get a 50-mpg-model rather than a 40-mpg-model when we replace our car. This would cut 1,800 pounds of CO_2 (versus 900 pounds). With collective efforts by individuals, industry, and government, a 20 percent cut in ten years is achievable, and as with our sample household, we may even do better than our target, giving us a lead on the much greater cuts ultimately needed.

6

Conclusion

Individual action must be supplemented by governmental action to help the entire U.S. economy go on a CO_2 Diet through improved energy policies, technologies, and investment.

We have seen that it is fairly easy for individuals to make a difference in solving the global warming problem by making informed choices about reducing greenhouse emissions in homes and transportation. They can shed CO_2 calories through a combination of management, investment, and sacrifice.[19] Tuning an oil burner or using a night setback involves management. Purchasing efficient appliances, and a new, more efficient car is an investment. Choosing to use a small car more frequently may be viewed as a sacrifice (e.g., of comfort).

However, while our sample household demonstrated that it was possible to cut its CO_2 calories by 14 percent over 10 years—it fell short of Audubon's 20 percent near-term goal by 6 percent. Based on these figures, we find that individual action alone is unlikely to achieve more than a 5 percent cut in U.S. emissions over the next 10 years, given that individuals are directly responsible for only a third of the nation's emissions. To attain a national cut of 20 percent, therefore, we must require industry and business to cut 300 CO_2 calories for every 100 cut by an individual.[20]

Ultimately, we can expect the biggest saving in greenhouse emissions to come through investment in technologies that are more efficient and less polluting. If, as a society, we make the right investments, our impacts will be easier to manage and we can maintain a high quality of life without the need for sacrifices.

We need, therefore, to push for policy changes to create even more efficient cars, more efficient appliances, benign replacements for halocarbons, and better access to energy conservation services and products. Decision makers need to redirect capital investments and public subsidies away from fossil fuel and other non-renewable energy supply systems, and promote the development of renewable sources of energy.

Audubon's *CO_2 Diet for a Greenhouse Planet* will help concerned individuals make a difference. But to really cut "fat" from our greenhouse emissions, the whole economy will have to go on a CO_2 Diet. It will take national as well as personal action to make that happen. By making a personal commitment to change, we will build the public consensus needed to achieve a healthy and sustainable global environment.

A

Appendix A

How Much Do We Need to Cut?

Climate scientists have performed careful analyses of the kinds of emission reductions needed to avoid a severe buildup of greenhouse gases. They conclude that over the next century, the cumulative worldwide CO_2 emissions from fossil fuels should be limited to about 1 trillion tons.[21] (This can be thought of as a global budget of greenhouse gas emissions for the people of the world.)

Ideally, the right to emit carbon dioxide should be allocated equitably across the globe. However, industrialized countries have already caused far more greenhouse gas pollution than developing countries. In fact, on the basis of simple equity, some industrialized countries—the United States in particular—have already used up their fair share of the world's fossil carbon budget.

To compensate for exceeding their share of the global CO_2 budget, industrialized countries need to start making immediate and drastic cuts in their greenhouse gas emissions by the first half of the next century. They should also provide technical and economic assistance to help developing countries build economies that are less dependent on fossil fuels.

Under one plan currently proposed,[22] industrialized countries would be collectively responsible for CO_2 emissions reductions of 20 percent by the year 2005; subsequent cuts needed would be 50 percent by 2015, and 75 percent by 2030. This goal has been endorsed by scientists worldwide. However, even among industrialized countries, the United States bears a greater than average obligation because of its past and present levels of excessive greenhouse gas pollution. This is the basis for Audubon's CO_2 Diet goal of a 20 percent reduction in 10 rather than 15 years.

"The United States bears a greater than average obligation to cut CO_2 emissions substantially because of its past and present levels of excessive greenhouse gas pollution."

It should be emphasized that this 20 percent goal is just the beginning of an ongoing "belt-tightening" needed to drastically cut back our global warming "calories." Ultimately, the United States must reduce its CO_2 emissions by at least 75 percent before the middle of the next century. This implies a transition to an economy that will no longer depend mainly on fossil sources for energy production.

B

Appendix B

CO_2 Equivalences for Other Greenhouse Gases

Many different gases can contribute to the greenhouse effect. The heat-trapping effect of a greenhouse gas depends on the way it absorbs heat (infrared radiation) coming from the Earth's surface. Gases that absorb heat at different wavelengths than does CO_2 can have a disproportionate effect on global warming.

One way scientists analyze the global warming impact is to use a factor called the *relative forcing coefficient* (RFC). The RFC measures the ratio of a gas's immediate contribution to the greenhouse effect as compared to that of CO_2. Atmospheric lifetime is also important in determining global warming impact, since the longer a gas persists in the atmosphere, the greater its long-term impact. A factor called the *global warming potential* (GWP) measures a chemical's long-term global warming impact (Lashof and Ahuja 1990).

Table B-1. CO_2 equivalences for common halocarbons

Compound	Lifetime (years)	RFC	GWP	CO_2 equivalence factor
Carbon Dioxide	250	1	1	1
CFC-12	120	7600	3600	5300
Halon-1301	110	5900	2600	3900
CFC-113	90	4900	1800	2900
CFC-11	60	5400	1300	2700
Halon-1211	25	5300	530	1700
HFC-134a	16	5600	340	1400
CFC-22	15	5600	340	1400

Notes:

RFC is the relative forcing coefficient, reflecting the immediate greenhouse impact.

GWP is the global warming potential, which accounts for atmospheric lifetime.

The CO_2 equivalence factor given here is the geometric mean of the RFC and GWP values, based on Cook (1990).

RFC, GWP, and the equivalence factor are all given on a mass basis, e.g., pounds of CO_2 equivalence per pound of compound.

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Although it is quite certain that halocarbon emissions have a significant greenhouse effect, uncertainties remain about the proper values to use when comparing compounds. We use the geometric mean of the GWP and RFC to obtain a mid-range value for the CO_2 equivalence factor (Cook 1990), as given in Table B-1 along with the atmospheric lifetime, RFC, and GWP values used to calculate them. The factors in Table B-1 are given on a mass basis, so that one would multiply the mass (e.g. kilograms or pounds) of a chemical emission by its equivalence factor to obtain the mass of CO_2 that would have the same impact on global warming.

The equivalence factor therefore permits us to calculate the warming effect of a gas in terms of the amount of CO_2 it would take to produce the same effect. This forms the basis of the unit "pounds of CO_2 equivalence" used throughout this report.

Halocarbons with short atmospheric lifetimes, such as HCFC-22 and HFC-134a, may be used as replacements for the halocarbons with longer lifetimes that are currently in widespread use (particularly CFC-11 and CFC-12). The impetus for these replacements has been concern about damage to the ozone layer; the shorter-lifetime halocarbons break down more quickly and so cause less ozone depletion in the stratosphere. However, increased use of these chemicals without controls can result in atmospheric concentrations high enough to aggravate the greenhouse effect. Therefore, although their global warming potentials are lower, they should still be strictly regulated.

C

Appendix C

Behind the CO_2 Diet Calculations

This appendix lists the CO_2 emissions factors for various substances and discusses the calculations used to develop the worksheet and reduction plan estimates used for the CO_2 Diet. Table C-1 gives the energy contents of fuels and some common materials. Table C-2 gives the CO_2 emissions factors for electricity and the principal fossil fuels. These were used to determine the CO_2 emissions associated with various forms of energy consumption.

Table C-1. Energy contents of fuels and other materials

Substance or activity	Conversion factors
Coal, bituminous, approx 75% Carbon (ASHRAE 1989)	32 MJ/kg, 29 GJ/ton
Natural gas, 1.03 therm/ccf (by definition)	0.1055 GJ/therm
Oil, average value (ASHRAE 1989)	45 MJ/kg
Household refuse (Mazria 1979)	5 kBtu/lb, 12 MJ/kg
Paper products, combustion (Gaines 1981)	8 kBtu/lb, 19 MJ/kg
Plastics, combustion (Gaines 1981)	15 kBtu/lb, 35 MJ/kg
Propane, measures (100lb/ 23.5gal), energy content (ASHRAE 1989)	4.3 lb/gal, 0.51 kg/l 50 MJ/kg, 97 MJ/gal
Wood, (800 kg/m^3, 3.2 tons/ cord) energy for hardwoods, (EIA 1987, Mazria 1979)	128 ft^3/cord 60 GJ/cord, 18 GJ/ton 21 MJ/kg

Specific calculations

The following are descriptions of how the CO_2 emissions factors for particular activities were obtained.

Air travel is based on data from the Oak Ridge National Laboratory (ORNL 1989) for primary energy use per passenger mile. A calculation based on 1987 data from Bureau of the Census (1987), p. 593, divides U.S. passenger miles (pmi) travelled by fuel consumed to get 27.2 pmi/gal (using a fuel factor of 22 lb CO_2/gal to get 0.816 kg CO_2/pmi). This is comparable to the figure derived from ORNL (1989) and may reflect improved fuel use efficiency from the earlier base year of ORNL to 1987.

For electric rail, presume ORNL data are primary, and convert using kgCO_2/GJ.

Table C-2. Carbon dioxide emission factors			
Fuel or product	**kg CO_2/GJ**	**(a)**	**Common units**
Coal (b)	95	3.1	6,100 lb CO_2/ton
Oil (b)	77	3.5	22 lb CO_2/gallon
Natural gas (b)	51	2.8	11 lb CO_2/therm
Propane (bottled gas)	59	3.0	20 lb CO_2/gallon
Electricity, per unit of end-use (c)	200	—	1.5 lb CO_2/kWh
Wood, non-renewable burning	85	1.8	3,600 lb CO_2/ton

Notes:

(a) Numbers in this column are specific CO_2 emission rates, that is, mass of CO_2 emitted per unit mass (e.g., kg CO_2/kg or lb CO_2/lb).

(b) Carbon dioxide emission rates for fossil fuels are based on SRI (1979). For comparison, some other references were checked: Williams et al. use 90 (coal), 73 (oil), 50 (gas); Lovins et al. use 87 (coal), 70 (oil), 50 (gas). These values were converted to kg CO_2/GJ using 116 (kg CO_2/GJ) per (PgC/TWyr). The value for wood is consistent with Rotty (1986), p. 315.

(c) Average U.S. electricity generation by source is taken to be 57% coal, 18% nuclear, 10% hydro, 10% gas, and 5% oil (EIA 1987, p. 35). The denominator is end-use energy, so that the emissions factor gives primary energy-related carbon emissions per unit of electricity consumption. The exact value of this factor would vary according to a utility's generation supply mix.

For taxi rides, assume 15 mpg to get 1.5 lb/mile.

For garbage, the CO_2 emissions factors (kgCO_2/kg product) for its components and the averaging calculation for typical garbage are summarized in Table C-3. Composition breakdown is from Franklin Associates (the same numbers are given by the Council for Solid Waste Solutions); energy content data from Gaines (1981) were used to compute the CO_2 factors.

The estimated CO_2 emissions factor for paper includes the carbon content of the wood input, which means we are treating paper as if none of the pulpwood is re-

Table C-3. Estimation of CO_2 emissions from household waste

Typical Urban Refuse	Emission Factor (lb CO_2/lb waste)		
Composition	% by wt	virgin	recycled
Paper	35.6	2.8	1.9
Metals—Al	1.2	20.0	3.1
Fe, etc.	7.7	4.2	3.0
Glass	8.4	1.5	1.1
Plastic	7.3	6.5	1.8
Other	39.8	1.8	0.9
Average waste	100.0	2.9	1.6

newably grown. The result is an estimate that about 35 percent of the CO_2 emissions associated with paper products can be saved through recycling.

Metals are broken down (by weight) as aluminum (Al, 14 percent) and all others (Fe—mostly ferrous, 86 percent), from Franklin Associates (1988), Table C-3.

The CO_2 emissions factor for plastic is based on the average proportion of energy contained in the feedstock, 72 percent (Gaines 1981, Table C-3), and an assumption that recycled plastics require only the non-feedstock portion, i.e., 28 percent, so that their CO_2 contribution is 28 percent of 6.5, which gives the value of 1.8 shown in the table.

The "other" category includes mostly biomass-type products, such as yard wastes, food, wood, and textile scraps. We assume that these items are like wood as far as energy content is concerned, although the process energy associated with their production may be larger.

There may also be associated halocarbon emissions, particularly for food product wastes. As an approximation, we base the emissions factor for the "other" category on the carbon content of biomass.

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NOTES

1. In this report, we give emissions estimates in terms of the mass of carbon dioxide, rather than carbon, as given in some discussions of global warming. The ratio of molecular weights of CO_2 to C is 44:12, or 3.67, so that a pound of carbon emissions corresponds to 3.67 pounds of CO_2 emissions.

2. Krause et al. (1989), p. I.5-4; the estimated population of the United States is 250 million in 1990 (Bureau of the Census, 1987, p. 15); the estimated world population exceeded 5 billion in 1987 (Keyfitz 1989).

3. Schneider, S.H. (September 1989).

4. Lester, R.T., and J.P. Myers (1989).

5. It is estimated that CO_2 accounts for 57 percent of the current greenhouse effect and that CFCs account for 25 percent; methane and nitrous oxide account for 12 percent and 6 percent, respectively (Hansen et al. 1989).

6. Halocarbons are halogenated hydrocarbons, i.e., chemicals based on compounds of hydrogen and carbon into which halogen atoms (fluorine, chlorine, bromine, or iodine) have been incorporated.

Halocarbons include CFCs (some of which are also called freons), halons, and other compounds such as methyl chloroform and carbon tetrachloride (Fisher et al. 1989).

Greenhouse effects of halocarbons are discussed by Fisher et al. (1989); Hansen et al. (1989); Ramanathan et al. (1985); Lacis et al. (1981); among others.

Halocarbons, particularly CFCs, are also notorious for another global problem: stratospheric ozone depletion (the "ozone hole"). International agreements have already been made to phase out the use of CFCs for this reason. Some of the proposed replacement chemicals that are less harmful to the ozone layer still cause global warming, however, so the global aspect of the emission problem cannot truly be solved by switching from one chemical to another while still using the atmosphere as a dumping ground.

7. Methane is the main component of natural gas; it is also released in decay and fermentation processes. Nitrous oxide is a byproduct of natural soil processes and is also generated in combustion; one may be more familiar with nitrous oxide by the name "laughing gas" since it is sometimes used as an anesthetic—although the amounts used for that purpose are so small that they are not of concern for global warming.

8. Most thermal generation of electricity (i.e., generation that uses a heat source, such as a fossil fuel or nuclear reaction) uses about three times as much energy at the power plant than is consumed at the place of end-use, such as the home.

9. We thank R. and M. Bolze for providing us with measured weights for compacted home trash.

10. The CO_2 equivalence factors we use here for products containing halocarbons are based on U.S. stocks at the time of publication. Recent international agreements for stratospheric ozone protection will result in a rapid phase-out of current halocarbons and consequently their global warming impact should be greatly reduced within the next decade.

11. The estimate of 18,000 pounds of CO_2 equivalence per capita per year is obtained as the sum of all residen-

tial sector CO_2 emissions (7,900 lb); the automobile, air, bus, and passenger rail portions of transportation CO_2 emissions (7,680 lb); and the mobile air conditioner and residential refrigeration portions of halocarbon emissions (2,760 lb CO_2 equivalence).

12. The CO_2 emission reduction estimates are greater for electricity than for gas using similar energy conservation measures, because most electricity is coal-generated and there are added energy losses in electricity production.

13. This figure is based on consumption and savings estimates in *Home Energy* 5(4):15 (1988) and assumes an 80°F temperature rise with water heater recovery efficiencies of 0.8 for gas and 1.0 for electric.

14. Deborah Gangloff, Global ReLeaf Program, American Forestry Association (personal communication, March 1990). According to the American Forestry Association, the type of tree planted matters less than that it be well placed, kept healthy, and not crowded by other trees or plants.

15. ACEEE (1990), p. 128.

16. The example estimate of 2,500 lb/year for a two-person household corresponds to about 3.5 lb/day per person. This is somewhat lower than the estimate of 4.5 lb/day per person for garbage production in the United States given by Olkowski et al. (1979), p. 23.

17. Bureau of the Census, Statistical Abstract of the U.S., p. 593.

18. Reductions related to fuel oil use were estimated as follows: (1) The boiler tune-up estimate is based on a measured combustion efficiency gain of 9 percent, bringing it up to about 80 percent. Assuming a corre-

sponding reduction in fuel-oil-related CO_2 emissions, which were initially 13,800 pounds, yields a 1,200 pound cut. (2) Currently, 240 square feet of the window area in our house is single pane. Installing the storm windows is estimated to reduce the heat loss rate by 0.6 Btu/(h ft^2 °F). In the local climate (4,200 heating degree days) the resulting CO_2 emissions reduction would then be 3,200 pounds. (3) Finally, installing a high-efficiency (90%) furnace would reduce the post storm window emissions of 9,400 pounds to 8,400 pounds, for an additional CO_2 calorie cut of 1,000 pounds.

19. Kempton et al. (1984) pointed out the value of viewing conservation measures in these terms.

20. The sample CO_2 Diet estimates here are not constructed to be representative of all United States households. Rather, they are the attempt of one of the authors to make a realistic assessment for his household. Our judgement, nevertheless, is that the 3-to-1 ratio is a good estimate for the extent of national effort needed to complement individual action in reducing greenhouse gas emissions.

21. Krause et al. (1989) define the budget in terms of fossil carbon resources that can be burned when the weight of the oxygen is added, giving a global budget of 300 gigatons (Pg) of carbon from 1985 to 2100. This corresponds to emissions of 1100 GT of CO_2 from fossil sources, which, assuming a rapid halt to halocarbon emissions and reductions in anthropogenic methane and nitrous oxide emissions, should serve to prevent an effective doubling of pre-industrial CO_2 concentrations in the atmosphere.

22. A goal of 20 percent reduction of CO_2 emissions within 15 years was adopted by the World Conference on the Changing Atmosphere in Toronto (1989).

Krause et al. (1989) discuss a number of options for allocating the fossil carbon budget and give emissions allowances for various countries of the world. Another discussion of the issue is given by Smith (1990), who relates fossil-based CO_2 emissions to a "natural debt" incurred by individuals or nations.

23. For inspiration for our title, we give recognition to F.M. Lappé's book *Diet for A Small Planet*, Friends of the Earth/Ballantine (1971).

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CO_2 DIET FOR A GREENHOUSE PLANET

Worksheet for helping you calculate what you emit			
Consumption or activity	**Your use (units per year)**	**CO_2 factor (lb CO_2/unit)**	**Annual emissions (lb CO_2 eq.)**
Residential Utilities			
Electricity	kWh	1.5 lb/kWh	
Oil	gallons	22 lb/gal	
Natural gas	therms	11 lb/therm	
Propane or bottled gas	gallons	20 lb/gal	
Transportation			
Automobiles	gallons	22 lb/gal	
Other motor fuel use	gallons	22 lb/gal	
Air travel	miles	0.9 lb/mile	
Bus, urban	miles	0.7 lb/mile	
Bus, intercity	miles	0.2 lb/mile	
Railway or subway	miles	0.6 lb/mile	
Taxi or limousine	miles	1.5 lb/mile	
Household Waste			
Trash (anything discarded)	pounds	3 lb/lb	
Recycled items	pounds	2 lb/lb	
Halocarbon Products			
Refrigerators and freezers	(number)	830 lb each	
Car air conditioners	(number)	4,800 lb each	
Other halocarbon products (see Table 4 for equivalences)			
TOTAL ANNUAL GREENHOUSE GAS EMISSIONS (pounds CO_2 equivalent)			

This worksheet accompanies Chapter 3 (pg. 19), and is reproduced here so that you can cut it out and use it to calculate your CO_2 emissions.

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ABOUT THE AUTHORS

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CO_2 DIET FOR A GREENHOUSE PLANET:

A Citizen's Guide To Slowing Global Warming

This diet is about how to reduce your global warming calories—the carbon dioxide and other greenhouse gas emissions associated with our lifestyles. For once you don't have to count the calories in the food you eat. Instead, Audubon's *CO_2 Diet for a Greenhouse Planet* shows you how to tally up your personal emissions of the major greenhouse gases (from your cars, appliances, houses, and trash) and how to cut your excess "CO_2 calories."

By following our diet tips, you will learn how to cut your greenhouse gas emissions by 20 percent over the next 10 years, a significant step toward the 75 percent or more that is required to make a dent in global warming.

Personal "dieting" is not enough to achieve our nation-wide goal, however. Individuals must also get involved politically in order to move the United States away from its current pattern of greenhouse gluttony. By merging political activism with personal activism, we can put the whole nation on a CO_2 diet that will ensure a healthy and sustainable global environment for generations to come.

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