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Hearing on

Rebalancing the Carbon Cycle

Committee on Government Reform
Subcommittee on Energy and Resources
House of Representatives

September 27, 2006

Thank you Mr. Chairman for holding this hearing on what I believe should be a critical priority for the federal government: rebalancing the carbon cycle. My name is Daniel A. Lashof, and I am the science director of the Climate Center at the Natural Resources Defense Council (NRDC). NRDC is a national, nonprofit organization of scientists, lawyers and environmental specialists dedicated to protecting public health and the environment. Founded in 1970, NRDC has more than 1.2 million members and online activists nationwide, served from offices in New York, Washington, Los Angeles and San Francisco. I have worked at NRDC since 1989 and have served on committees of the National Research Council, the President's Council of Advisors on Science and Technology, and the Intergovernmental Panel on Climate Change. Prior to joining NRDC I was a scientist at the Environmental Protection Agency, where I was the lead author of a report to Congress on policy options for stabilizing global climate. I am particularly pleased to appear at this hearing because my doctoral dissertation at the University of California addressed the role of the biosphere in the global carbon cycle.

Out of Balance

Mr. Chairman, this hearing is particularly timely because the carbon cycle today is more out of balance than at any time in history. Each year emissions from burning fossil fuels and destroying forests put about twice as much carbon dioxide (CO_2) into the atmosphere as natural sources can remove. As a result, the amount of carbon dioxide in the atmosphere is rising worldwide and the rate of growth is increasing. The average CO_2 concentration in Earth's atmosphere is now over 380 parts per million by volume (ppm), which is higher than it has been for at least 650,000 years[1]. In 2005 the concentration of carbon dioxide in the atmosphere increased by 2.5 ppm, the third largest annual increase ever recorded[2]. Although there is considerable variation from year to year in the rate of increase in atmospheric carbon dioxide, the rise has been more than 2 ppm in 3 of the last 4 years and preliminary 2006 data indicate that this trend is continuing.

The unprecedented buildup of carbon dioxide in our atmosphere endangers our environment, our health, and our economy. Carbon dioxide traps heat in the earth's atmosphere, preventing it from escaping into space. So the imbalance in the carbon cycle has also thrown the earth's energy balance out of whack, which means that each year the earth absorbs more energy from the sun than it radiates back into space. Global warming is the inevitable result and the human fingerprint on Earth's climate is now clearly visible. The consequences have become all too apparent in recent years:

- More severe hurricanes as ocean temperatures rise[3];
- More severe droughts and wildfires, particularly in the western United States, as mountain snowpacks decline and evaporation rates increase[4];
- Coastal flooding and inundation as melting mountain glaciers and polar ice sheets raise sea levels[5];

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[1] Siegenthaler, U., T.F. Stocker, E. Monnin, D. Luthi, J. Schwander, B. Stauffer, D. Raynaud, J. Barnola, H. Fischer, V. Masson-Delmotte, and J. Jouse (2005) Stable Carbon Cycle-Climate During the Late Pleistocent, *Science*, 310, p. 1313-1317.

[2] Tans, P. (2006) Trends in Atmospheric Carbon Dioxide, NOAA ESRL, available at: http://www.cmdl.noaa.gov/ccgg/trends/

[3] Mann, M.E. and K.A. Emanuel (2006) Atlantic Hurricane Trends Linked to Climate Change, *Eos*, 87(24), p. 233-244.

[4] Westerling, A.L., H.G. Hidalgo, D.R. Cayan and T.W. Swetnam (2006) Warming and Earlier Spring Increase Western U.S. Forest Wildfire Activity, *Science*, published in Science Express on 6 July 2006, doi: 10.1126/science.1128834

[5] Overpeck, J.T., B.L. Otto-Bliesner, G.H. Miller, D.R. Hugs, R.B. Alley and J.T. Kiehl (2006) Paleoclimatic Evidence for Future Ice-Sheet Instability and Rapid Sea-Level Rise, *Science*, 311, p.1747-1750.

- Ecosystem destruction and species extinctions as climate change and ocean acidification destroy polar bear habitat, spread disease among harlequin frogs, and dissolve coral reefs[6].

Time Is Running Out

The good news is that we can avoid the worst effects of global warming if we act decisively now to begin rebalancing the carbon cycle by reducing emissions of carbon dioxide from power plants, automobiles, and other sources. Significant emission reductions are needed, and delay only makes the job harder. As the National Academy of Sciences stated last year:

> Despite remaining unanswered questions, the scientific understanding of climate change is now sufficiently clear to justify taking steps to reduce the amount of greenhouse gases in the atmosphere. Because carbon dioxide and some other greenhouse gases can remain in the atmosphere for many decades, centuries, or longer, the climate change impacts from concentrations today will likely continue well beyond the 21st century and could potentially accelerate. Failure to implement significant reductions in net greenhouse gases will make the job much harder in the future—both in terms of stabilizing their atmospheric abundances and in terms of experiencing more significant impacts.[7]

We are already beginning to see the effects of global warming and scientists are increasingly concerned that we are approaching a tipping point beyond which severe and irreversible impacts will become inevitable. For example, recent observations show that the Greenland ice sheet is melting more rapidly than expected and that global warming of as little as 2 degrees Celsius (3.6 degrees Fahrenheit) from 19th Century levels could

[6] Pounds, J.A., M.R. Bustamante, L.A. Coloma, J.A. Consuegra, M.P.L. Fogden, P.N. Foster, E. La Marca, K.L. Masters, A. Merino-Viteri, R. Puschendorf, S.R. Ron, G.A. Sanchez-Azofeifa, C.J. Still and B.E. Young (2006) Widespread amphibian extinctions from epidemic disease driven by global warming, *Nature*, 439, p. 161-167, doi:10.1038/nature04246.

[7] National Academy of Sciences, *Understanding and Responding to Climate Change: Highlights of National Academies Reports*, p.16 (October 2005), http://dels.nas.edu/dels/rpt_briefs/climate-change-final.pdf (emphasis added).

cause it to eventually collapse, raising sea levels by as much as 20 feet[8]. A similar amount of warming could put millions of people at risk of water stress, hunger, and malaria and cause the collapse of many vulnerable ecosystems, including most alpine meadows and more than 90% of coral reefs[9].

We have a reasonable chance of staying within this 3.6 degree Fahrenheit envelope if atmospheric concentrations of CO_2 and other global warming gases are kept from exceeding 450 ppm CO_2- equivalent. This implies a budget for cumulative global and U.S. carbon dioxide emissions designed to rebalance the carbon cycle in time to stay within this 450 ppm target. A reasonable allocation of that budget to the United States over the period 2000 to 2050 would limit cumulative U.S. emissions over that period to less than 40 times our emissions level in 2000. To live within this budget we must stop U.S. emissions growth within the next 5-10 years and cut emissions by 60-80 percent over the next 50 years. U.S. action on this scale – together with similar cuts by other developed countries and limited emissions growth followed by reductions from developing countries – would keep the world within that 450 ppm limit.

So here is our choice. If we start cutting U.S. emissions soon, and work with other developed and developing countries for comparable actions, we can stay on the 450 ppm path with an ambitious but achievable annual rate of emission reductions – one that gradually ramps up to about 3.2% reduction per year. (See Figure 1.)

But if we delay a serious start and continue emission growth at or near the business-as-usual trajectory for another 10 years, the job becomes much harder – the

[8] Overpeck et al, 2006.
[9] Warren, R. (2006) Impacts of Global Climate Change at Different Annual Mean Global Temperature Increase, in H. Schellnhuber, et at., (*eds.*) *Avoiding Dangerous Climate Change*, Cambridge University Press, New York.

annual emission reduction rate required to stay on the 450 ppm path jumps between two- and three-fold, to 8.2% per year. In short, a slow start means a crash finish – the longer emissions growth continues, the steeper and more disruptive the cuts required later.

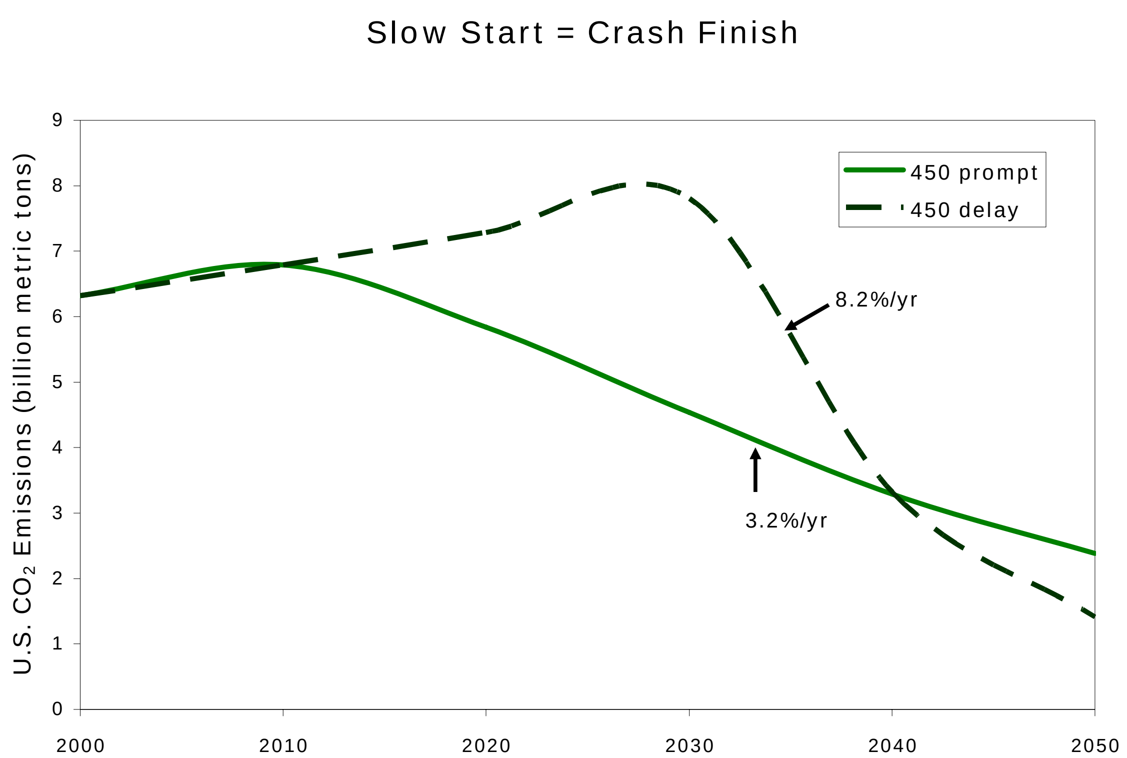

Figure 1. Prompt start and delay pathways consistent with stabilizing heat-trapping gases at 450 ppm CO_2-equivalent. Global emissions 2000-2100 are 1760 Gt CO_2 from Meinshausen's S450Ce scenario.[10] The U.S. share of global emissions is assumed to decline from 25% to 5% linearly between 2000 and 2100. This results in an emissions budget for the U.S. of 308 Gt CO_2 in the 21st Century. In the prompt start case emissions decline by 1.5%/yr from 2010 to 2020, 2.5%/yr from 2020 to 2030 and 3.2%/yr thereafter. The delay case assumes that emissions grow by 0.7%/yr from 2010 to 2030, a reduction of 0.5%/yr compared to the Energy Information Administration forecast;[11] they must decline by 8.2%/yr thereafter to limit cumulative 21st Century emissions to 308 Gt CO_2.

[10] Simple Model for Climate Policy assessment (SiMCaP), available at: http://www.simcap.org/

[11] Reference case from U.S. Department of Energy, Annual Energy Outlook 2006 with Projections to 2030, Report # DOE/EIA-0383(2006)

Here's a common sense illustration of what this means. Imagine driving a car at 50 miles per hour, and you see a stop light ahead of you at a busy intersection. If you apply the brakes early, you can easily stop your car at the light with a gentle deceleration. The longer you wait to start braking, the harder the deceleration. There's some room for choice. Within some limits, you can brake late and still stop in time. But the higher your speed, the earlier you must start braking. If you wait too long, you'll find yourself in the middle of the intersection with your forehead through the windshield.

The captain of the Titanic learned a similar lesson. If he had started turning just a couple of minutes earlier, he would have missed the iceberg. But traveling at full speed, by the time he saw the iceberg, it was too late to miss it. He lost his ship. Will we repeat the same mistake?

Administration officials suggest that, rather than establish enforceable emission limits now that begin to gradually reduce emissions within a few years, it is still cheaper to delay mandatory emission cuts because (somehow) we will develop breakthrough technologies in the interim and these will enable faster reductions later at lower cost. But this argument is implausible for two reasons. First, as already demonstrated, delaying the start of reductions dramatically increases the rate at which emissions must be lowered later. Reducing emissions by more than 8 percent per year would require deploying advanced low-emission technologies at least several times faster than conventional technologies have been deployed over recent decades. Second, delay means that a whole new generation of capital investment will be made in billions of dollars of high-emitting capital stock – conventional power plants, vehicles, etc. that will be built or bought during the next 10-20 years in the absence of meaningful near-term limits. Under the delay scenario, our children and grandchildren would then have to bear the costs of prematurely retiring an even bigger capital stock than exists today. Even taking discounting into account, it is virtually impossible that delaying emission reductions is cheaper than starting them now.

Voluntary Measures Won't Balance the Carbon Cycle

Limited as it is to R&D and voluntary measures, the administration's Climate Change Technology Program has no hope of preventing the "crash finish" scenario. The inadequacy of a voluntary program is plain to see for a growing number of business leaders, state and local elected officials, and a majority of the U.S. Senate, as well as to nearly all other nations.

In 2002, President Bush recommitted the United States to "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system" – the objective of the climate change treaty (the U.N. Framework Convention on Climate Change) adopted and ratified by his father. The president said his goal was to "slow, stop, and reverse" U.S. global warming emissions growth. He set a purely voluntary target of reducing the emissions *intensity* of the U.S. economy – the ratio of emissions to GDP – by 18 percent between 2002 and 2012.

But emissions *intensity* is a deceptive measure, because what counts for global warming is *total* emissions. Even if the president's target were met (and recent reports indicate that it may not be), *total* U.S. emissions will still increase by 14 percent between 2002 and 2012 – exactly the same rate as they grew in the 1990s. (See Figure 4.)

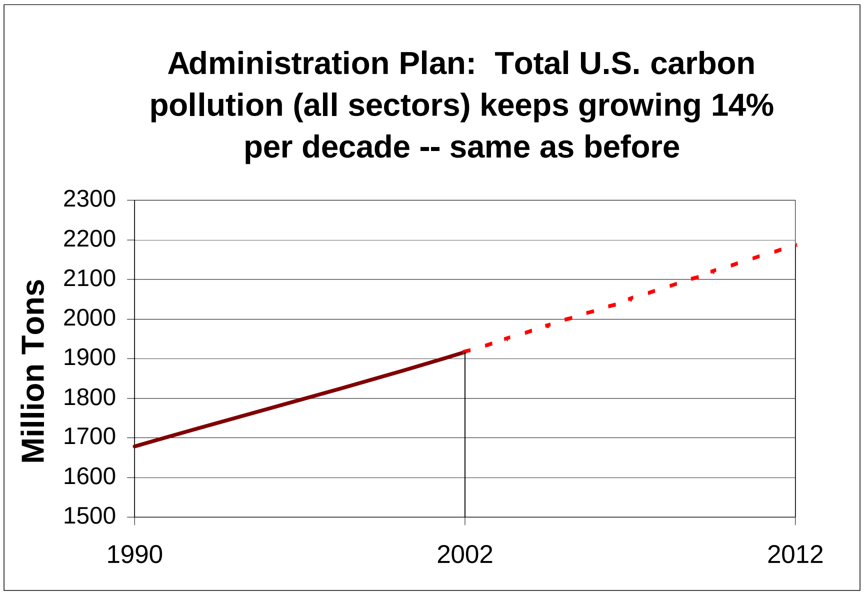

Figure 2

While the administration clings doggedly to the voluntary fiction, most political, civic, and business leaders in the United States are moving on. As Science Committee Chairman Boehlert told this Committee last week:

> As many outside commenters have noted, the plan does not establish clear priorities or a method for doing so. It does not provide clear criteria for determining which programs to fund, when to fund them, or how much funding to provide. It does not clearly connect specific programs with any particular policy goal, such as the Administration's (rather minimal) goal of reducing greenhouse gas intensity. Given that the Plan is about three years late, these failings are particularly unfortunate. The Plan also explicitly fails to deal with what is perhaps the key issue in climate change technology - technology deployment. Creating a market for technologies that could limit climate change - especially, creating a market soon enough that the action can make a real difference - will require government policy, whether that be tax incentives, regulations or some other measures. Simply undertaking research and development (R&D) is not enough, to put it mildly.

A majority of the Senate agrees, having voted last year for a Sense of the Senate resolution endorsing the need for "mandatory, market-based limits" that will "slow, stop, and reverse the growth" of global warming pollution. The resolution affirms that U.S.

mandatory action can be taken without significant harm to the economy and that such action "will encourage comparable action by other nations that are major trading partners and key contributors to global emissions."

State and local governments are leading, with mandatory limits on power plant emissions in the northeast and in California. California and 10 other states have adopted limits on global warming emissions from motor vehicles. Last month, California – the 12th largest emitter in the world – enacted the most far-reaching state plan to reduce the state's global warming pollution to 1990 levels by 2020. The state's new law enjoys wide support from businesses and other constituencies, going well beyond the usual environmental suspects: PG&E; Silicon Valley Leadership Group; Bay Area Council; Sacramento Municipal Utility District; Waste Management; Calpine; California Ski Industry Association; the cities of Los Angeles, San Francisco, Oakland, and Sacramento; the American Academy of Pediatrics; the California Nurses Association; CDF Firefighters; and Republicans for Environmental Protection.

Many other states have adopted standards to increase the percentage of renewable power generation. Stakeholder processes to address global warming are underway or in development in a growing number of states in all regions of the country. More than 200 cities have announced plans to reduce their global warming pollution.

The constituency for real action is broadening and growing. Earlier this year, more than 80 evangelical leaders called for mandatory limits on global warming pollution, citing their duty to care for God's creation.

In April, appearing before the Senate Energy Committee, some of the largest electric utilities, suppliers of generating equipment, and electricity customers called for mandatory limits. Huge companies such as Duke Energy, Exelon, and GE said that voluntary programs won't work and that they need certainty and clear market signals in order to make sensible investments in new power plants that will last 50 years. Big electricity consumers like Wal-Mart endorsed mandatory limits and committed to cut their energy use and emissions through investments in energy efficiency and renewable energy.

They all get it. Voluntary programs and tax incentives are insufficient to get these technologies deployed at a sufficient scale and speed to avoid a climate catastrophe. The market conditions for these new investments will not be created without a limit on CO_2 emissions.

Technologies for Balancing the Carbon Cycle

Scientific American devoted its September issue to "Energy's Future Beyond Carbon." This special issue includes five articles that describe technologies available today to reduce carbon dioxide emissions by improving energy efficiency in transportation, buildings and industry, and by harnessing renewable energy sources and scrubbing carbon dioxide from fossil fuels. With appropriate policy support these technologies can be deployed in a portfolio capable of keeping the United States within the carbon budget described earlier, which is necessary to avoid dangerous global warming. There are many options for assembling such a portfolio. In the scenario illustrated below the largest reductions are obtained from energy efficiency improvements in electrical end uses, non-electric stationary end uses, and motor vehicles.

Additional reductions come from renewable fuels and electricity and carbon capture and disposal at coal-fired power plants and other high-concentration industrial CO2 vents.

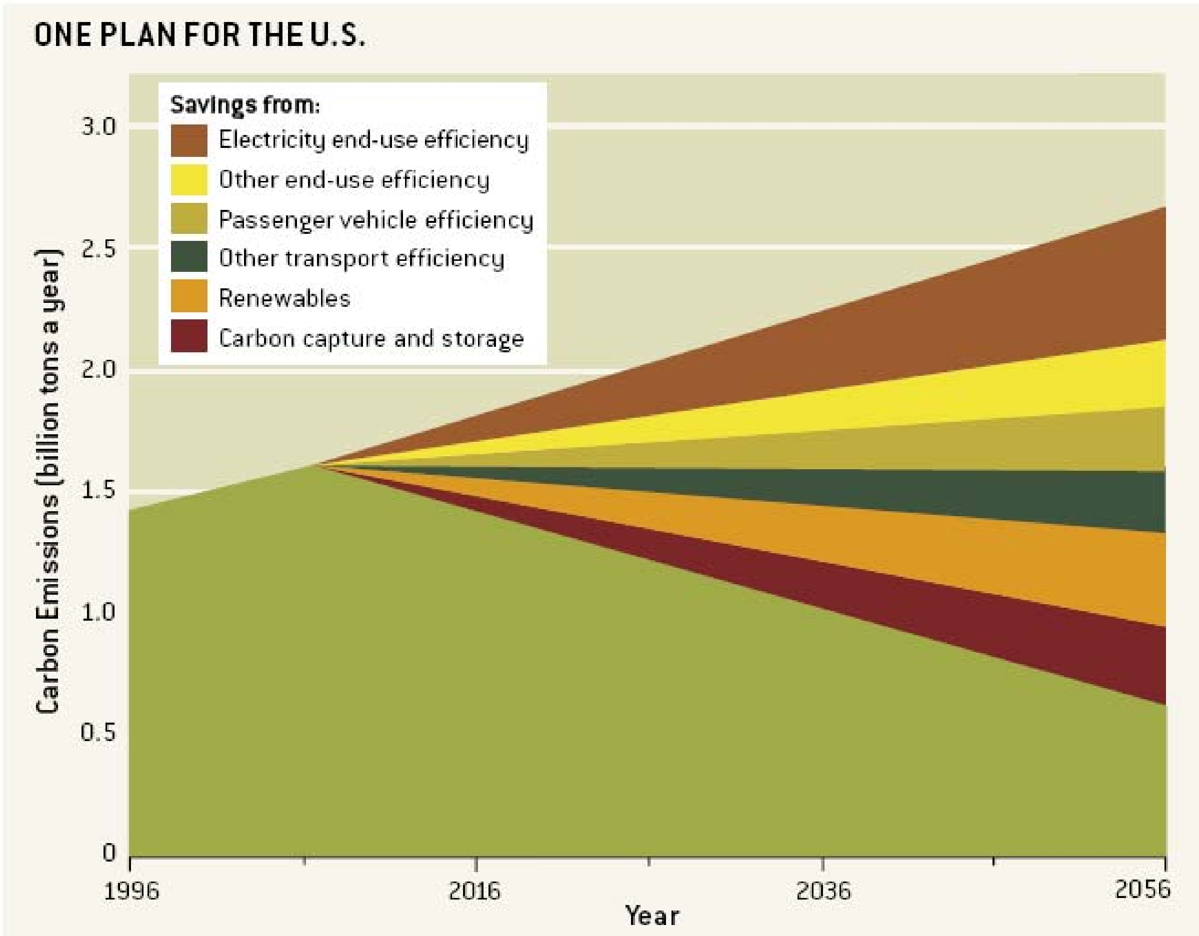

Figure 3. *Source*: Lashof and Hawkins, NRDC, *in* Socolow and Pacala, *Scientific American*, September 2006, p. 57

The elements of this scenario are briefly outlined below.

1. **Electric end-use efficiency (0.54 GtC):** Efficiency improvements in motors, lighting, refrigeration and other electrical equipment reduce total electricity consumption by 40% in 2056 compared to BAU. Resulting total electricity consumption is 4400 billion kilowatt-hours (BkWh), 20 percent greater than current consumption levels. California has demonstrated in practice that such reductions are possible. Sustained policies to promote energy efficiency through a combination of appliance standards, building code enforcement, and utility

efficiency programs have stabilized per capita electricity consumption in California over the last 30 years while national per capita electricity use continued to grow such that per capital electricity consumption in California is now more than 40% lower than in the rest of the country.[12]

2. **Other end-use efficiency (0.28 GtC):** Improvements in building designs and industrial processes result in a 40 percent reduction in non-electric energy consumption by stationary sources compared to BAU. Overall emissions from these sources decline by 15 percent from current levels.

3. **Passenger vehicle efficiency (0.27 GtC):** Widespread use of hybrid vehicles, as well as improvements to conventional vehicles, raises the average fuel economy of the in-use vehicle fleet to 54 miles per, compared with 24 mpg under BAU.

4. **Other transport efficiency (0.23 GtC):** Heavy truck fuel economy increases to 13 mpg, compared with 7 mpg under BAU and aircraft efficiency increases to 105 seat miles per gallon (smpg), compared with 80 smpg under BAU. In addition, smart growth policies reduce total travel demand by 10 percent.

5. **Renewable energy (0.39 GtC):** Renewable energy (e.g. wind and biomass) accounts for 30 percent of total electricity generation by 2050, compared with less than 5 percent under BAU. This much electricity could be supplied by 500 GW of wind (e.g. 250,000 2-MW-turbines). Turbines would be spread over 20 million acres, but the land could also be used for crop production or livestock grazing. In addition, 40 percent of transportation fuel is provided by sources with zero net CO_2 emissions (e.g. cellulosic ethanol with soil carbon increases compensating for fossil carbon inputs; Fischer-Tropsch diesel from biomass with geologic carbon sequestration compensating for fossil carbon inputs; renewable electricity supplied to plug-in hybrids). This corresponds to 80 billion gallons of biofuels, which could be supplied from energy crops grown on 60 million acres of land, assuming productivity of 12 tons/acre.[13] Alternatively, this could be supplied by 40 billion gallons of biofuels plus 520 billion kWh of additional renewable electricity supplied to plug-in hybrids.[14]

6. **Carbon capture and storage (0.32 GtC):** Carbon capture and storage technology is applied to 160 GW of coal-fired integrated gasification combined cycle power plants, capturing 0.19 GtC in 2050. Additional carbon dioxide is captured from natural gas production facilities, large industrial sources, and ethanol plants, contributing 0.12 GtC to the 2050 emission reductions. The total volume of carbon dioxide put into storage would be 30 times the volume currently used for enhanced oil recovery and would be equivalent to 5 times the annual flow of natural gas through buffer storage facilities. In addition, increased thermal

[12] http://www.nrdc.org/air/energy/fcagoals.asp
[13] N. Greene, et al., 2004. *Growing Energy: How Biofuels Can Help End America's Oil Dependence.* (NRDC, New York, 2004)
[14] Assumes 13 kWh displace 1 gallon of gasoline in a plug-in hybrid.

efficiency at power plants from replacing older units reduces emissions by 0.03 GtC.

Conclusion

The carbon cycle is out of balance, causing an accelerating build up of heat-trapping carbon dioxide in the atmosphere that endangers our environment, our health, and our economy. The good news is that with decisive action initiated now we can deploy available technologies to rebalance the carbon cycle in time to avoid the worst consequences of global warming.