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CARBON FOLLY

The Facts About CO2 Emissions

Excerpts from the forthcoming book:

Carbon Folly
by
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THE SECOND OF AUGUST
When most delegates signed the
Declaration of independence

Executive Summary

There is a hue and cry for the United States to reduce its CO_2 emissions 80% by 2050.

But few people ask:

> Is it possible for the U.S. to cut its CO_2 emissions by 80%?

Some in Congress believe it is possible, and have submitted legislation to establish Cap & Trade regulations trying to force the U. S. to cut its CO_2 emissions by up to 80%.

Carbon Folly examines each sector to determine whether there are alternatives for generating electricity or replacing gasoline and natural gas or reducing CO_2 emissions by other means.

> The Electric Sector is examined to determine whether clean coal technologies and sequestration can result in significantly lower CO_2 emissions. Renewables are investigated to see how much they can contribute to reducing CO_2 emissions.
>
> The gasoline sector is examined to see how gasoline usage can be drastically cut. Plug-in Hybrid Electric vehicles are studied to determine how much they can cut CO_2 emissions.
>
> The Transportation (other than gasoline), Residential, Industrial and Commercial Sectors are scrutinized for possible reductions in CO_2 emissions.

Carbon Folly also examines the role conservation can play in drastically cutting CO_2 emissions.

The difficulties surrounding Cap & Trade regulations are analyzed, citing examples from the European Cap & Trade program.

In light of Europe's lower CO_2 emissions, a comparison is made between the United States and Europe to determine whether Europe represents an objective comparison; especially in view of Europe's stable or declining population.

Conclusions:

With America's population increasing 139 million people by 2050, there will be tremendous pressure for more electricity and more cars.

Few of the proposed technologies, including sequestration and carbon capture from exiting coal plants, have been proven to be viable.

Given today's technologies, it will be very difficult to cut CO_2 emissions significantly by 2050 without restructuring American society.

Research for developing breakthrough technologies that can displace today's products is essential for any significant improvement in energy intensity or potential reduction in CO_2 emissions.

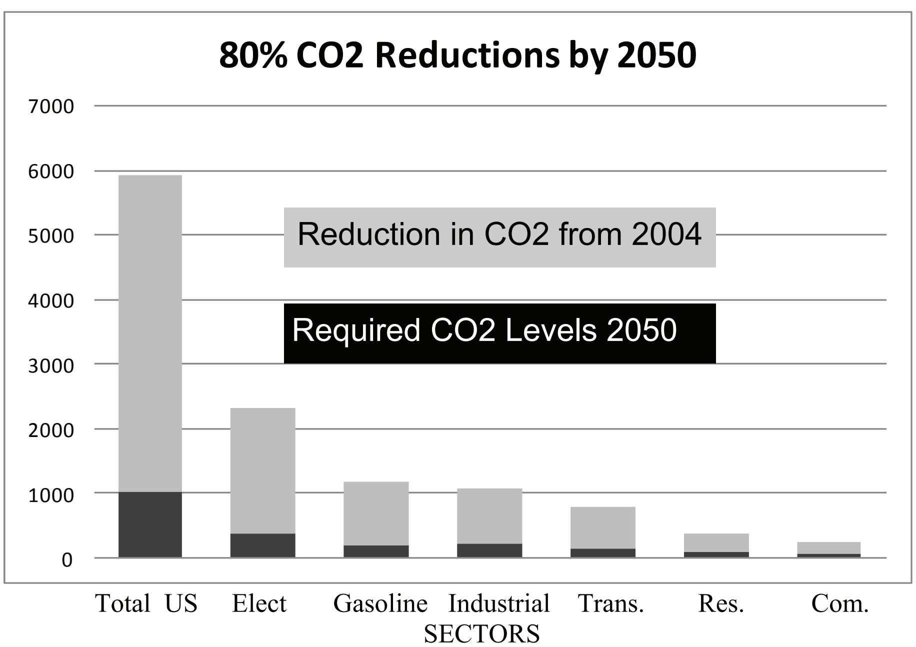
The first step in establishing a climate policy is to recognize how difficult it is to reduce CO_2 emissions by anywhere near 80%.Trying to force dramatic reductions in CO_2 emissions could cause irreparable harm to America's economy and society.

The table and graph show the huge cuts in CO_2 emissions required to meet an 80% reduction by 2050

U.S. CO_2 Emissions with 80% Reduction from 1990 levels by 2050 (in MMT).			
Source	**2004 Actual**	**2050 80% Reduction Below** 1990 Levels	**Required Reduc- tions.** From 2004 Actual
Electric Generation	2,298.6	360.6	**1,938.0**
Gasoline	1,162.6	191.0	**971.6**
Industrial	1,069.3	212.7	**856.6**
Transportation (Excluding Gasoline)	771.1	122.9	**648.2**
Residential	374.7	67.9	**306.8**
Commercial	228.8	44.7	**184.1**
United States Total	5,905.1	999.9	**4,905.2**

Table I

2004 Total excludes approximately 70 MMT of CO_2 emissions from miscellaneous sources..Source: 2004 *Emission of Greenhouse Gasses in the United States 2005* by DOE Energy Information Administration. MMT = Million Metric Tons



CARBON FOLLY

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The above Table of Contents is for the complete book. Only excerpts are included here.

The complete book together with notes will be available in 2008.

PART ONE

This book does not address global warming per se. It asks the question:

> Is it possible to cut CO_2 emissions by 80%? Or 60%? Or any significant amount?

There are other Green House Gasses (GHG) besides CO2, but CO2 represents the bulk of GHG and is used throughout as a surrogate for all GHG's.

One response to this book will be, "it's better to do something rather than nothing at all."

First, *Carbon Folly* doesn't recommend doing nothing.

What it does recommend, is to make improvements in energy efficiency so as to improve the United States' productivity and competitiveness. To the extent improvements in energy efficiency reduce CO2 emissions, so much the better.

Second, it's important to analyze what is meant by "doing something."

Does this include wasting resources?

Why take actions that will hurt economic growth when those actions can't affect global warming? All the pronouncements from those favoring action say that the world will suffer a disaster if CO2 emissions aren't reduced by 50% to 60% below 1990 levels.

Is it possible to cut CO2 emissions by 80%?

Or by 60%?

Or by 50%?

If the world is unable to achieve large reductions in CO2 emissions, the disaster won't be avoided. If disaster can't be avoided, wouldn't it be better to expend resources doing those things that would mitigate the impact of global warming?

Shouldn't our resources be spent on achieving economic growth and reducing poverty? And on research that can produce breakthrough technologies—technologies that change everything?

Virtually every newspaper and magazine article, as well as press releases from organizations such as the PEW Charitable Trusts and the National Resources Defense Council (NRDC), presumes that it is possible to reduce CO2 emissions by 80%. But what if it's not possible to reduce emissions by this amount? Or by 60%? Or by any significant amount?

It would be like starting to drive to a destination on a dead-end road. We would come to the end of the road long before reaching our destination. Wouldn't that be a waste of resources?

Chapter 1

Proposed Congressional Action

Several bills have been introduced in Congress to establish Cap & Trade regulations.

With these regulations the emphasis is on CAP. There is nothing to trade if a Cap hasn't been established for CO2 emissions. Under this system a company would have to have a permit for every metric ton of CO2 it emits. If it emits more CO2 than it has permits, it must buy permits from companies having surplus permits.

A Cap & Trade system is viewed by many as a way to allow market forces to work. The 1990 Clean Air Act established a Cap & Trade system for SO2 (Sulfur Dioxide) and it was viewed as a success.

Cap & Trade bills have been introduced in the Senate calling for reducing CO2 emissions by up to 80%[1].

When the government establishes a cap on CO2 emissions it creates a scarcity, which creates value where none existed before. It's possible to call a Cap & Trade system a scam because there is no underlying value. Value is arbitrary and created by government. Government is influenced by lobbyists trying to gain an advantage for the industries they represent. The system can also be gamed.

CO2 permits will impose a cost on all sectors of the economy, including, the residential sector where costs will ultimately be absorbed.

The government will establish caps for each industry, thereby determining whether an industry receives sufficient permits to cover its emissions.

Each year (or some other period established by the government) caps will be lowered so that industries will have increasingly lower levels of permitted CO2 emissions. If they do not have permits to cover their emissions over the cap, they will have to purchase permits from industries that have excess permits.

As industries buy permits they will incur costs. These costs will increase as the caps are lowered.

An individual company or utility can invest in new equipment to lower its emissions in order to remain within its lowered cap.

This assumes, of course, that new technologies are available for decreasing CO2 emissions.

Industries will recover all of their increased costs by increasing prices. In the final analysis, it is the consumer who will pay the bill.

It is clear from the above that there is room to game the system and create inequities.

Utilities that generate electricity using nuclear power want permits allocated based on the amount of electricity generated. This would give them excess permits that could be sold. Other utilities want the caps based on the amount of CO2 emitted. In this instance, the nuclear power companies would receive few if any permits.

Or caps could be established based on the most recent year. Or based on an average number of years. Companies that have invested in new equipment or processes would want the cap based on an average over the preceding years rather than the most recent year.

Coal producing states will want caps established at the point of usage, not at the point of origin. Coal producing states, like West Virginia, Pennsylvania and Wyoming, will pressure their Senators on this issue.

Some states with forests may want to receive credit for the CO2 absorbed by their trees.

Lobbyists in Washington will earn huge salaries for lobbying Congress to produce legislation favorable to the industries they represent.

The average consumer will have very little say in these negotiations or the legislation produced by Congress.

Financial businesses will be big winners with a Cap & Trade system as they will be able to buy and sell permits. Think ENRON.

Unless the Cap & Trade system is adopted world wide, it is very likely that manufacturers will move their plants to foreign countries to avoid the added cost of buying permits. This will mean the further loss of jobs. If developing countries such as China and India do not cap their CO2 emissions, worldwide CO2 emissions will increase even if the U.S. reduces its CO2 emissions.

If foreign countries refuse to join a worldwide Cap & Trade system and cap their emissions, C. Boyden Gray, US ambassador to the European Union, said retaliatory steps could be taken against China and India. Rep. Rick Boucher (D-VA.) suggested requiring them to purchase credits from the U.S. in order to export goods into the United States. This type of proposal is similar to threats made by the European Union against the U.S.

The complexity of a worldwide Cap & Trade system is mind-boggling.

Chapter 2

U.S. CO2 Emissions

The U.S. Energy Information Agency tracks CO2 emissions and publishes a report annually showing the source of CO2 emissions. See Table II.

- The generation of electricity accounts for 39% of all CO2 emissions in the United States.
- Gasoline, primarily from powering automobiles and light trucks (SUV's), accounts for 20% of all U.S. CO2 emissions
- Industrial emissions accounted for 18% of total U.S. CO2 emissions. Manufacturing accounted for approximately 84% of Industrial emissions[2]. Agriculture, forestry, fishing, construction and mining accounted for the rest of the industrial sector's CO2 emissions.
- Transportation other than gasoline accounted for 13% of total U.S. CO2 emissions. These emissions came primarily from heavy trucks, locomotives, ships and jet fuel.
- The residential sector accounted for 6% of total U.S. CO2 emissions. Space heating and appliances accounted for these CO2 emissions. (Lighting and air conditioning are accounted for under Electric Generation.)
- The commercial sector represents 4% of total U.S. CO2 emissions. These emissions came mostly from space heating (primarily natural gas) from office buildings, shopping malls, schools and hospitals. (Lighting and air conditioning emissions from electricity are included in the Electric Sector.)

Some non-governmental organizations (NGO's) have championed major cuts in CO2 emissions. The NRDC supports an 80% reduction in CO2 emissions from 1990 levels by 2050. The European Union (EU) has proposed a 50% reduction from 1990 levels[3]. The United Nations also endorses an 80% reduction for the U.S. so that developing countries, such as China and India, can continue to increase their CO2 emissions, but at a slower rate of increase.

U.S. CO2 Emissions 2004		
Source	**MMT**	**% Total**
Electric Generation	**2,298.6**	**39%**
Gasoline	**1,162.6**	**20%**
Industrial	**1,069.3**	**18%**
Transportation (Excluding Gasoline)	**771.1**	**13%**
Residential	**374.7**	**6%**
Commercial	**228.8**	**4%**
United States Total	**5,905.1**	**100%**

Table II

Total excludes approximately 70 MMT of CO_2 emissions from miscellaneous sources.
Source: *Emission of Greenhouse Gasses in the United States 2005* by DOE Energy Information Administration. MMT = Million Metric Tons

The phrase "common but differentiated responsibilities" is included in treaties and agreements[4]. It has been interpreted by many to indicate that developed countries (e.g., the U.S.) should provide financial or technical support to developing countries to assist them in cutting their CO_2 emissions[5]. In other words, the U.S. taxpayer should help pay China and India to reduce their emissions. Another interpretation is that there is a common responsibility to reduce emissions, but that each country can have different targets.

Table I with its accompanying graph shows CO_2 emission levels by sector that would have to be achieved for the U.S. to reduce CO_2 emissions by 80% below 1990 levels.

A cursory glance at Table I immediately raises the question as to whether it is even possible, let alone desirable, to achieve these huge reductions.

Three issues impact whether it's possible to cut CO_2 emissions by 80% or 60% Or by any significant amount?

1. Are there replacement technologies available that result in substantial reductions in CO_2 emissions?
2. Is there the political will to adopt these technologies?
3. Can conservation achieve the legislated targets?

In addition to the above three issues there is the very real problem of a growing population and the effect it will have on U.S. CO_2 emissions.

The Census Bureau estimates that the U.S. population in 2050 will be 420 million. This is an increase of 139 million from the 2000 census. This increase of 139 million happens to equal the total population of the United States during WWII.

The U.S. population in 2050 is therefore forecast to increase by 49% from 2000. These additional Americans will want to heat and light their homes, use air conditioning and drive automobiles. They will also want jobs.

The increased population will result in more CO_2 emissions and make it even more difficult for the U.S. to achieve the 2050 CO_2 emission targets.

It should be noted that it will be easier for Europe to achieve its targets as its population growth could be negative. European population could decline from 375 million in 2000 to fewer than 300 million by 2050 if present trends continue[6]. This projection doesn't include immigration which could offset much of the decline.

While demands for electricity and automobiles will increase in the United States, demand for these items in Europe will decline or remain unchanged.

Europe's pronouncements about what the U.S. should do to cut its CO_2 emissions should be viewed in this light.

Chapter 3

Europe's Cap & Trade Experience

The European Union (EU) began its Cap & Trade system, or carbon market, by establishing quotas for CO_2 emissions for its member states. Unfortunately, the quotas were set too high creating a glut of CO_2 credits (permits) which caused the price for CO_2 credits to collapse.

Now, in an effort to correct its initial mistake, the EU is attempting to tighten the quotas for each state in the next round of its Cap & Trade system that begins in 2008.

This has led to the poorer new member states, which already have low per capita CO_2 emissions, being assigned even lower emission quotas.

Latvia is typical of the new EU states that were formerly part of the Soviet Union. Latvia has the lowest per capita greenhouse gas emissions in the EU, yet the EU is attempting to force Latvia to cut its proposed emissions by around 50%.

As reported elsewhere, the ability of new EU members (such as Czech Republic, Latvia and Lithuania) to grow their economies is being "impaired because they lack the resources to confront the massive <u>business lobbies</u> of the EU's most developed and richest countries."

The system is being gamed at the expense of the little person.

The EU also allows businesses to buy credits from foreign countries (e.g., China and India) to help them meet their targets. Obviously this won't reduce Europe's CO_2 emissions. It also gives richer companies an advantage over smaller companies in Eastern Europe.

Then there is the proposal to include forests in the trading scheme. Under the proposal, "forests and other land would be credited as stores of carbon, allowing landowners to sell the resulting permits" to factories that emit CO_2. But what happens if forest fires or drought release the CO_2 stored in the forests. Permits would have been issued for CO_2 that wasn't safely stored in trees[7].

Population to Increase by 139 Million.

Imposition of Caps on European industries and utilities is increasing costs and the consumer is paying the price.

In spite of all these efforts to establish a Cap & Trade system, the EU has not been able to reduce its CO2 emissions over the past few years. EU emissions increased 1 – 1.5% in 2006

Congressional White Paper

A White Paper issued by the U.S. Congress' Committee on Energy and Commerce acknowledges the problems associated with Cap & Trade regulations.

The paper discusses where the "point of control" for CO2 emissions should be placed: Upstream, Downstream or Midstream. They describe the complexities surrounding emissions from automobiles; a downstream point of regulation complicated by the millions of individual emission sources. The White Paper suggests it is best to regulate emissions at the upstream source which are the refineries.

The White Paper fails, however, to examine the realities of controlling Transportation Sector emissions.

The point of regulation the White Paper seems to prefer is the refineries and importers. Refineries, however, do not control how much gasoline is used. Gasoline usage is controlled by millions of individual drivers. The only way refineries could control emissions from automobiles is by raising the price of gasoline to astronomic levels or by refusing to produce gasoline. Neither option is realistic.

Alternatively, the "point of control" could be the manufacturer of automobiles. Here, the government could mandate that only certain cars could be sold in the U.S.: For example, only those cars that achieve 100 mpg of gasoline or diesel fuel. (Or impose a Cap that accomplishes the same objective.) By one estimate, 100 mpg is required for there to be any significant reduction in gasoline usage[8].

Or the government could impose gasoline rationing to control emissions from the source if the downstream "point of control" is selected. While the complexities of the Transportation Sector are obvious, the same issues surround the Commercial and Residential Sectors.

Chapter 4

Developing Countries

China and India are the largest of the developing countries and they have repeatedly said they will not adopt fixed commitments for reducing CO2 emissions.

China will pass the United States as the largest emitter of CO2 this year or next. India says it has only one fourth the per capita emissions as China and should be viewed differently.

All the developing countries site the principle of "common but differentiated responsibilities." All place the onus on the United States and other rich countries to cut CO2 emissions.

If China grows at 7% per year (approximately the rate of current growth) China's economy will double in ten years. Presumably, CO_2 emissions will also double.

Sunita Narain, an Indian environmentalist told Reuters, "With climate change, we are looking at sharing the resources of the world and we are looking at bringing some justice in the way they are distributed -- so the rich world has to reduce its emissions so that the poor world can increase theirs."

The U.S. Energy Information Administration estimates that by 2010, developing countries will emit 20% more CO_2 than the developed countries.

At this writing, it is clear that developing countries do not intend to adopt fixed targets for cutting CO_2.

What is the outcome if developing countries refuse to cut their CO_2 emissions while the United States forges ahead with Cap & Trade regulations?

One must wonder about China's motives when China refuses to cut its emissions while demanding the United States cut's its emissions.

Perhaps the question is unfair, but where will the world be with a powerful China and a weak United States?

PART TWO

Part two examines the lack of alternatives for achieving an 80% or any significant reduction in CO_2 emissions. Alternatives for generating electricity are examined in Chapter 5. Alternatives for reducing gasoline usage are examined in Chapter 6. Other areas are examined in Chapter 7.

Chapter 5

Alternatives for Generating Electricity

Generating electricity accounts for 39% of total U.S. CO_2 emissions. Currently coal accounts for nearly half of the electricity generated in the U.S.; Nuclear accounts for 20%; Natural Gas for 21% and Hydro for 7%. (Currently oil accounts for less than 2% of total electricity generation[9].)

Coal accounts for 82% of CO_2 emissions from the generation of electricity.

Natural Gas accounts for 13% of CO_2 emissions from the generation of electricity.

Nuclear.

It would seem that nuclear power, that emits zero CO_2, would be the natural choice for reducing CO_2 emissions from the generation of electricity.

Two obstacles stand in the way of achieving any significant reductions in CO_2 emissions with nuclear power.

1. Expiring operating licenses.
2. Political will.

There are 104 nuclear power plants in the U.S. Most of these have already received a 20 year extension to their operating licenses, and all the remaining nuclear plants are expected to also receive 20 year extensions.

As a result of these extensions, all 104 nuclear plants can continue to operate until the expiration of their updated licenses.

There is a question as to how many of these nuclear power plants will receive a second extension to their operating license. Some will probably receive extensions, but others will not.

At issue will be the design life of the plants.

As a result, an unknown number of nuclear power plants may have to be shut down by 2053. Some may have to be shut down beginning in 2029, and more may have to be shut down during the 2030's.

Unless all the shuttered plants are replaced over the next fifty years, the percentage of electricity produced by nuclear power will decline.

The only alternative to nuclear power is coal or oil. Building new coal fired plants to replace nuclear plants will increase CO2 emissions. Not building new power plants to replace the shuttered nuclear plants will result in a shortage of electricity. (Wind and other alternatives are discussed later.)

The first obstacle, therefore, is to replace the nuclear power plants currently in operation that are shut down.

The second obstacle is whether America has the political will to build new nuclear power plants. Twenty five new nuclear plants are on the drawing board with the first of these to be completed in 2015.

Many of these 25 plants are proposed for sites where there are existing nuclear power plants. While there will be opposition to building these plants, the fact that they will be next to existing plants favors their approval.

But what about nuclear power plants at new locations?

Will there be the political will to build Greenfield plants?

Coal

The words *Clean Coal* and *sequestration* are on the lips of every person involved in the coal industry. They have great public relations value, even though environmentalists say *Clean Coal* is an oxymoron.

The reality is, that neither of these technologies are in place today; except for trial applications.

Clean Coal refers to a process where coal is cooked with steam and hot pressurized air to form gasses. CO2 is then separated from the gasses, and the remaining gasses, primarily methane and hydrogen, are burned in a gas turbine that drives a generator to generate electricity. The unused heat leaving the gas turbine is used to generate steam in a boiler which then drives a steam turbine that drives a generator to generate electricity.

These plants are known as Integrated Gasification Combined Cycle (IGCC) plants.

Only two IGCC demonstration plants have been built. As yet, no one has demonstrated the costs and practicality of capturing carbon in an IGCC plant.

IGCC plants require a larger investment and the electricity generated by these plants will be more expensive.

The purpose of IGCC plants is to capture CO_2 before the combustion process, but if there is no place to put the CO_2 the process is futile. This is where sequestration enters the picture.

The theory behind sequestration is that CO_2 can be liquefied and then pumped underground where it will remain so as not to enter the atmosphere.

While CO_2 may be captured from new IGCC power plants, assuming they work as proposed, the question remains about what to do with existing coal fired power plants.

Assuming existing plants can be modified, which will not always be possible due to space limitations, the issue becomes which process to use. Thus far, only field prototypes exist of the most promising processes for capturing CO_2.

Importantly, carbon capture processes can require de-rating existing coal fired power plants by 30 to 45%. Essentially, one new power plant may have to be built to replace the electricity no longer being generated when three power plants are retrofitted for carbon capture. Some units can be completely rebuilt with little loss of output, but this is analogous to building a new IGCC plant[10].

While it probably will be possible to build new IGCC power plants capable of separating CO_2, there is no proven technology for separating CO_2 from existing coal fired power plants.

Sequestration

Assuming it will be possible to retrofit all existing coal fired power plants to allow for carbon capture, and that all new coal fired power plants will be of the IGCC variety that allow for carbon capture, the CO_2 will have to be stored either underground or in the ocean.

Currently the largest underground sequestration operation is the Sleipner gas field where one million metric tons of CO_2 are injected annually into a saline aquifer under the North Sea.

For comparison purposes, the U.S. currently produces about 1,900 million metric tons of CO_2 each year from coal fired power plants.

While the federal and state governments are currently inventorying geologic formations, regulatory bodies will need to be established to ensure that the sequestered CO_2 doesn't escape into the atmosphere or into adjoining geologic formations where it might cause harm.

Many geologic formations, especially where oil and gas drilling took place, have abandoned wells or openings whose locations are not known. Each geologic formation will have to be surveyed to identify these and other possible escape routes for CO_2.

The issue of ownership of geologic formations has not yet been addressed.

Sorting ownership issues could take decades, or require government intervention through "takings" by eminent domain … if eminent domain is even applicable.

Another unresolved issue involves legal liability if CO_2 escapes or causes harm.

Finally there is the issue of how to transport the liquid CO_2 from the coal fired power plant to the appropriate geologic formation.

Transporting all the captured CO_2 to an appropriate geologic formation is an immense task.

If two thirds of all CO_2 emissions from coal fired power plants were captured and compressed to a liquid, its volume would equal America's consumption of 20 million barrels of oil per day[11].

Sequestration will require building thousands of miles of new pipelines.

Will people want pipelines built in their back yard or neighborhood?

Permitting, land acquisition and rights of way, including "takings" by eminent domain, are not trivial issues.

Natural Gas

Natural gas power plants produce about 45% less CO_2 per kWhr than do traditional coal fired plants. Many communities are prohibiting the construction of coal fired plants leaving newly developed large (480MW Combined Cycle) natural gas power plants as the only alternative.

Even if was possible to do so, replacing all existing coal fired plants with natural gas would not achieve an 80% reduction in CO_2 emissions for the electric sector.

Natural gas is becoming increasingly scarce and its price has risen considerably in recent years. Higher prices will hurt homeowners who heat with natural gas.

Hydro

Conventional hydro power, as differentiated from pumped storage, emits no CO_2. (Some environmental groups oppose this assertion and say that reservoirs created by dams can emit CO_2.)

Currently, Hydro accounts for 7% of total electricity generation. Every indication is that the amount of electricity generated from Hydro will decline rather than increase.

Environmental groups are insisting that dams be dismantled, either to protect Salmon or to restore scenic vistas and historic sites. Four dams on the Snake River are being targeted for removal because they interfere with Salmon.

In April 2007, the California Senate rejected a proposal to build two new hydroelectric dams.

It is doubtful that new dams will be built and it is very likely that dams, especially smaller ones, will be dismantled.

Wind

Wind power is being touted as a way to generate electricity without producing CO_2.

But, can wind power replace existing coal fired plants or be a substitute for new coal fired plants?

Coal fired and nuclear power plants are base load plants. They typically are around 1,000 MW in size and produce large amounts of electricity on a steady basis. This is in contrast to natural gas power plants that generally provide peaking power[12]. (Peaks in usage of electricity occur when there are unusually large air conditioning loads or at certain times of the day, such as in the evening when cooking and lighting loads coincide.)

Wind turbines can not be used for base loads because they provide electricity intermittently. If the wind doesn't blow wind turbines can't generate electricity. Or, if the wind blows too hard the wind turbines must be shut down.

A wind turbine rated 1.5 MW (typical size of today's units[13]) is actually a .5 MW unit after considering its capacity factor. (The wind blows 33% of the time so units only operate 33% of the time.)

This means it would require 2,000 wind turbines to replace one 1000 MW coal fired or nuclear power plant. Only 1,533 wind turbines were installed in the U.S. during 2006[14].

Wind supplied a minuscule amount of electricity in the U.S. in 2006. (See Table IV)

Wind turbine manufacturers were at capacity in 2006 and would be hard pressed to produce enough wind turbines to replace even one coal fired or nuclear power plant, let alone several hundred.

Wind turbines are also coming under attack from several quarters, including environmentalists. Wind turbines kill birds and bats and interfere with historically valuable scenic vistas. Wind turbines are also an expensive way to generate electricity[15].

Other Renewables

Table IV shows the amount of electricity generated by renewable sources (other than Hydro).

It is doubtful that any of these sources can be substantially increased. Additionally, some of these renewable sources, such as wood, produce GHG.

While recent laboratory advances in solar film may make solar more attractive, solar is bound to remain a niche player for the foreseeable future.

Other solar technologies, such as concentrating technologies, could potentially generate substantial electricity. They would be limited to the Southwest U.S. due to available sunlight. Experimental methods for generating electricity include wave power and tidal action. A few such installations have been built. No knowledgeable person is saying that these experimental methods could supply a significant amount of electricity.

U.S. Sector/ Source	2006 Thousands kWhr	% Total
Biomass	55,574,081	1.37%
Geothermal	14,842,067	0.37%
Solar/ PV	505,415	0.01%
Wind	25,781,754	0.64%
Total US Net Generation	4,052,968,000	100%

Table IV
Data from U. S. Energy Information Agency

Conclusion relating to alternative sources of electricity.

It is not possible with today's technologies to reduce CO_2 emissions by 80% from the generation of electricity without decreasing the supply of electricity and thereby causing blackouts, factory closings and unemployment.

Since the generation of electricity accounts for 39% of U.S. CO_2 emissions, it is unreasonable to expect other sectors to reduce their emissions by substantially greater than 80% to make up for any short fall in the electric sector.

The reasons for this conclusion include:

- Nuclear power plants could decrease in number by 2050 as their operating licenses expire.
- IGCC *Clean-Coal* power plants are still under development. Only two developmental plants have been built and neither is carbon capture ready.
- Sequestration is still only a concept that needs to overcome four hurdles.
    1. Capturing CO_2 in existing coal fired power plants as well as in new IGCC plants.
    2. Building thousands of miles of pipelines to transport liquid CO_2
    3. Identifying underground geologic formations that won't leak.
    4. Resolving ownership and legal issues.
- Wind can not substitute for coal fired or nuclear power plants.
- Other renewables such as solar are too limited as to where they may be applicable and are too small in scale to substitute for coal fired or nuclear power plants
- The population is forecast to increase by 139 million new Americans by 2050.

With nuclear plants having to be decommissioned when their operating licenses expire; and with 139 million additional Americans wanting air conditioning and lighting, new coal fired plants will have to be built.

But, if the government prevents the construction of new coal fired power plants so as to reduce CO_2 emissions, there will be, short of restructuring America, a shortage of electricity.

Chapter 6

Gasoline Alternatives

Gasoline usage accounted for 20% of U.S. CO_2 emissions in 2004. Virtually all of this gasoline was used for cars and light trucks (SUV's). There were 223 million cars and light trucks on the road in the U.S. in 2003.

Primarily because of an increase in population, the number of cars and light trucks forecast to be on the road in 2050 is 321 million.

Once again, the increase in population will make it increasingly difficult to reduce CO_2 emissions from gasoline by 80%.

Another factor that will make it difficult to achieve any near term reductions in gasoline usage, is that cars and light trucks have an average lifespan of 15 years. Cars sold today will be on the road using gasoline in the mid 2020's.

Ethanol

Currently, U.S. Ethanol is produced from corn. There is serious concern about using corn to make Ethanol. Corn is a basic food crop and is used as feed to produce beef[16]. Using corn for Ethanol could drive up the cost of food (which it already has done in Mexico with higher prices for tortillas).

Research is being conducted on how to make Ethanol from cellulose. If cellulosic Ethanol becomes viable it will allow making Ethanol from corn stover (i.e., corn stalks) or switchgrass or other fast growing grasses or trees.

There currently are 30 million acres of unused farm land in the U.S. enrolled in the Conservation Reserve[17]. If all 30 million acres were added to the acreage currently used to grow corn used for making Ethanol, a total of around 1.3 million barrels per day of Ethanol could be produced in the U.S. This represents around 10% of daily gasoline usage in the U.S.

Theoretically total production could be doubled if corn stalks could be used for making Cellulosic Ethanol.

Under the most favorable conditions, it might be possible to reduce gasoline usage by around 20% by using both Ethanol from corn and Cellulosic Ethanol.

This would represent a corresponding 20% reduction in CO2 emissions from gasoline; a far cry from 80%.

Electric Vehicles

Electric vehicles, probably in the form of Plug-in Hybrid Electric Vehicles (PHEV'S), have the potential for achieving significant reductions in gasoline usage and a moderately large reduction in CO2 emissions.

Prototype PHEV's built by interested groups have demonstrated the PHEV's ability to get over 100 miles per gallon of gasoline. They achieve this performance by operating much of the time on battery power. The PHEV would only use the gasoline engine when it was driven at higher speeds. Since most cars are driven only 35 miles each day for commuting, most cars will not need to use very much gasoline. The batteries will be recharged nightly from a 120 volt outlet. In essence, every garage becomes a battery charging station. Estimates indicate that up to 75% of drivers have access to a plug for recharging batteries[18].

PHEV's depend on improved battery technology. Currently the most promising new battery technology is the Lithium-ion battery.

A123Systems Corporation is developing a Li-ion battery using nanophosphate battery chemistry. This nano technology was developed at MIT and its developers help found A123Systems Corporation. The A123Systems Li-ion batteries have been used by Black and Decker in their hand tools.

Their next challenge will be to demonstrate that their batteries can be used in PHEV's with satisfactory lifetime performance. Toward this objective, GM has selected A123Systems as one of its battery suppliers for its new E-Flex drive system in its *Volt* automobile.

GM has indicated it will produce the *Volt* in 2010. This could be the first year that a mass produced PHEV will be available for the average consumer[19].

If 7,000 PHEV's are sold in 2010 and the number sold increase by 30% every year thereafter, it won't be until the mid 2050's before 75% of the cars on the road are PHEV's. Since PHEV's can use Ethanol in their internal combustion engine it can be assumed that only the remaining 25% (61 million vehicles) will use gasoline[20].

This is clearly a very ambitious forecast. It assumes a 30% annual increase in PHEV's sold which is highly unlikely because PHEV's will cost up to $10,000 more than conventional cars due to the higher cost of the Li-ion battery.

There is a possibility that existing Hybrid vehicles can be retrofitted with a Li-ion battery. This would slightly increase the number of PHEV's on the road.

While PHEV's can result in reduced CO2 emissions from gasoline, the electric utility will emit CO2 as it produces electricity for recharging the batteries.

A study by the Pacific Northwest National Laboratory[21] determined that 43% of the existing cars and light trucks could be PHEV's before new generation and transmission infrastructure would be required. Because the number of vehicles will increase due to population growth, this percentage would decrease to around 30% in the mid 2050's when 75%[22] of vehicles would be PHEV's (under the previous optimistic assumptions).

In other words, new generating capacity will be required at some point in the future. More importantly, the issue is: How much additional CO2 will be produced from generating the electricity required to recharge PHEV Li-ion batteries that displace the use of gasoline?

This depends on what energy source is used to generate the needed electricity. A combination of coal fired and natural gas is the most likely source.

A rough calculation shows that if 75% of the vehicles on the road in 2050 are PHEV's, CO2 emissions will be approximately 959 MMT (540 from generating the required electricity plus 418 from the 25% of gasoline powered cars remaining on the road) compared with 1162.6 MMT from gasoline alone in 2004.

While these calculations are admittedly rough, an optimistic scenario would have PHEV's reducing CO2 emissions by 18% by 2050.

Converting 75% of all cars and light trucks (SUV's) to PHEV's by 2050 will still result in CO2 emissions of 959 MMT which far exceeds 191 MMT. (CO2 emissions of 191 MMT from gasoline would be allowed under the proposed legislation requiring an 80% reduction in CO2 emissions.)

Hydrogen Powered Vehicles

The alternative to electric vehicles that has received considerable attention is the use of hydrogen to fuel the vehicles[23].

The three most significant reasons why hydrogen vehicles are not likely to become available in the near future are:

- The problem of storing hydrogen on the vehicle
- The cost of fuel cells
- The problems associated with producing and distributing hydrogen

Storage:

Compressed hydrogen has been stored on demonstration cars in cylinders at 10,000 psi. These cylinders require considerable space on a vehicle, and it is extremely difficult to design a vehicle around these cylinders. While these cylinders are probably safe, there is some concern about the high pressure and what might happen in an accident.

Hydrogen has also been stored in demonstration vehicles in liquid form. This requires cooling hydrogen to -423 degrees F and then storing it in, what is essentially a thermos bottle, on the vehicle. This method of storage raises similar concerns as storage in high pressure cylinders.

Research is underway to find a metal hydride that can absorb hydrogen and quickly release it on demand. Until now no such material has been discovered or developed.

Fuel Cells

"Fuel cells of various types have been under development for many years and have been used successfully in the space program and in stationary power generation. Commercial fuel cells are on the market today for power generation, either as back up power, remote stand alone power plants or cogeneration."

"Proton Exchange Membrane (PEM) Fuel Cells that operate at relatively low temperatures seem to be the type receiving the most attention at this time for possible use in vehicles and in residential applications."

Fuel cells are extremely expensive.

Hydrogen Production and Distribution

Hydrogen can be produced using electrolysis, from methane gas and in high temperature nuclear reactors.

Electrolysis is the most practical method for producing hydrogen in a distributed system. (Methane is too expensive and in increasingly short supply.)

Producing hydrogen from methane (possibly from IGCC plants) or in nuclear reactors would be done at central locations. Hydrogen produced at central locations will have to be trucked in liquid form (with an energy loss from liquefying the gas) to distributed fueling stations. Alternatively, a new system of special pipelines would have to be built. (Natural gas pipelines are not suitable for hydrogen as the hydrogen will attack the pipes.)

Conclusions: Alternatives for Gasoline.

Short of prohibiting people from owning automobiles or rationing gasoline, it is not feasible to reduce CO2 emissions from gasoline by 80% by 2050.

Ethanol can not by itself, under the most favorable of scenarios, reduce CO2 emissions by any where near 80%.

Electric vehicles may be able to reduce emissions by about 18%, but not until 2050. The savings from gasoline emissions are largely offset by CO2 emissions from additional generation of electricity.

Conclusions: Alternatives for Gasoline. (Continued)

Hydrogen powered vehicles are not likely to become feasible for decades, and similar to electric vehicles, can not reduce CO2 emissions significantly; certainly not anywhere near 80%. Producing hydrogen by electrolysis, probably the most logical approach to hydrogen production and distribution, could result in an increase in CO2 emissions due to the additional generation of electricity.

PART THREE

There is considerable press about how conservation can eliminate the bulk of CO2 emissions.

Conservation can play a role in saving energy, but claims about significantly reducing CO2 emissions are mostly flawed. Part Three addresses the realities about conservation and examines how people overstate the results that can be obtained from conservation.

Chapter 8

Traditional Approaches to Conservation

A: Electric Sector

Lighting

Lighting represents the greatest opportunity for conservation in the Residential, Industrial and Commercial Sectors, though the Residential Sector offers the best opportunities.

Industrial and commercial installations are designed to provide the amount of light required to perform tasks efficiently and safely.

The Illuminating Engineering Society has published tables showing recommended light levels for various tasks.

Reducing these light levels can impede productivity and create unsafe environments.

Most commercial buildings (stores, hospitals, office buildings etc.) already use fluorescent lighting wherever possible[24]. Factories also use fluorescent lighting and high energy discharge lighting where fluorescent lighting isn't applicable. (When ceiling heights are too high, such as in manufacturing bays, more powerful high intensity discharge (HID) lighting is required.)

The only major opportunity for commercial and industrial organizations to reduce electricity usage from lighting will be the emergence of Light Emitting Diodes (LED)[25]. LED's have recently been developed that produce white light. Until these recent developments LED's have been limited to applications where colored lighting is used. For example, LED's are being used in traffic signals to great effect.

While fluorescent lighting reduces electricity usage by around 75% when compared with incandescent bulbs, LED's reduce electricity usage by around 90%.

LED's will, however, be suitable for use in hotels and commercial applications where compact fluorescent bulbs are now used.

LED's are still viewed as a niche product and their costs are where compact fluorescent bulbs were fifteen years ago, or about $19 for a 100 watt lamp

Because industry and commercial organizations already use very efficient lighting, they will have fewer opportunities to achieve significant reductions in electricity usage from lighting through conservation.

Residential lighting affords genuine opportunities to reduce the use of electricity through conservation.

Replacing incandescent bulbs with compact fluorescent bulbs has become the smart thing to do. A 100 watt incandescent bulb uses 100 watts while a 100 watt Compact fluorescent uses only 23 watts of electricity. The Lumen output in modern CFL's is about the same as incandescent bulbs.

Total Electricity used for residential lighting was 101 billion kWhrs in 2001. The EIA had calculated that 35% of this could be saved by replacing incandescent bulbs that burned more than four hours with CFL's. This would result in reducing CO2 emissions by 24 MMT.

If all incandescent lights were replaced with CFL's, 52 MMT of CO2 could be eliminated. Population growth would slightly reduce these savings.

A 52 MMT reduction in CO2 emissions is miniscule when compared with the 80% reduction required from the Electric Sector by proposed legislation.

CFL's are the low hanging fruit of conservation.

Their first cost is low, the payback is quick and they are easy to install.

<u>Refrigeration</u>

Refrigeration is a large user of electricity in the Residential Sector accounting for approximately 139 MMT of CO2. (Approximately twice the CO2 of all residential lighting.)

Refrigerators have a high first cost and long payback period when existing refrigerators are replaced with new Energy Star units.

Replacing a 1990's refrigerator with a new unit will reduce its CO2 emissions by around 13%[26].

In spite of the high cost and long pay back, nearly all refrigerators will be replaced by 2050 because of their average lifespan. It's reasonable to assume that CO2 emissions from refrigerators will be reduced by 20%. (This assumes some continuing improvements in refrigerator efficiency.)

If CO2 emissions for refrigerators are reduced by 20%, it will account for a reduction of 28 MMT CO2.

<u>Other appliances</u>

The life of appliances is fairly short so it is reasonable to expect that all existing residential appliances (washers, driers, etc.) will be replaced by 2050.

If all other appliances are replaced with new appliances having a 15% reduction in electricity usage, CO2 emissions would be reduced by 94 MMT.

Conclusion: Conservation from Electric Sector

The conservation efforts itemized above, achieve a reduction of 174 MMT of CO2, compared with total CO2 emissions from the Electric Sector of 2,298.6 MMT. This is an 8% reduction compared with the 80% reduction required by proposed legislation. Conservation is good and improves the nation's productivity, but will play a small role in reducing CO2 emissions from generation of electricity.

B: Gasoline Sector

As described earlier the best solution for reducing gasoline usage will be to manufacture PHEV's, but what about existing vehicles and those built in the future that are not PHEV's?

A simple way to reduce gasoline usage is to stop using air conditioning and revert to the 4 and 40 system that was predominantly used before the 1960's; four windows open at 40 mph.

Car pooling and teleworking have been promoted for at least twenty years. If they were meaningful solutions they would have been widely adopted by now.

Another proposal has been to impose a gasoline tax. No one has any information about how high the tax would have to be for people to cut their driving by 10%, or 20% or even 30%. But it would require an 80% reduction to achieve the reductions in CO2 emissions from gasoline proposed in pending legislation.

CAFÉ standards that would increase gasoline mileage by 20% (from 27.5 mpg to 33 mpg) in current production models would also reduce CO2 emissions by 20%. While this is a significant reduction, it will be offset by increased population.

With a combined improvement in gasoline mileage of 20% and increased population of 139 million, CO2 emissions may increase by about 14%. (The PHEV that can achieve substantial reductions in gasoline usage is considered to be a new technology rather than an effort at conservation.)

Conclusion: Conservation from Gasoline Sector

Short of imposing gasoline rationing, it is not feasible to reduce CO2 emissions from gasoline by 80% through conservation.

C: Residential and Commercial Sectors

Natural Gas.

Natural gas represented 71% of CO2 emissions from the Residential Sector and 71% from the Commercial Sector.

Turning down the thermostat to save on heat is a way to save natural gas. Japan has done this and required employees to wear sweaters or coats at work.

Replacing old furnaces could reduce natural gas usage. According to the DOE 25% of homes have furnaces that are more than 20 years old.

If all 25% of old furnaces were replaced with new furnaces having an average improvement in efficiency of 30%, and assuming that natural gas in residential sector is primarily used for heating, CO2 emissions might be reduced by 20 MMT. 20MMT represents an 8% reduction in CO2 emissions from natural gas in the Residential Sector.

Since most of these old furnaces will fail by 2050, it can be assumed that the 8% reduction will occur. The increase in population could more than offset this reduction.

Though DOE doesn't estimate how many furnaces in the Commercial Sector could be replaced, it might seem reasonable to estimate that another 12 MMT of CO2 emissions can be eliminated by replacing all furnaces in the Commercial Sector.

Conclusion: Conservation from Residential & Commercial Sectors

It is highly unlikely that conservation can significantly reduce CO_2 emissions from natural gas from the Residential or Commercial Sectors. The estimates shown above might reduce CO_2 emissions from the use of natural gas in the Residential and Commercial Sectors by about 32 MMT. Total natural gas usage in these sectors accounted for 428 MMT of CO_2 emissions in 2004.

Conservation Rhetoric versus Objectivity

It is easy to be distracted by the hype surrounding conservation.

Emotion is a powerful tool for influencing people. For example, Iceland is the poster child for those supporting geothermal energy. Roughly two thirds of Iceland's energy comes from geothermal sources. But, the population of Iceland is around 300,000 people or the size of mid-size American city such as Toledo, Ohio, or Aurora Colorado, or Tampa, Florida.

Iceland should be commended for how it has used its available natural resources, but their experience with Geothermal is hardly relevant to a discussion of the energy needs of United States. As shown earlier, Geothermal is hardly worth mentioning when it comes to generating electricity in the United States.

Then there is the argument based on the question: How do You Eat an Elephant? The answer: One bite at a time!

The inference is that a series of small reductions in CO_2 emissions can add up to achieve an 80% cut in CO_2 emissions. Small improvements in energy efficiency shouldn't be ignored as they do add up and do improve the nation's productivity and competitiveness. But an examination of the magnitude of the CO_2 reductions required from each Sector and the technologies available for making those reductions, demonstrate that it is not possible to achieve an 80% reduction in CO_2 emissions.

The rhetoric leaves the impression that it is easy to achieve huge reductions in CO_2 emissions. Objectivity is required to understand the rhetoric. Each piece of rhetoric should be examined to determine whether it really accomplishes very much and to see whether the technology for achieving the reductions are actually available.

For example, people talk about sequestration as though it was a proven technology and a done deal, when, as we have seen, it is not proven and there are many problems that need to be resolved before anyone can say with certainty that sequestration will work on the scale needed.

Chapter 9

Restructuring America

The strongest argument that proponents of GHG reductions have is that America has high per capita GHG emissions.

The U.S per capita emissions are more than twice as great as are Europe's.[27]

By coincidence, it would require a nearly 60% reduction in U.S. per capita emissions to equal Europe's.

Carbon Folly Describes Many Specific Examples of Differences Between Europe and the United States

At face value it would appear as though Americans are sloth and wasteful.

But, American's have a higher standard of living than Europeans.

The GDP per capita is $43,444 for Americans and only $28,213 for Europeans.[28]

With a GDP about 50% higher than Europe's, it would appear as though Americans aren't slothful.

Americans, in fact, work harder, longer and smarter than Europeans and have earned their higher standard of living.

Should Americans reduce their standard of living so as to be on a par with European's?

America's higher GDP may not account for all the differences between per capita GHG emissions; there are other differences between America and Europe that also make a difference.

Books have been written examining the geographic and social structures of the U.S. and Europe. There isn't room here to examine all the differences, but it is worth examining some of the differences. Americans aren't slothful or particularly wasteful as some would claim.

There is no argument that the U.S. and EU are different geographically and structurally. The question is: Should the U.S. change so as to conform to Europe's structure? Or is it even possible given their contrasting geographies?

Both continents developed differently.

It has only been the last fifty years that European national boundaries have begun to come down.

An American from Chicago thinks nothing of driving to St Louis, Missouri. The Parisian is not likely to drive to Frankfurt, Germany; a comparable distance.

For better or worse, where Americans live and work is spread out. Americans have taken advantage of the space the American continent has afforded them. From the very early colonial period, when Americans started to move west to find new land for their families, Americans have viewed space as an asset for development and not something to be horded by the few elite in the ruling class.

To reduce American living standards and reorganize American society is how proponents of GHG reductions envision the process of mandatory reductions in GHG emissions working.

Restructuring America is the ultimate form of conservation.

Without restructuring and changing American society it is difficult to even contemplate how the United States could reduce its CO_2 emissions by 80%.

OVERALL CONCLUSIONS

Based on the factual information contained in Carbon Folly, it is reasonable to conclude that it is not possible to cut U.S. CO_2 emissions by 80% below 1990 levels. Or by 60%. Or by any significant amount. An increase in population virtually precludes significantly cutting CO_2 emissions.

Electric Sector

Electric Sector Accounts for 39% of CO2 Emissions.

The Electric Sector accounts for 39% of total U.S. emissions, so it is critical that CO_2 emissions from this Sector be cut by 80% below 1990 levels if there is to be any possibility of meeting mandated targets.

- Nuclear power generation will probably not help cut CO_2 emissions. Because of license expirations, some nuclear may have to be replaced with coal fired power plants.
- Only demonstration IGCC *Clean Coal* power plants have been built, none with carbon capture capability, so there may be little help from IGCC power plants in cutting CO_2 emissions. In addition, if CO_2 is captured from IGCC plants it has to be stored underground and large scale underground storage may not prove feasible.
- Existing coal fired power plants will continue to emit CO_2 unless a way is found to capture their CO_2 emissions, either before combustion, during combustion or afterwards. As yet no system has been proven capable of doing this.
- Sequestering CO_2 underground requires building thousands of miles of pipelines to transport the liquid CO_2. It also requires identifying geologic storage formations that won't leak. Legal and ownership issues haven't started to be addressed and could consume decades before they are settled relative to underground storage.
- Natural gas can reduce CO_2 emissions from coal fired power plants, but requires replacing all coal fired plants with natural gas to achieve a 45% reduction from coal fired power plant CO_2 emissions. Natural gas is becoming in short supply so efforts to replace coal with natural gas will increase costs for all users of natural gas, including home heating. The shortage would become acute unless drilling in the Gulf of Mexico is permitted.
- Hydro power will probably decline due to several environmental issues, thereby requiring additional CO_2 emission reductions from other power generation sources if the lost power is to be replaced.
- Wind power is totally inadequate for replacing base load power plants.
- Other renewables are incapable of realistically supplying anything more than a modest increase in electricity.

Gasoline Sector

Gasoline Sector Accounts for 20% of CO2 Emissions.

- There is insufficient crop land to produce enough Ethanol or Cellulosic Ethanol to replace more than 20% of gasoline. There are ethical issues surrounding using food crops for Ethanol, making it essential that Cellulosic Ethanol be developed.
- Cellulosic Ethanol is still in the development phase.

- Plug-in Electric Vehicles (PHEV's) have the greatest potential for reducing CO_2 emissions from this Sector.
- PHEV's are still experimental.
- PHEV's, once developed, may be able to reduce CO_2 emissions from gasoline by 18% by 2050.
- Hydrogen powered vehicles are unlikely to mature before 2050.

Industrial Sector

- Natural Gas and Oil account for 82% of CO_2 emissions from this Sector, but are used for producing product as well as for use in manufacturing processes.
- Industry generally installs the most efficient equipment so there are fewer opportunities for making substantial reductions in CO_2 emissions by replacing equipment.
- There are always ways to improve processes, so it will be possible to make modest reductions in CO_2 emissions.
- Achieving substantial reductions in U.S. CO_2 emissions requires moving industry off-shore.

Other Sectors Can't Make Up Shortfalls From Electric or Gasoline Sectors.

Transportation (excluding gasoline) Sector

- Distillates (diesel fuel) account for 56% of the CO_2 emissions from this Sector. Diesel fuel is primarily used by the railroads and trucking firms that carry America's products and produce. An increasing population needs food and products, so CO_2 emissions from this Sector are likely to increase rather than decrease.
- Jet engines account for 31% of this Sector's emissions. As we have seen, jet engines have been constantly improved so there are limited opportunities to squeeze additional reductions of CO_2 emissions from jet engines. Increased population will likely result in more air travel and additional, rather than fewer CO_2 emissions.

Residential Sector

- With 139 million additional Americans needing places to live and work, the only possible way to reduce CO_2 emissions from the Residential Sector is with conservation.
- New building materials may be called green because they create fewer CO_2 emissions during their manufacture, but they will not reduce emissions from this Sector. (Reductions would be accounted for in the Industrial or other Sectors.)
- Electric usage from lighting and appliances are accounted for in the Electric Sector. Reductions in CO_2 emissions from electricity usage will have to come from conservation.

Commercial Sector

- Natural gas, which accounts for 71% of this Sector's CO_2 emissions, is used primarily for heating. Conservation is the only way to significantly reduce CO_2 emissions from this Sector.

Conservation

Conservation can improve the nation's productivity and is valuable for this reason alone, but conservation can not reduce U.S. CO2 emissions by 80% below 1990 levels.

Lighting has the greatest potential for reducing CO2 emissions from conservation.

- The most optimistic forecast of CO2 reductions from CFL's is 52 MMT, a fraction of the 4900.8 MMT required to reduce CO2 emissions by 80%.

Refrigeration is the next largest opportunity for reducing CO2 emissions from conservation in the Residential Sector.

- The most optimistic forecast of CO2 emissions from replacing all currently operating refrigerators by 2050 is 28 MMT.

Other appliances have relatively short operating lives so it is reasonable to assume that all appliances currently in operation will be replaced by 2050 with Energy Star units.

- Replacing all other appliances with Energy Star appliances by 2050 may reduce CO2 emissions by as much as 94 MMT.

CO2 reductions from Natural Gas by replacing 25% of existing furnaces (those identified as old by the Dept. of Energy) might result in a reduction of 20 MMT.

These are the low hanging fruit of conservation and taken together they account for less than 4% of the needed reductions in CO2 to achieve an 80% reduction in CO2 below 1990 levels by 2050.

Energy savings for each technology or appliance follows a learning curve, and learning curves are asymptotic. Simply stated, as production doubles, costs decline by a percentage associated with each technology or product. Savings accrue rapidly early in the life cycle but become increasingly more difficult to achieve as the product or technology matures.

The only way to achieve major improvements is with breakthrough technologies. The breakthrough technology makes a large improvement and then establishes its own learning curve.

Need to Focus On Research for Breakthrough Technologies

Overall Summary

It is highly unlikely that the United States can cut its CO2 emissions 60% or 80% below 1990 levels by 2050. Attempting to achieve reductions such as these could be disastrous to the American economy.

- To achieve a 60% reduction below 1990 levels by 2050 requires the U.S. to cut its CO2 emissions by 3905.2 MMT.
- To achieve an 80% reduction below 1990 levels by 2050 requires the U.S. to cut its CO2 emissions by 4905.2 MMT. (Table I)

Scientific breakthroughs are essential for improving energy intensity or to reduce CO2 emissions. Breakthroughs in areas such as these would be revolutionary.

- Super conducting transmission lines to dramatically reduce losses.
- Storage of electricity on a large scale.
- Space based solar power beamed electromagnetically to the grid.

Notes:

1. *Backgrounder* by Heritage Foundation, October 11, 2007
2. From 2002 EIA report.
3. The 50% proposal is based on allowing CO2 in the atmosphere to increase slightly, while not allowing temperatures to rise more than 2 degrees C. The UN's proposal to cut emissions world wide by 60% from 1990 levels is to maintain CO2 levels in the atmosphere at current levels. The UN proposes that developed countries reduce emissions by 80% while continuing to allow developing countries to increase emissions; overall the world would achieve a 60% reduction.
4. Included in the UNFCCC or Rio Agreement, in the Kyoto Protocol and in The September 2007 APEC Declaration.
5. From *Centre for International Sustainable Development Law (CISDL) Origins and Scope For the World Summit on Sustainable Development 2002 Johannesburg, 26 August."*
6. Study by Wolfgang Lutz, of the Austrian Academy of Science in Vienna, and Brian O'Neill, of the International Institute for Applied Systems Analysis in Laxenburg, Austria, 2003
7. Fires may destroy Europe's emission trading scheme; Financial Times, August 2007
8. The number of vehicles in the U.S. could increase from around 226 million in 2004 to around 321 million in 2050 due to population growth. By one calculation, if 80% of all vehicles on the road in 2050 had gasoline mileage of over 100 mpg, oil usage, and CO2 emissions, would be cut by approximately 50%. See *A Strategy for Achieving Independence from Foreign Oil*, at www.tsaugust.org
9. US Energy Information Administration, Electric Power Monthly, March 2006, Tables 1.6b and 1.8b
10. See *The Future of Coal, Options for a Carbon Constrained World.* MIT 2007*: and* Power Magazine, July 2007 for additional information on sequestration.
11. *The Future of Coal, Options for a Carbon Constrained World.* MIT 2007
12. Larger natural gas power plants, rated approximately 500 MW, have recently been built. These could be used as base load plants.
13. The Average size of wind turbines in 2006 was 1.6 MW with a total of 1,532 units installed in 2006. *Page 22, Annual Report on U.S. Wind Power Installation, Cost, and Performance Trends: 2006*
14. Ibid
15. *A Critical Evaluation of the Energy Plans and Actions Announced in April 2007 by New York's Governor, NYSERDA and New York PSC;* published by EMPA
16. *Biofuels, Food, or Wildlife? The Massive Land Costs of U.S. Ethanol;* By Dennis Avery
17. Ibid
18. From California CalCars
19. The Volt is slightly different than other proposed PHEV's. The volt will use a small gasoline engine for recharging the battery while deriving its power for operating the car from its battery; not from the small gasoline engine. PHEV's, similar to the prototypes, will use the gasoline engine to power the car at speeds over around 40 mph and rely on the battery for powering the car at slower speeds. These batteries will be recharged from a standard 120 volt outlet.
20. See *A Strategy for Achieving Independence from Foreign Oil*, www.tsaugust.org
21. *IMPACTS ASSESSMENT OF PLUG-IN HYBRID VEHICLES ON ELECTRIC UTILITIES AND REGIONAL U.S. POWER GRIDS*, Michael Kintner-Meyer, Kevin Schneider, Robert Pratt
22. The Pacific Northwest National Laboratory report Table 2, shows a total of 91 million vehicles being recharged during the 12 hour overnight off peak period. This is 30% of the 321 million vehicles forecast to be on the road in 2050.
23. See *Hydrogen Today, April 2004*; published by TSAugust .
24. According to the EIA approximately 89 percent of commercial building floor space already use fluorescent, HID or Halogen lighting.
25. LEDs, or light-emitting diodes, are essentially semiconductor chips that emit light when they come in contact with electricity.
26. Environmental Law Policy Center
27. "German chancellor Angela Merkel and others [are] suggesting that a per-capita emissions quota be considered when it comes to fair burden sharing in the future." From *Deutsche Welle, 10 September 2007*.
28. GDP per capita based on purchasing power. *From the International Monetary Fund*.

www.tsaugust.org