Report for ES 102

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Carbon Emissions:
A Proposal for Global Mitigation Strategy

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Executive Summary

The world is in a state of crisis. Currently, global temperatures are rising at an unprecedented rate and human actions are driving this drastic change. We are already seeing the effects of climate change – drought conditions have intensified across the U.S., flooding events are increasing, coral reefs are disappearing, and ground-level ozone pollution related death rates are increasing annually.[1] If CO_2 levels are not stabilized within the next fifty years, temperatures will increase by at least five degrees and the consequences will be irreversible. The Intergovernmental Panel on Climate Change (IPCC) reports that a stabilization of CO_2 emissions around 550 parts per million (ppm) would lead to a "middle-of-the-road" emissions scenario, which is estimated to lead to a maximum average temperature change between 1.5 to 3°C.[2] We recommend adopting a policy option that implements technologies which will stabilize CO_2 at levels identified in a "middle-of-the-road" emissions scenario rather than one that would allow the temperature to continue rising by more than 3°C.

Although U.S. environmental politics have been in relative stasis until recently, many environmental activists are rallying around reducing emissions to 350 ppm. However, this carbon mitigation level is not necessarily the most viable option due to the incredible strength of lobbyists on both sides and the threat of gridlock in Congress. Because of these political obstacles, any mitigation that is more drastic than stabilizing at 560 ppm is likely to be halted in Congress. Therefore, stabilizing carbon emissions to 560 ppm by 2056 is the most feasible option for the near future. We propose to accomplish this goal by adopting 7 to 8 of Socolow and Pacala's Stabilization Wedges (see Figure 1) which establish a framework for international carbon mitigation implementation,

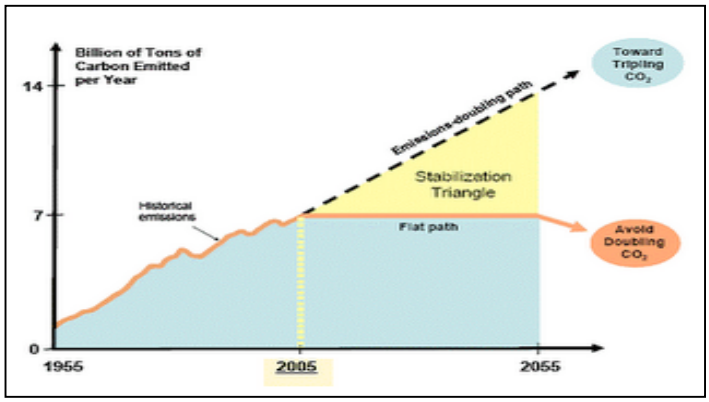

Figure 1 Socolow and Pacala's Stabilization Triangle

Our overall goal is to be more sustainable by phasing out our reliance on fossil fuels. As we

[1] Mann, Michael E., and Lee R. Kump. Dire Predictions: Understanding Global Warming. New York: DK Inc., 2008. Pg. 32, 49, 51, 53, 85, 88, 90, 98, 100, 108, 114, 115, 118, 124, 126.

[2] Shaheen, Susan A., and Timothy E. Lipman. "Reducing Greenhouse Emisisons and Fuel Consumption." IATSS Research 31 (2007): 6-20.

consciously change, we should begin to adopt cleaner, more efficient forms of energy. As a conservation sector strategy, we will focus on conservation tillage, ignoring other potential strategies that are costly and continue our reliance on fossil fuels. This strategy allows a funnel of money and efforts into cleaner energy. In replacement of fossil fuels, wind and solar energy technology will be adopted to make electricity through the use of wind turbines and photovoltaic technology, respectively. Furthermore, our policy's conservation sector will increase the efficiency of buildings, furnaces, and lighting.

Due to the transportation sector's immense expenditure of fossil fuels, it is a large contributor to the nation's greenhouse gas emissions. It is essential that we expand on our current technology to double the fuel efficiency of vehicles and manufacture vehicles that run on carbon neutral fuels. We need to improve public transportation in both rural and urban centers, so that people are encouraged to drive less and decrease our carbon footprint. The greatest impact will come from the combined implementation of these suggestions.

Nearly all of our proposed implementation strategies carry a significant financial cost. We recognize the challenges of financing such actions in our current world economy. However, in the long run, these large-scale projects will provide much-needed jobs to hard-working Americans, opening up a new market. Additionally, taking action now will prevent future costs to our health, environment, and industries.

The precautionary principle states that there is reason to act when there is conclusive scientific data, there is the risk of significant consequences, and if action now would be cheaper than action in the future. The scientific community recognizes anthropogenic climate change and suggests curbing emissions to lighten its effects. As research by economist Nicholas Stern states, climate change will cost the world a loss of 5%-20% of GDP per year, causing a significant disturbance in the global market. If the U.S. and other countries take the path of inaction, we could lose: our cities on the coasts (i.e. New Orleans, Miami, and New York), species that could lead to medicinal breakthroughs, quality of life on an international level. Too much is at stake to stay inactive. This proposed mitigation strategy must be implemented before it becomes too late.

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Overview of Science

Ellen Willis-Norton

Climate change is already occurring. Humans' release of greenhouse gases, specifically carbon dioxide, methane, and nitrous oxide, is driving global temperature change by means of the greenhouse effect.[1] The greenhouse effect is a natural process in which greenhouse gas molecules in the troposphere absorb infrared heat energy reflected by the earth's surface and readmit the energy back to earth. For millions of years this system has warmed the climate, regulating temperature[1]. However, humans are releasing increased levels of greenhouse gases and consequently more and more heat is reflected back down to earth. Although the earth has endured drastic climate changes throughout time, the rate of warming today is 10,000 times greater than the rate of warming measured during any major climatic change in earth's history.[3] During the last two centuries nitrous oxide and carbon dioxide levels have increased by 25 percent and the release of methane has tripled.[1] Consequently, the warmest summer in over 500 years was recorded in 2003.[1] In 2004, a scientific consensus "emerged" regarding the reality of human induced climate change as a result of increasing greenhouse gas emissions.[4] By 2007, the rate of carbon dioxide emissions was rising at a rate even faster than the Intergovernmental Panel on Climate Change's (IPCC) projected as a worst case scenario.[5]

This "A2" scenario, as designated by the IPCC, predicts an average 2.5-6.5 degree Celsius change in global temperatures from 2000 to 2100.[1] If this trend continues, the destruction of the coral reefs and the melting of the West Antarctic Ice Sheet (WAIC) will possibly occur.[6] Coral reefs are not only a locus for biological diversity, but provide food and are a source of revenue for millions of U.S. citizens.[1] The melting of the WAIC, which is predicted to occur with a two degree Celsius rise, will cause a sea level rise of 5 meters[1]; low-lying areas such as Southern Florida, the northeast coastline, and the mid-Atlantic in the U.S. are only 4-8 meters above the current sea level.[1] Additionally, if temperature increases by as much as 2.2 degrees Celsius it is predicted that 15 to 37 percent of all living species will be extinct.[1] If temperatures exceed three degrees Celsius, the thermohaline circulation will possibly slow down or shutdown, creating a food crisis due to cooling on the east coast of the U.S. and in northern Europe.

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[3] Hansen, James E. Statement of witness James E. Hansen. Rep. Greenpeace.
[4] Climate change what it means for us, our children, and our grandchildren. Cambridge, Mass: MIT P, 2007.
[5] "Global CO2 emissions exceed IPCC worst case scenario." Climate Shifts. 10 May 2009 <http://www.climateshifts.org/?p=492>.
[6] O'Neill, Brian, and Michael Oppenheimer. "Dangerous Climate Impacts and the Kyoto Protocol." Science. (2002): 1971-972.

Furthermore, the melting of the Greenland ice sheet will likely add five to six meters of sea level rise if the temperature exceeds three degrees.[1] Even if there is only a one degree Celsius change, which is plausible in the IPCC's most "aggressive emissions scenario" (a one to three degree change in temperature), 60 percent of coral reefs will die by 2050.[1] Also, rising temperatures will lead to ground-level ozone production, which is an air pollutant,[1] and will result in 1,000 "pollution-related deaths in the U.S." with a one degree temperature change.

The aforementioned consequences of climate change are climate markers that emphasize the risks associated with warming at different temperature levels. However, most of climate change's consequences cannot be determined at a specific temperature. As temperatures rise there will be a faster cycling of water creating both increased evaporation and precipitation rates.[1] The frequency of droughts and more intense rainfall events will result[1]. Drought conditions will be formed as the range of descending dry air, normally found in the subtropics, expands[1]. Consequently, the U.S. will experience more frequent heat waves and a decrease in food production due to decreased soil moisture in the southwest.[1] More intense rainfall events will increase flooding, storm damage, and decrease water quality.[1]

Although it is important to understand that the future consequences of climate change are dire, it is also necessary to realize that climate change is occurring now. Recently, continuous drought conditions on the west coast of the U.S. have been recorded which could possibly be due to increased ocean surface temperatures in the western Pacific Ocean.[1] Drought conditions have increased the likelihood of wildfires in North America; the frequency of wildfires in the U.S. is now four times greater than it was in 1986 due to longer and warmer summers.[7] Recently, the U.S. has spent around $1.7 billion annually on wildfire prevention.

Stabilizing carbon dioxide levels at 450 parts per million signifies an increase of one to two degrees Celsius, which the IPCC predicts can occur if an aggressive emissions scenario is implemented.[2] On the other hand, stabilizing carbon dioxide levels at 550 parts per million implies a 1.5 to three degrees Celsius rise in temperature, which is considered the "middle of the road" scenario by the IPCC. If carbon dioxide is not stabilized it is predicted that temperatures will rise over five degrees Celsius, a change that is unsustainable for most current life forms.[1]

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[7] Running, Steven W. "Is Global Warming Causing More, Larger Wildfires." Science Magazine 10 May 2009: 927-28.

Overview of Policy Frameworks

Jenna E. Miller

Before any true comprehension of the political challenges facing these mitigation proposals is possible, an understanding of Robert Socolow and Stephen Pacala's stabilization wedges must be reached. In 2007, Socolow and Pacala established a framework that considers two potential futures for emissions—either emissions double between 2006 and 2056, or they stay at current levels.[8] At current rates, a doubling of emissions is at the median of most estimates. By stabilizing emissions, this doubling of CO2 can be prevented; this will require cutting roughly 7 billion tons of carbon emissions annually worldwide.[9] These carbon savings will total around 175 billion tons and are referred to as the "stabilization triangle." The stabilization triangle is divided into seven wedges, each of which represents a mitigation strategy that would cut 1 billion tons of carbon emissions by 2056[10]. By implementing these strategies, we would move closer to establishing a balance with our earth.

Since Socolow and Pacala presented this strategy, debates over the amount of reductions necessary to avert climate change have ensued. Socolow and Pacala suggest stabilizing emissions with seven wedges at roughly 560 ppm during the next fifty years,[11] which is similar to the 550 ppm levels recommended in the Stern Review.[12] Stern argues that climate stabilization will be significantly more cost effective than waiting, and delaying action may lead to a lost opportunity.[13] Congressmen Henry Waxman (D-CA) and Edward Markey (D-MA) introduced the American Clean Energy and Security Act of 2009 to Congress on March 31, 2009. The draft addresses renewable energy, clean fuels, carbon capture and sequestration, energy efficiency, and the creation of green jobs, and it proposes a cap and trade initiative for carbon mitigation.[14] Controversy has centered predominantly on the proposal for cap and trade that would reduce emissions by 83% from 2005 levels by 2050.[15] Many Republicans, and others in opposition, have deemed the bill to be a "carbon tax," which will increase energy

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[8] Roberta Hotinski, "Stabilization Wedges: A Concept & Game," Princeton Carbon Mitigation Initiative.
[9] Ibid.
[10] Ibid.
[11] Robert Socolow and Stephen Pacala, "A Plan to Keep Carbon in Check," Scientific American, Inc.
[12] Stern, "Stern Review: The Economics of Climate Change."
[13] Stern, "Stern Review: The Economics of Climate Change."
[14] "American Clean Energy and Security Act of 2009 Discussion Draft," http://energycommerce.house.gov/Press_111/20090331/acesa_discussiondraft.pdf
[15] Ibid.

prices, harm the poor, cause great economic harm, and do little to impact climate change.[16] In truth, this is misinformation and solutions are addressed within the legislation.[17] Cutting emissions by this amount would lead to 450 ppm, the level also proposed by climate scientist Joseph Romm, and the U.S. Climate Action Partnership (between 450-550 ppm). Using the stabilization triangle framework to conceptualize the type of infrastructural changes necessary, it becomes clear that this scope of change would be hugely challenging to implement politically. Even harder to actualize would be the 350 ppm levels proposed by Bill McKibben[18] that climate change interest groups such as PowerShift have rallied around. Current levels are around 385 ppm, and though a level of 350 ppm is still technically feasible, it would require immediate action that is just not feasible in today's political arena.[19]

With special interest groups lobbying from every side, and with the economy in a recession, gridlock has arrested Washington, making it nearly impossible for any lasting legislation to make it through the system quickly. We propose that the target level of reductions be set at around 560 ppm, or the equivalent of 7 or 8 wedges because this is the most feasible level of regulation. Because we have proposed many wedges, which can avoid upsetting the powerful fossil-fuel industry lobbyists too extensively, we believe that this is far less likely to be halted in Congress. Additionally, the tools necessary for implementation are plausible or already available for the wedges we propose, and the options we have set forth will actually be better for our economy in the long run. Stabilizing to 560 ppm by 2056 is by far the best, and most feasible option for the future.

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[16] "Cap and Trade: Eight reasons why cap and trade harms the economy and reduces jobs," Institute for Energy Research, http://www.instituteforenergyresearch.org/wp-content/uploads/2009/03/Cap_and_trade_Primer.pdf

[17] Edward Markey, "Republican Energy and Climate Distortions 'Wrong in So Many Ways'," http://markey.house.gov/index.php?option=com_content&task=view&id=3589

[18] Bill McKibben, "Remember This: 350 Parts Per Million," The Washington Post, http://www.washingtonpost.com/wp-dyn/content/article/2007/12/27/AR2007122701942.html

[19] James Hansen, "The new testimony before Congress," http://www.grist.org/article/twenty-years-later

Overview of Energy Sector Strategies

Phoebe Handler

One important area of focus for addressing climate change is the energy sector. While there are many options for reducing our impact on the climate by limiting green house gas emissions, we have chosen to focus on three integral energy sector strategies. Each strategy will work toward eliminating one wedge, moving us closer to our target emissions level by year 2056.

Our first energy sector strategy is to increase efficiency of buildings through improved insulation, furnaces, and lighting. This will be achieved by using the best available technologies, such as compact florescent light bulbs, Energy Star appliances, and more efficient insulation in all residential and commercial buildings. This wedge functions by using cleaner energy sources, or inputs, as well as reducing energy loss. Improving building efficiency on this scale is very feasible because all of the necessary technologies are already available and used widely in both residential and commercial structures. The challenge, however, comes in financing the implementation of this strategy on a wide enough scale. Though these technologies currently cut American's energy bills by over $7 billion each year in total, they can still be expensive to install. Additionally, buildings built before 1976, or three quarters of the nation's buildings, would require renovation before these technologies could be implemented. These expenses can be overcome using tax incentives and government subsidies, and will ultimately save Americans money each year. [20] We advocate for this option because it is minimally invasive, does not depend on future innovations, and can be implemented systematically. This strategy, because it is based in individual homeowners' actions, does rely on government financial support for those who cannot feasibly afford these updates.

Wind electricity, or energy harnessed from wind currents using wind turbines, is our second energy sector strategy. This strategy is possible because wind energy is completely clean, emitting no greenhouse gasses. Additionally, it is a renewable, domestic resource that has the potential to supply approximately 20 percent of the United States electricity requirements. Wind energy produced by turbine technology will be sent to a general energy pool, and would thus be easy to integrate into our current energy infrastructure at a local level. Though, in order to siphon the energy from ideal wind spots to urban centers, a SmartGrid or a similar system would need to be created. Currently, wind energy technology is successfully being used across the nation and

[20] Bourque, Morrow, Wedge #3

could easily be bolstered. This project would require three percent of the nation's land area to build wind farms. The financial costs include manufacturing and installing the turbines and the potential large scale restructuring of our energy infrastructure.[21] As a domestic resource, wind energy will take necessary pressure off our nations' international relationships and will ultimately foster homeland safety. Additionally, this technology is renewable and has an incredibly small carbon footprint. Though initial costs are necessary, the benefits promised by wind energy technology prove worthwhile and are not constricted by an expiration date.

A third wedge will use solar electricity technologies to produce photovoltaic (PV) energy. At least 20,000 km^2 of solar panels, which covert sunlight to direct current (DC) electricity, must be installed in order to replace the pollutants that would be emitted if this energy were coal-based. This can be achieved either through solar panels on building roofs or by way of solar towers. Recently, this technology has been used in many countries around the world as a source of electricity, with Germany and Spain producing the most PV energy worldwide. The manufacture of solar panels can be fairly energy expensive as well as costly, though, depending on the material, PV panels are affordably priced. Potentially more costly, however, is the challenge of converting solar energy to be available for home use; solar panels produce DC power, while alternating current (AC) power is the energy channeled to nearly all grid-tied homes in America. While solar energy is available universally, certain regions (such as the Southwest) would be much more productive than others (such as the Northeast) creating distribution and reliability issues for this energy source.[22] A solution to this would be using wind and solar energy regionally. Still, the sun is one of the greatest untapped resources for human energy use. In using PV energy, which is a valuable domestic and renewable source, America will be moving toward a more efficient use of surface area and will begin reducing its carbon footprint.

These three energy sector strategies move us away from fossil fuels, require little technological advancement past current levels and pose few challenges besides cost of implementation. However, as the United States move toward a more sustainable future in the face of global climate change, these costs are dwarfed by the necessity of their ends. In total, these strategies represent America's commitment to a more clean and secure energy future.

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[21] Henry, Hazzard, Wedge #10
[22] Lillard, Howard, Wedge #11

Overview of Transportation Sector Strategies

Genea Foster

According to data collected from the Energy Information Administration in 2007, transportation is responsible for 32% of the United State's total CO2 emissions.[23] Transportation is a large part of our daily lives and cutting emissions from this sector could contribute to our goal of stabilizing CO_2 emissions to 560 ppm by 2056. The best strategies for reducing emissions, based on cost and energy-required to implement, are to double the efficiency of vehicles, create an infrastructure for a cleaner fuel source, and provide incentives to conserve the amount of miles driven.

One wedge could come from doubling the efficiency of the world's cars from 30 miles per gallon to 60 miles per gallon. Car manufactures will be responsible for technological changes and the government will be responsible for making sure the efficiency requirements are adhered to. The vehicles used for public transportation, transport of consumer goods, and personal vehicles should all double their efficiency. Car companies can work to change the structure of vehicles; making them smaller and lighter. They can also improve the efficiency of engines to match the size of the vehicle. Vehicles such as hybrids and those fueled by high-efficiency diesel are currently on the market and are more efficient than the average car[24]. We should work on further improving their efficiency to 60 mg by 2056 as well. Vehicles can also be powered on fuels that do not produce CO_2 as waste; for example hydrogen gas. There are several hundred hydrogen vehicles in use today, which have a fuel-equivalence of 60mg.

Hydrogen gas that is used to power hydrogen vehicles could be produced from hydrocarbons and water. When it is extracted from hydrocarbons, CO_2 is still released and must be captured and stored (CCS). We would like to stay away from these CCS strategies because it requires additional energy to store the CO_2 and there is always the possibility of leakage. Instead, wind is an abundant resource, which could be used to power turbines that separate hydrogen gas from water. Producing hydrogen from wind is cheaper and cleaner than producing hydrogen from hydrocarbons. If we use hydrogen to power half of the world's cars it will account for one wedge. This wedge could work simultaneously with the efficiency-transport wedge (meaning the majority of vehicles would be replaced by hydrogen vehicles and the few fuel-powered vehicles would work up to 60 mpg efficiency), and we could be looking at up to

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[23] "Emissions of Greenhouse Gases Report", Energy Information Administration, http://www.eia.doe.gov/oiaf/1605/ggrpt/

[24] Al-Mashouk and Barnes. Wedge#1

three mitigation wedges. For this conservation strategy a hydrogen infrastructure needs to be created with more factories producing hydrogen gas and more refueling stations being built nationwide (since there are currently only 63 hydrogen refueling stations[25] as compared to our 168,000 gas stations)[26]. Because wind is a plentiful resource, the production of the gas is not very expensive and most of the money for implementing this technology will go towards safety during transport.

If we effectively encourage people to drive fewer miles, we can curb emissions. Socolow and Pacala estimate that reducing miles travelled by passenger and freight vehicles in half will equal one wedge. This assumption is based on the projected 2 billion cars achieving 5,000 miles a year (at 30 mpg) rather than the average 10,000.[5] If this conservation-transport wedge works simultaneously with the standards of the efficiency-transport wedge, these two wedges combined would actually mitigate an amount of carbon equivalent to three wedges.. In order to implement these changes incentives need to be provided for commuters and companies. Investments should be made to create better public transportation (to reach a wide range of areas) and coordinating carpools/vanpools. Implementing a tax on gasoline would cause prices at the pump to increase. Thus, less people would want to drive if mass transit were cheaper. On the local level, congestion fees could be distributed in city centers with too many vehicles[27]. For consumer transportation, we could build infrastructure for interstate freight trains in which several companies could ship goods at once, cutting down on miles travelled and extra emissions due to idling in traffic. Simply cutting back on how many miles are driven annually is the most cost-effective way to reduce individual carbon footprints, but for the people and companies that cannot curb their use of vehicles, finding alternative and cleaner fuels is necessary. Alternative fuel technology exists and only needs to be implemented on a larger scale. This proposal is very sustainable because the improved transportation system could last for generations.

Each of the proposed wedges could work to reduce CO_2 emissions on their own but they work even more effectively together. They do not require drastic changes but instead call on technology and rationale that already exists. The United States should take a leadership role to begin the of use new and improved technology in vehicles to promote the stabilization of CO_2 in the atmosphere.

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[25] Foster and French, Wedge #6
[26] "Number of Gasoline Stations 1994-2004", National Petroleum News, http://www.fueleconomy.gov/feg/quizzes/answerQuiz16.shtml
[27] Bax and Brown, Wedge #2

Overview of Sequestration Sector Strategies

Ana Thayer

As societies begin to implement Socolow and Pacala's sustainability wedges, the carbon sequestration strategy conservation tillage offers one technique that will move us closer to our carbon goal in 2056. We believe that implementing other sequestration strategies is not the best choice due to costs, technology, and unknown effects.

Countless acres are farmed each year to produce crops for human and animal consumption. Under current farming tillage techniques carbon is emitted from the soil and into the atmosphere when the fields are overturned. By implementing conservation tillage, the amount of carbon emitted into the atmosphere would be reduced and some carbon in the surrounding air would be sequestered into the soil. Under a no till conservation tillage technique, farmers would simply have to refrain from tiling their fields before planting. Debris left from the previous planting season would be cut at the end of the previous season and accumulate on top of the soil. The debris would decrease erosion due to water and wind and would be a healthy, protective cover for seedlings. Farmers must begin to practice crop rotation and plant cover crops during the times of the year when the field would normally remain barren in order to combat pests and help aerate the soil with oxygen and incorporate nutrients.[28] Buying a new seed planter is the only technology that farmers would have to invest in because under the new technique seeds need to be placed deeper in the ground below the debris.[29] Conservation tillage is an ideal wedge because it requires no new technology advances and small costs to society. At this time the strategy would only be implemented in the United States, but costs to low-income farmers and long-term on the international level have to be taken into consideration. Implementing conservation tillage would require few costs to these fragile farmers whose livelihood depends on their fields. Conservation tillage in the long run offers benefits to the environment including less erosion, less fossil fuels burned by tractors, and less run off.[30] The most difficult aspect to conservation tillage is informing and educating farmers of the benefits of conservation tillage and ensuring that they practice this technique. This is a small cost to pay in comparison to the benefits gained from practicing this technique.

Although conservation tillage is a viable wedge, other carbon sequestration strategies such as sequestering carbon from the production of electricity through the combustion of fossil

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[28] Smith, Thayer, Wedge #15
[29] Ibid.
[30] Ibid.

fuels, synfuels or through the production of hydrogen, are highly expensive and generate more costs than benefits. Furthermore, these wedges wouldn't be reducing our dependence on fossil fuels as we still would be deriving our fuel from these sources. Extracting hydrogen from fossil fuels is incredibly expensive, and technology doesn't exist for storage, transport and small-scale use of hydrogen. Hydrogen is highly explosive and storage would most likely occur in low-income or poverty stricken neighborhoods so a social concern arises. [31] All three of these options require large amounts of storage and transportation. If we were to invest in this technology it would be a costly investment and we wouldn't be fixing our initial goal of building a sustainable future and finding sustainable energy sources but would rather feeding our dependence on fossil fuels.

Halting deforestation offers low costs but the applicability of this wedge makes it another sequestration technique that would not be applicable to the entire international community because it would require all businesses and peoples to stop using and cutting down trees. Although this initially seems like a good idea, stopping deforestation in a period of fifty years would be incredibly detrimental to businesses and people who rely on forests for their livelihood. Implementing deforestation laws would also be a near impossible undertaking considering the lengths necessary to overcome lobbyists. Thinking internationally, implementing stopping deforestation would require all countries to participate and figure out a way to limit and then eliminate deforestation. It would impact hundreds of families and could put the government in opposition to the people who rely on the forests. Even today as deforestation in the United States attempts to become obsolete, our dependence on forests hasn't decreased, but rather we have are importing wood from other countries such as Canada and South America. Although a cap-and-trade system on the amount of deforestation would be the most effective implementation for this wedge, at this time the costs and problems associated with implementing the termination of deforestation is not reasonable.

Carbon sequestration strategies, at this time, with the exception of conservation tillage, are unreasonable, costly, and morally, not a sound decision. We need to work to eliminate our dependence on fossil fuels through the implementation of other non carbon sequestration wedges and conservation tillage.

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[31] Foster, French, Wedge #6