A Primer on Carbon Footprint Reduction

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The sound-bite summary

1. Add up your footprint
2. Insulate your house
3. Buy less gas and oil
4. Eat less meat

Introduction

Our climate problem is complex, severe, and urgent. Many people are confused or cynical about their options or abilities to affect the problem. Yet there are many actions we can all take to reduce our personal greenhouse gas (GHG) contributions and to affect the carbon intensity of our infrastructure. At the risk of oversimplification, this primer is meant to introduce the topics with enough detail to lead to productive actions and to also provide references for further study.

Several years ago one of the IPCC scientists was asked what we should do to mitigate climate change; he started with, "Eat less meat." That's a good start and a memorable sound bite, but it's not sufficient to get us there. It does focus responsibility on individuals and force people to think about food chain effects, so I've used sound-bite headings to group the personal actions people should take. While these sound bites aren't very technically accurate, they do map into the major carbon emissions.

The process starts with calculating your personal or household carbon footprint. This provides the lay of your landscape and which are the big rocks to move--you may be surprised by how little your recycling affects your carbon emissions vs. your driving habits or the cross-country air travel you enjoy. Our big rocks tend to be our inefficient and carbon-intensive houses, buildings, transportation, agriculture, and product supply chains. So one of your personal responsibilities is to search and destroy energy wastes in your house and its contents and how you use them. Transportation is the most measurable impact because you can easily add up the gasoline you burn and the emissions of other transportation modes you use. Our carbon footprint from the food and other products we purchase ("embedded carbon" or "embodied carbon") is very difficult to estimate because we have little or no infrastructure for tracking the carbon used in each step of the product's creation. In spite of this, it's pretty clear that locally produced products can add less transport carbon than those shipped from overseas, and your vegetable garden has a far smaller footprint than the 1000-mile salad from the supermarket.

Americans' typical footprints include tremendous energy wastes because our products were historically designed as if energy was free; indeed, in the first half of the 20th century energy costs kept falling, so assuming continued cost reductions was the prudent cost optimization. But as the global oil supply peaked in 2006 and demand has continued to outstrip supply, the costs of fossil fuels have clearly grown to be an economic impediment (Figure 1) as well as an environmental disaster.

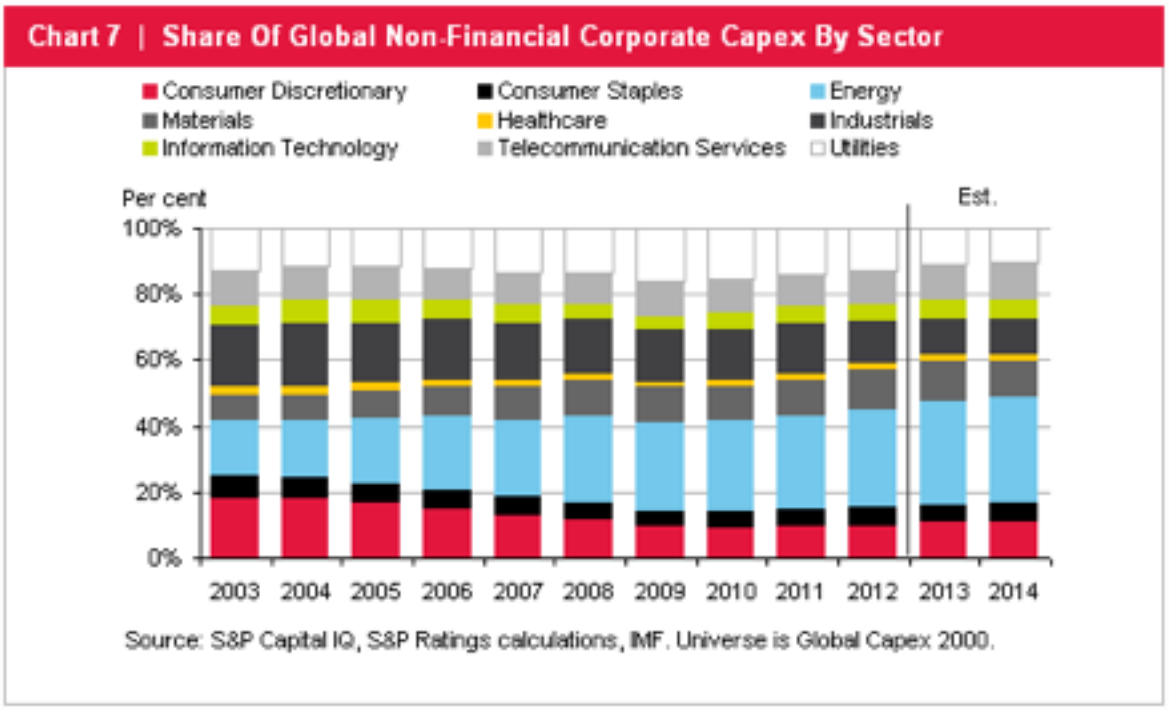


Figure 1.Global distribution of corporate capital expenditures (capex) over the past decade. Note how the energy sector has squeezed consumer and industrial sector investments.

Begin with the end in mind, as Steven Covey says. The big picture of GHGs in the atmosphere is scary and getting scarier. Not only must we stop global GHG emissions—we should also go carbon-negative to eventually return the atmospheric concentrations to pre-industrial levels. The rate of GHG reductions necessary is becoming steeper as we continue our business-as-usual policies--preferably reaching about 50% reduction within 10 years: http://paulgilding.com/fileshare/p091101-The-one-degree-war-plan.pdf or longer, if a 2°C target is adopted: http://www.realclimate.org/index.php/archives/2014/04/mitigation-of-climate-change-part-3-of-the-new-ipcc-report/

One at a time: The enormity of the climate challenge is daunting and can be depressing, yet we all have our part to play. The Northwest AIDS Project has a mantra: "Getting to Zero--One Person at a Time." Fixing GHG emissions is like stamping out a disease. We know how to do it, but it must be done with everyone involved--one car at a time, one household at a time, one utility at a time, one airline at a time, one state at a time,…

The American Dream must change. Probably the biggest changes necessary are between our ears—our cultural values, our heroes, our aspirations. We must now radically and urgently revamp the American Dream to enable the very survival of our descendants. The New American Dream will espouse sustainable prosperity for all, instead of unlimited abundance for the winners. Sufficient is better, instead of bigger is better. And so forth…

Feedback encouraged: This is a work in process, and all corrections, additions, and rational debates are welcome.

1. Add Up Your Carbon Footprint

Basic carbon calculators

Generally these add up emissions from your house and its contents, your transportation, your food supplies, and other purchases. The methods and assumptions are all different and I've found some to be pretty inaccurate. Below is a sampling of a few good calculators.

UC Berkeley calculator:
http://coolclimate.berkeley.edu/carboncalculator
Gives local averages; allows you to use averages or get specific; easy what-if calculations

Claimed to be the web's leading carbon calculator:
http://www.carbonfootprint.com/calculator.aspx
Limits you to 3 flight itineraries per period; uses an average kg/kWh for electricity in your state; no calculation of what-if scenarios.

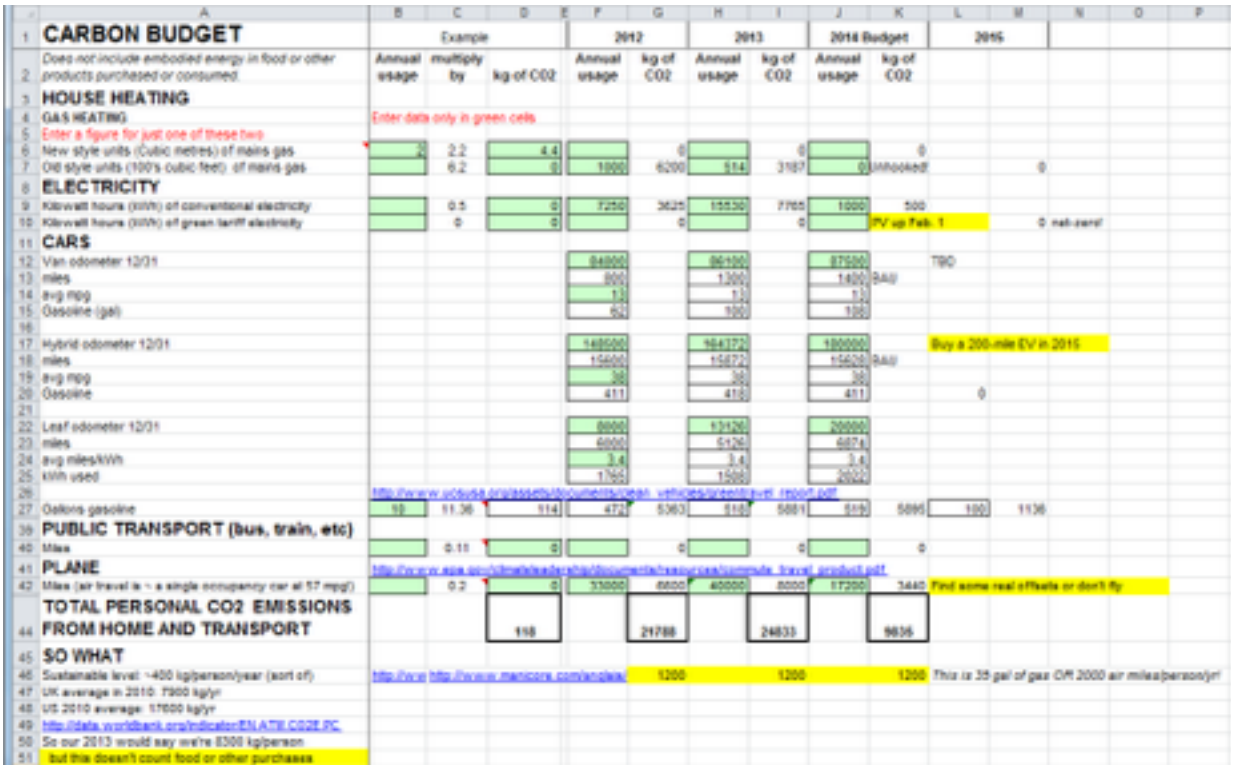
EPA carbon calculator is reasonably accurate, except it doesn't include air travel! Calculates effects of what-if scenarios. http://www.epa.gov/climatechange/ghgemissions/ind-calculator.html

UCS report on travel footprints (Dec 2008)
http://www.ucsusa.org/assets/documents/clean_vehicles/greentravel_report.pdf

Definitive air travel numbers
http://www.epa.gov/climateleadership/documents/resources/commute_travel_product.pdf

Areal carbon footprint data http://coolclimate.berkeley.edu/maps

Roll your own: For those with detailed interest and basic spreadsheet skills a customized spreadsheet is not difficult. I've used this to track some annual objectives:



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	**CARBON BUDGET**	Example				2012		2013		2014 Budget		2015				
2	*Does not include embodied energy in food or other products purchased or consumed*	Annual usage	multiply by	kg of CO2		Annual usage	kg of CO2	Annual usage	kg of CO2	Annual usage	kg of CO2					
3	**HOUSE HEATING**															
4	GAS HEATING	Enter data only in green cells														
5	Enter a figure for just one of these two															
6	New style units (Cubic metres) of mains gas	2	2.2	4.4			0		0		0					
7	Old style units (100's cubic feet) of mains gas		6.2	0		1000	6200	514	3187	0	Uncooked		0			
8	**ELECTRICITY**															
9	Kilowatt hours (kWh) of conventional electricity		0.5	0		7250	3625	15530	7765	1000	500					
10	Kilowatt hours (kWh) of green tariff electricity		0	0			0		0		PV up Feb. 1		0	net-zero!		
11	**CARS**															
12	Van odometer 12/31					84000		86150		87500		TBD				
13	miles					800		1300		1400	BAU					
14	avg mpg					13		13		13						
15	Gasoline (gal)					62		100		108						
16																
17	Hybrid odometer 12/31					148000		164172		180000		Buy a 200-mile EV in 2015				
18	miles					15400		15872		15828	BAU					
19	avg mpg					38		38		38						
20	Gasoline					411		418		411			0			
21																
22	Leaf odometer 12/31					6000		11126		20000						
23	miles					6000		5126		8874						
24	avg miles/kWh					3.4		3.4		3.4						
25	kWh used					1765		1508		2609						
26		http://www.ucsusa.org/assets/documents/clean_vehicles/greentravel_report.pdf														
27	Gallons gasoline	93	11.36	514		472	5363	518	5881	519	5895	100	1136			
39	**PUBLIC TRANSPORT (bus, train, etc)**															
40	Miles		0.11	0			0		0		0					
41	**PLANE**	http://www.epa.gov/climateleadership/documents/resources/commute_travel_product.pdf														
42	Miles (air travel is ~ a single occupancy car at 57 mpg!)		0.2	0		33000	6600	40000	8000	57200	3440	Find some real offsets or don't fly				
44	**TOTAL PERSONAL CO2 EMISSIONS FROM HOME AND TRANSPORT**			118			21788		24833		9835					
45	**SO WHAT**															
46	Sustainable level: ~400 kg/person/year (sort of)	http://www	http://www.mancorp.com/anglea/				1200		1200		1200	This is 35 gal of gas OR 2000 air miles/person/yr!				
47	UK average in 2010: 7900 kg/yr															
48	US 2010 average: 17600 kg/yr															
49	http://data.worldbank.org/indicator/EN.ATM.CO2E.PC															
50	So our 2013 would say we're 8300 kg/person															
51	but this doesn't count food or other purchases															

2. Insulate your house

Tighten the envelope: About 21% of all GHG emissions in the US are from heating, cooling, and powering our residences, and another 22% are from commercial and industrial buildings. The highest and quickest payback on building improvements is usually reducing heat losses from the building envelope--walls, ceilings, doors, windows, floors--especially on older homes. Air infiltration is typically more important than insulation—this can be measured by a blower-door test. Older houses are usually very leaky; depending upon specifics the envelope losses can often be cut in half or more. Fixing infiltration amounts to sealing air leaks everywhere, which can be quite a chore on an older house. Since older homes were built as if energy was free, there are usually leaks everywhere—in and around doors and windows, fireplace dampers, can lights in attic spaces, around electrical switches and outlets, fans, plumbing and electrical penetrations, and also through old walls. A good contractor today will know how to seal up new installations and may recommend extra layers of insulation and sealing (but be sure to ask where the dew point will be in the wall). http://www.tlpca.org/images/articles_condensation.pdf

To provide the air circulation required by code (at least 3 air changes per hour) in a tight envelope, a heat-recovery ventilator can be used to provide fresh air while recovering up to 80% of the heat of the exhaust air. http://www.ecobuildingpulse.com/green-products/recovery-time.aspx

Heat pump: Consider more efficient heating or cooling systems, especially heat pumps. Businesses should do the same. Governments should require better energy efficiencies in any new construction, and encourage remodeling activities that lower GHG emissions. Heat pump technologies are improving rapidly, so that now an air-source heat pump (ASHP) is almost as efficient as a ground-source heat pump and doesn't require the wells or ground loop burial.
http://en.wikipedia.org/wiki/Heat_pump
http://energy.gov/energysaver/articles/heat-pump-systems

For zero emissions: install renewable power generation on the building (usually PV panels) to reach net-zero or positive energy. Whether new construction or remodeling, the basic formula to reach zero emissions is to tighten up the building envelope, improve the heating/cooling systems, and do the rest with renewables. For example, reducing envelope losses by a factor of two and using a ASHP with coefficient of performance (COP) of 3.5 makes your house heating and cooling 7 times as energy efficient. For new construction, the added cost to reach net-zero energy use can be very affordable—why not finance what makes your house warm along with what makes it dry? Building codes in parts of California will soon require new homes to be net-zero. http://www.zerohomes.org/

Remodeling: Beginning with the end in mind is always good counsel when remodeling, because house surgery is expensive and you want to do it only once if you're going to endure the disruption and cost of remodeling. So if you're redoing the siding or some windows, think about what the ideal remodel would eventually look like and plan accordingly.

Electric loads: Consider replacing old refrigerators, TVs, PCs, and other often-used appliances with newer, more efficient models. Note the standby power on electrical appliances--I found that I had a TV that used 27 watts when it was off, or 19 kWh per month! A $20 Kill-A-Watt power monitor is useful to measure the instantaneous load power or energy used over a period.

LED lighting is now a bargain—made in the USA, no mercury, dimmable, extremely efficient, a 60-watt equivalent bulb starts at $7 and lasts over 20 years. Replace the most-used lights

first. http://www.homedepot.com/p/Cree-60W-Equivalent-Soft-White-2700K-A19-Dimmable-LED-Light-Bulb-BA19-08027OMF-12DE26-2U100/204592770?N=5yc1vZbol

Hot water heaters are also getting more efficient. A solar domestic hot water (SDHW) system captures heat directly from the sun on roof panels, but the newer hot water heaters with integrated air-source heat pumps are even more efficient. http://energy.gov/energysaver/articles/heat-pump-water-heaters

Resources: In Oregon, the Energy Trust of Oregon (ETO, http://energytrust.org/) provides many opportunities for testing your house, identifying partnering contractors, and providing financial incentives for improving your home's energy performance. ETO also helps businesses upgrade the energy performance of their buildings and processes.

Overdoing efficiency: Improving the efficiency of a building envelope can be overdone, in that there is an economic (and embedded carbon) minimum somewhere between simply adding solar PV panels and rebuilding the envelope to reach passive house performance. For example, for a given energy performance it's likely cheaper to add more PV (if you have an efficient heat pump) than to go from double- to triple-pane windows. Mother Earth only cares about GHG inventories, not how efficient we are!

3. Buy less gas and oil

Overview: About 27% of all US GHG emissions are from various forms of transportation, and your transportation choices directly affect your emissions. Reduction options include:

- Drive less (plan trips to be more efficient or to carpool)
- Drive a smaller car or one with better gas mileage
- Drive at the speed limit to improve your fuel efficiency. A typical car gets twice the gas mileage at 45 mph as at 70 mph.
- When you buy a car, consider the fuel costs and service costs over the lifetime of the car. Today the Nissan Leaf electric vehicle (EV) is by far the lowest cost of ownership for a commuter vehicle (even without the federal tax credit). Soon there will be more EVs with 200+ mile driving range.
- Commute via public transportation or bicycle.
- Consider biodiesel for your fuel (the footprint of corn ethanol is no better than gasoline!)
- Reduce your air travel. I know people who do not travel by air because of the carbon footprint.
- Consider teleconferencing instead of traveling.

Businesses should also do all these, in addition to reducing the carbon intensity of their operations, including understanding the embedded carbon in their supply chains.

For zero emissions: Ride your bike, charge your electric car from renewable power sources, and don't use air travel unless it uses carbon-neutral biofuels.

The Union of Concerned Scientists has shown various paths to reducing the carbon intensity of our transportation systems.
http://www.ucsusa.org/clean_vehicles/smart-transportation-solutions/vehicle-policy/current-policies-and-legislation/how-to-reduce-us-oil-use.html
EVs are evolving rapidly, enabled by better and cheaper battery technologies.
http://www.iea.org/publications/globalevoutlook_2013.pdf
http://www.mckinsey.com/insights/energy_resources_materials/battery_technology_charges_ahead
In the near future, forward-thinking utilities will be able to use the large distributed storage resources of grid-tied EVs for balancing the grid. By 2025 there will be many houses or

neighborhoods going off-grid because the costs of solar PV and batteries will obsolete their grid connection, similar to how cell phones obsoleted landline phones.
http://reneweconomy.com.au/2014/say-investors-wake-solar-pro-sumers-24413

As the transport and industrial sectors become more electrified and powered by renewables, the embedded carbon in products will decrease and, like housing, GHG emissions will become the focus, not necessarily efficiencies. Mother Earth responds to GHG inventories, not our efficiencies. So the road ahead does not lead to less of everything because today we produce everything with fossil fuels; rather, it leads to new infrastructure with zero GHG emissions. We needn't travel less if it causes zero emissions.

4. Eat less meat

Agriculture produces about 8% of all US greenhouse gas (GHG) emissions. Globally, the livestock sector is responsible for 18% of GHG emissions, more than transport. Meat is the least carbon-efficient food to produce--the grains used to feed the world's livestock would feed another billion people. A high-beef diet is about like owning an SUV. Beef and dairy cattle are by far the largest GHG emitters, with poultry a much smaller emitter. Some options:

- Increasing your intake of vegetables and fruits, reducing your intake of fats and sugars, and a discipline of regular, aerobic exercise has been shown to reduce rates of diabetes, heart disease, and cancers. Adopt "meat as a garnish".
- Go organic to reduce your exposure to pesticides, and to improve soils instead of impair them. US industrial agricultural soil management releases even more GHG than livestock, dominated by N_2O.
- Businesses should encourage healthier diets to reduce employee costs from sickness and to reduce health insurance costs.

Governments should understand and regulate carbon sequestration in soils and forests.

For zero emissions: buy only local, organic produce.

Livestock's Long Shadow: ftp://ftp.fao.org/docrep/fao/010/a0701e/a0701e00.pdf
Cowspiracy: http://www.cowspiracy.com