How Much do Carbon Emissions Need to be Reduced in Order to Stop Global Warming?

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Abstract- This article uses STELLA, a dynamic system modeling software, to analyze the factors that contribute to global warming. As energy consumption around the world continues to grow, the amount of carbon pollutants that are pushed into the air also increases and affects both the amount of carbon produced by the earth, as well as the amount that the earth can take out of the atmosphere. This article asks how quickly and by how much must human energy consumption decrease in order to stabilize the global temperature.

Introduction

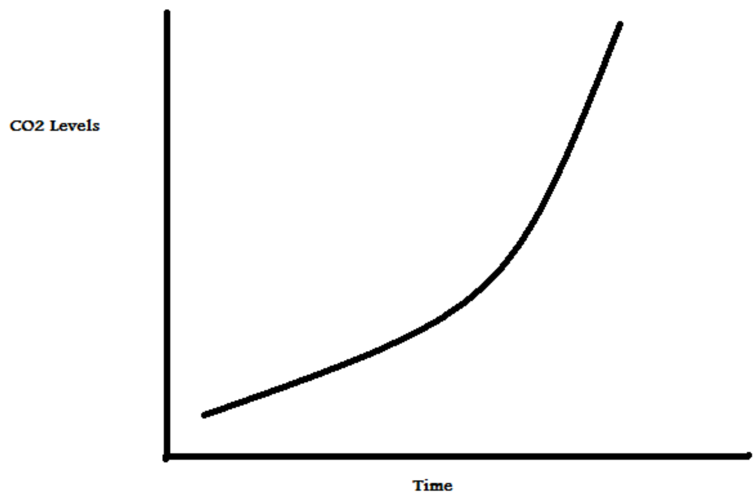
Since Humans first began to develop technology, all life has been based on the ability to burn things. Early humans began life by cutting down trees and burning them to produce heat. As humans developed into civilizations they had to cut down swaths of trees in order to create land for farming. As more and more technology was developed, more and more trees were cut down. This process continued until humans found coal, an even more efficient carbon byproduct that could produce energy for us. Then on one fateful day, humanity discovered oil could be used to fuel all of our technological creations. But this technological conquest comes with a price. Every tree that is burned, every drop of oil that we transform into energy, releases a carbon byproduct that drifts up and enters the atmosphere.

The planet receives an enormous amount of energy from the sun. Light travels from the sun and strikes the planet. A vast majority of those rays are then reflected back into space. But CO2 particles in the atmosphere distort this process. Instead of being reflect back into space, light energy is blocked by the CO2 particles and kept within our atmosphere, slowly warming the planet. Even more frightening is that very things are able to remove CO2 particles from the atmosphere are the very things that humans are consuming at an increasing rate. Trees and ocean water are some of the best ways that carbon can be removed from the atmosphere but as trees are cut down and the oceans are warmed these processes become less and less effective.

This leaves us in the year 2009; the level of carbon in the atmosphere has increased to roughly 283 PPM, up by 36% from the levels of the mid 1700s. Since temperature averages have been recorded, 12 of the hottest years have occurred in the last 15 years. There have been clear links between human energy consumption and the damage that is occurring to the planet. The model I have created seeks to measure how much humanity must alter their energy consumption and by when in order to avoid catastrophic changes.

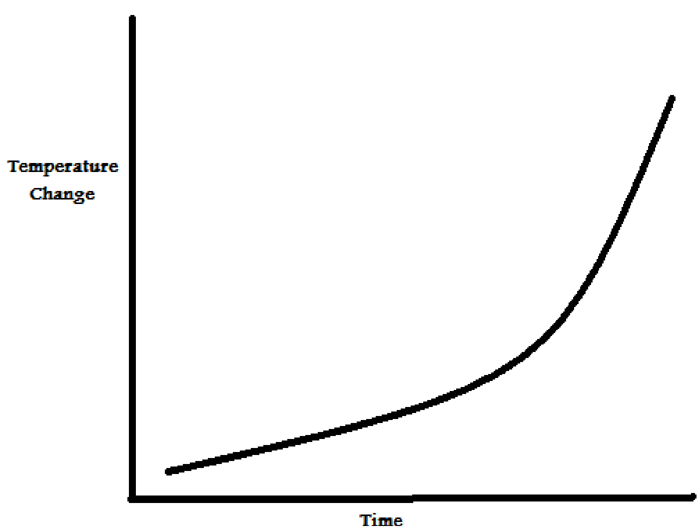
I have created three behavior over time graphs that show the general idea of the stock values in my model.

The first graph shows the estimated levels of CO2 (in parts per million) using a pessimistic and optimistic estimate.



Graph 1:BOTG for CO2 levels over time

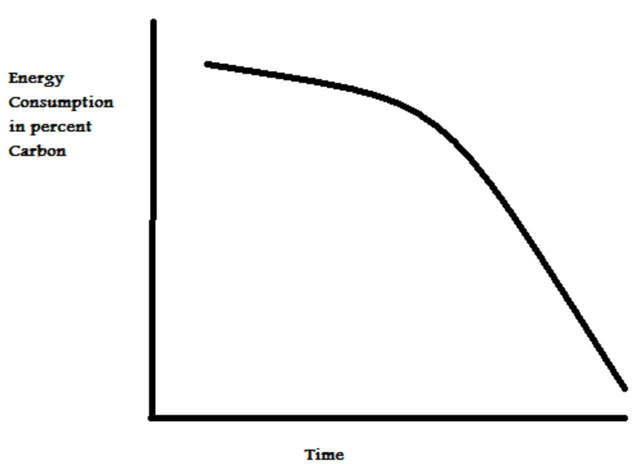
This second graph shows the estimated temperature change:



Graph 2: BOTG for Temperature Change over time

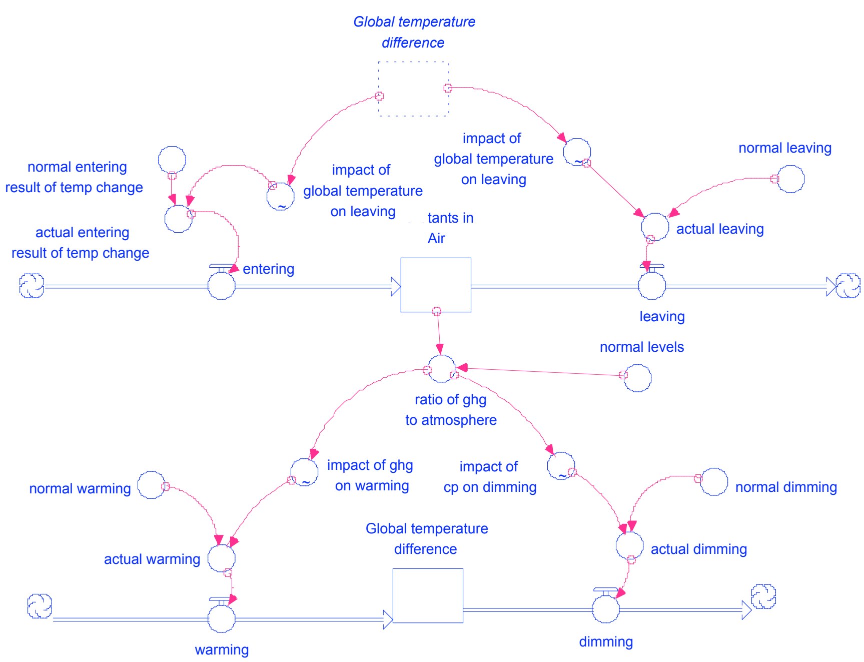
The third BOTG represents the amount of our energy that comes from carbon sources changing over time.

Graph 3: BOTG for Energy Consumption in Percent Carbon over time



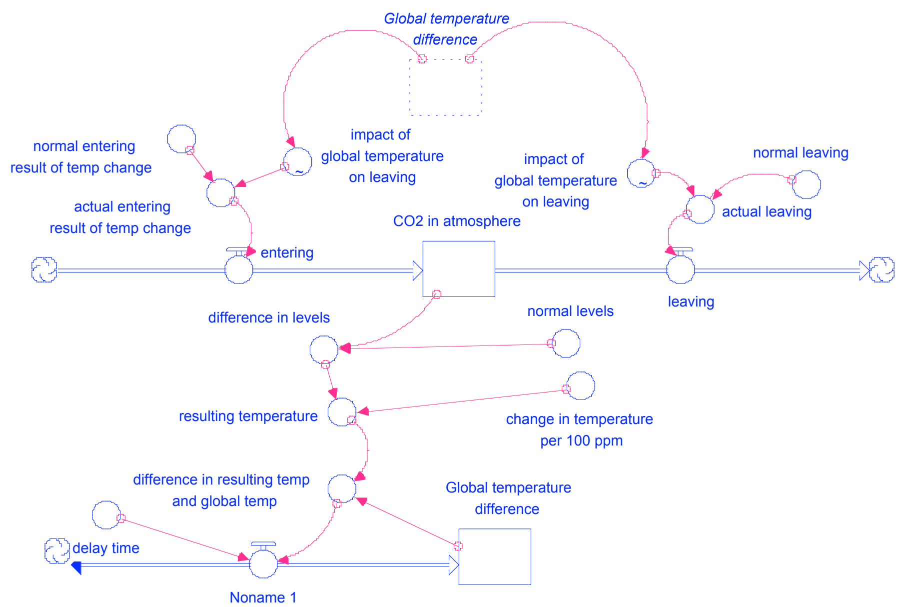
The Process of Model Building

I started to build the model by identifying the stock values I wanted to measure. I chose the CO_2 in the atmosphere, the change in the temperature on the planet, and the amount of human energy consumption. I then went ahead and added the flow values that are relevant to each section. One of the strategies that I use when building a model is to create a basic working model first and then slowly adding to it. The first iteration of the model included only the first two stocks, the CO_2 levels and the temperature change. From these two stocks I built a working model that showed the feedback between the increases in CO_2 levels and the change in the planets temperature.



Model 1: Initial version of the model

The second iteration occurred when I realized that CO_2 in the atmosphere doesn't continually warm the planet, instead it raises the maximum temperature the planet can be at. It's estimated that for every 100 ppm increase of CO_2 in the atmosphere the planet will eventually rise about 1.1 degrees Celsius. I did a little research and it turned out reaching the temperature after a change in the CO_2 levels took about 10-15 years. I added a delay function and changed the model accordingly. Another problem I was having was adding in the third stock. I had originally planned for the third stock to be totally energy consumption but that idea ended up being a dead end so I gave up and the second model looks as follows:



Model 2: Model incorporating new ideas about how the planet warms as a result of CO2

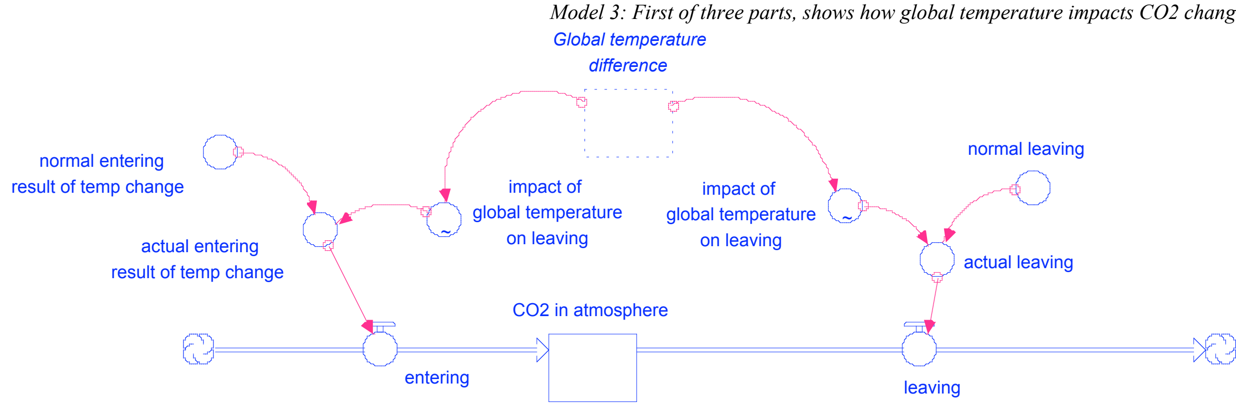
Finally I had a good idea about how to incorporate the third stock. Instead of total energy consumption, I would measure the percent of energy that comes from carbon and have a converter value that has the estimated energy use. I would then multiply the two together and have the amount of carbon generated from human energy consumption. After that the last thing to do was connect it to the model and create the last feedback loop. As the planet gets warmer people get more and more worried and create more and more conservation oriented energy policy. I created a graphical converter to measure that, added everything to the model and ended up with a finished model.

The Finished Model and how it Works

The finished model incorporates the three factors that I wanted it to: the CO2 in the atmosphere, the change in the global temperate and some mechanism by which we can measure energy policy. It shows the interactions between those factors neatly.

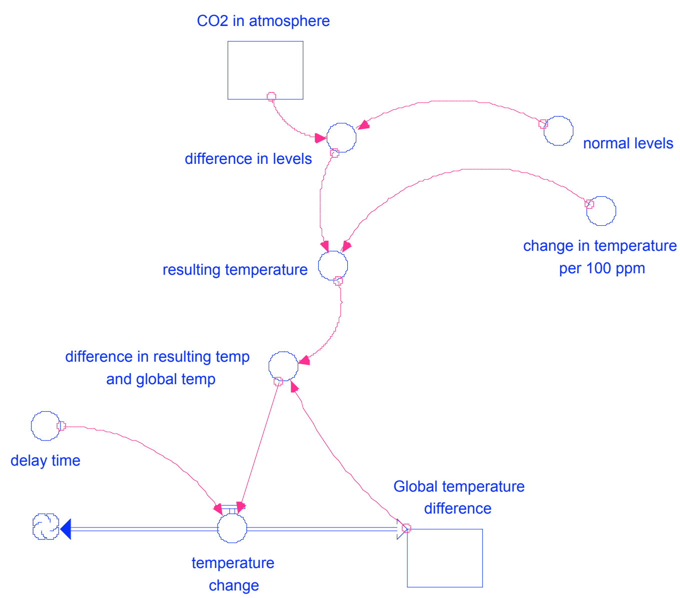
The first part of the model is the levels of CO2 in the atmosphere.

Model 3: First of three parts, shows how global temperature impacts CO2 changes



The planet does a remarkable job of keeping itself in equilibrium. Over the past 4000 years it has been able to maintain the levels of CO2 very nicely. But the human impact has changed that equilibrium. Trees and Oceans are able to remove carbon from the atmosphere but as trees are cut down and oceans are warmed those processes are slowed. On top of that as the planet warms, forests dry out making them more susceptible to forest fires. This increases the amount of carbon that the planet produces. The first segment of the model shows all of these changes as a result of the change in the global temperature.

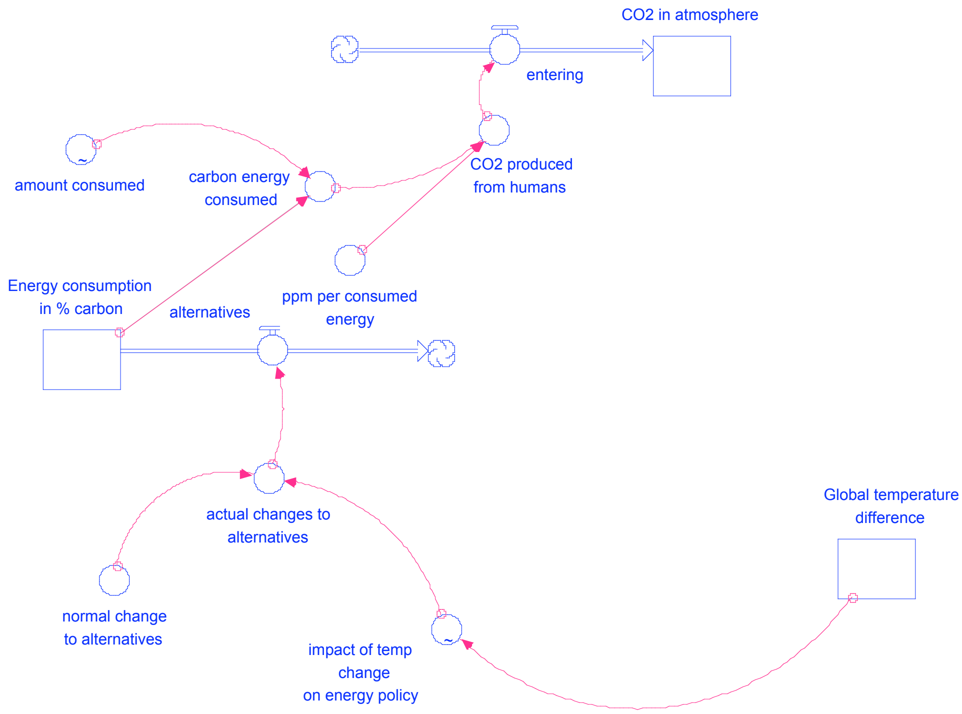
The second segment of the model focuses on temperature changes as a result of CO2 in the atmosphere.



Model 4: Second of three parts, Shows how CO2 impacts temperature changes

The earth has a normal amount of carbon in the atmosphere. For every 100 ppm increase of CO2 in the atmosphere, the temperature rises by about 1.1 degrees Celsius. It takes about 15 years for these changes to be implemented. This segment of the model calculates the difference in CO2 levels between the normal level and the actual level. It then calculates what the temperature of the planet should be as a result of the increased amount of CO2. It then calculates the difference between the actual temperature and the predicted temperature and then uses the flow value to have the actual temperature converge with the predicted. The delay time account for the delay in this process.

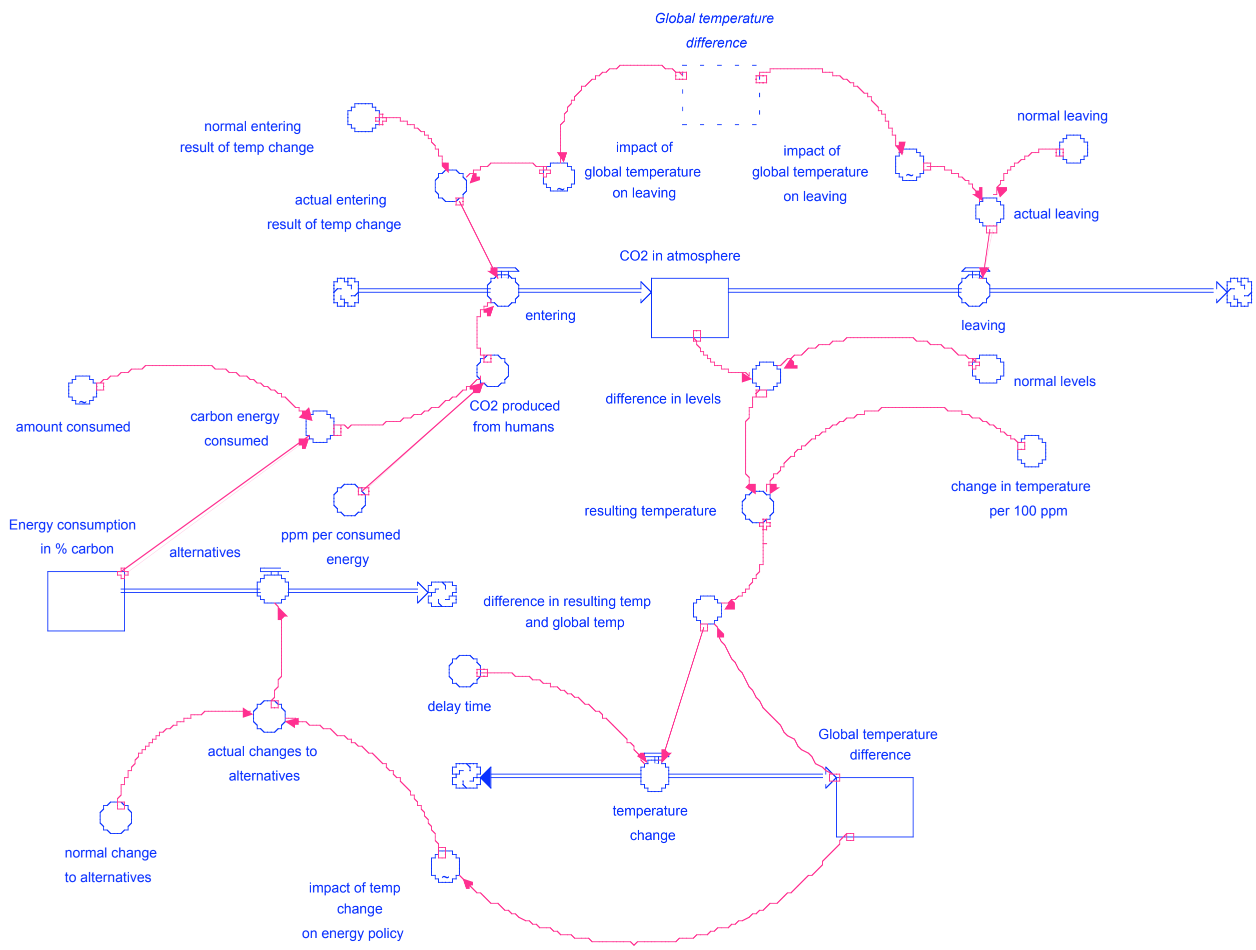
The final section of the model deals with human involvement:



Model 5: Third of three parts, shows the addition of the third stock

There are two somewhat distinct parts to this section of the model. The first part is the carbon produced by humans. About 85% of the energy consumed by humans comes from varbon but this number is improving slowly over time. In the converter amount consumed I created an estimate of the amount that humans will consume over the next 100 years. The current estimate is that in 50 years we'll consumed 2.5 times the amount consumed in 2000 and that by 2100 we'll consumed 4 times the amount that was consumed in 2000. I multiply the consumption by the amount that comes from carbon fuels to generate how much carbon will be consumed by people. I multiply this by the estimated ratio of ppm CO2 to energy consumption that I found and then I enter that into the CO2 level flow and stock.

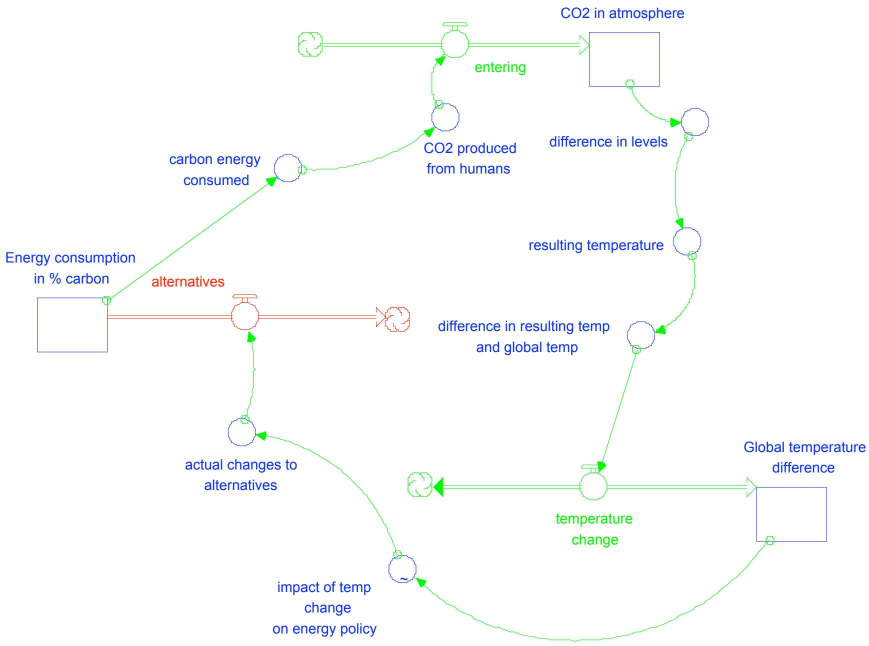
The second half of this segment is the impact that the global climate change is having on world leaders. The average man in 1990 had barley heard of global climate change but today it's in every other headline. As the problem gets worse, energy policy changes to compensate. I created a graphical converter to show the impact that has on the amount of alternative fuels that we generate.



Model 6: The final model

The Model Feedback &Loop

There are two major feedback loops in this model: the relationship between global temperature and energy policy and the relationship between CO2 levels and the global temperature. Unfortunately STELLA decided it didn't want to make the feedback loop for me so I'll just show it in my model instead…

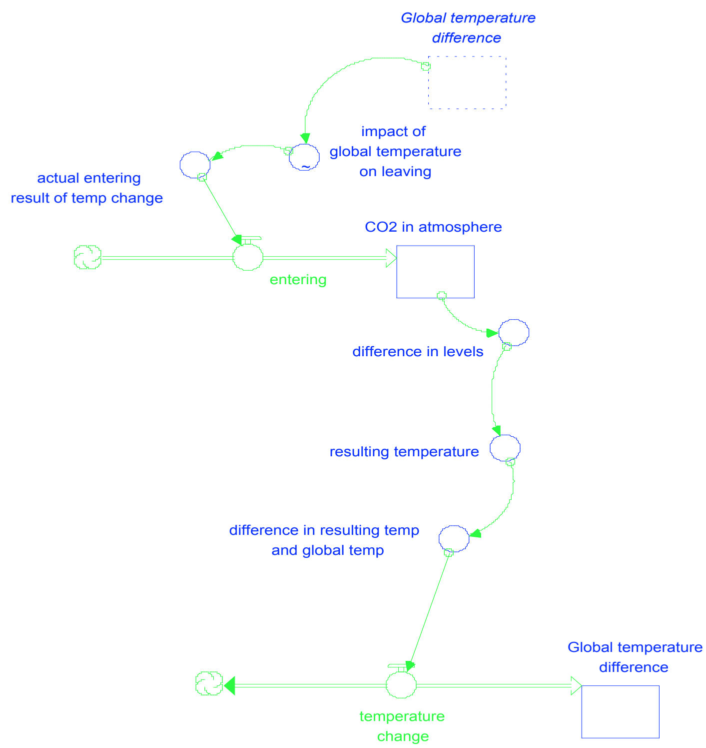


Feedback loop 1: Shows the relationship between warming and energy consumption

Red shows a counteracting relationship
Green shows a reinforcing relationship

The feedback loops shows that as the global temperature increases, the amount of energy that comes from carbon will decrease. As the amount of carbon consumed decreases, there is less in the atmosphere and this ultimately slows global warming, creating a counteracting feed back loop. The question then becomes is this feedback loops strong enough to counter global warming. The original BOTGs show that carbon emissions and the global temperature continue increasing in an unchecked manor, hopefully this feedback flattens out the growth of those graphs.

The second feedback loop highlights the relationship between CO2 in the atmosphere and the global temperature difference.



Feedback loop 2: shows the relationship between global temperature and CO_2 levels in the atmosphere
Green shows reinforcing behavior

The feedback loop shows that there is a reinforcing relationship. As CO_2 in the atmosphere increases so does the predicted temperature of the planet. As the temperature of the planet increases it means that there is more carbon entering the atmosphere. This feedback loop is critical to the problem of global warming because it is entirely possible where we could create a situation where the temperature of the planet is so warm that it creates its own dangerously high levels of CO_2. This is the feedback loop that shows the earths own equilibrium. As humans influence the planet the feedback loops is bumped out of equilibrium. These changes cause the exponential growth we saw in the original BOTGs.

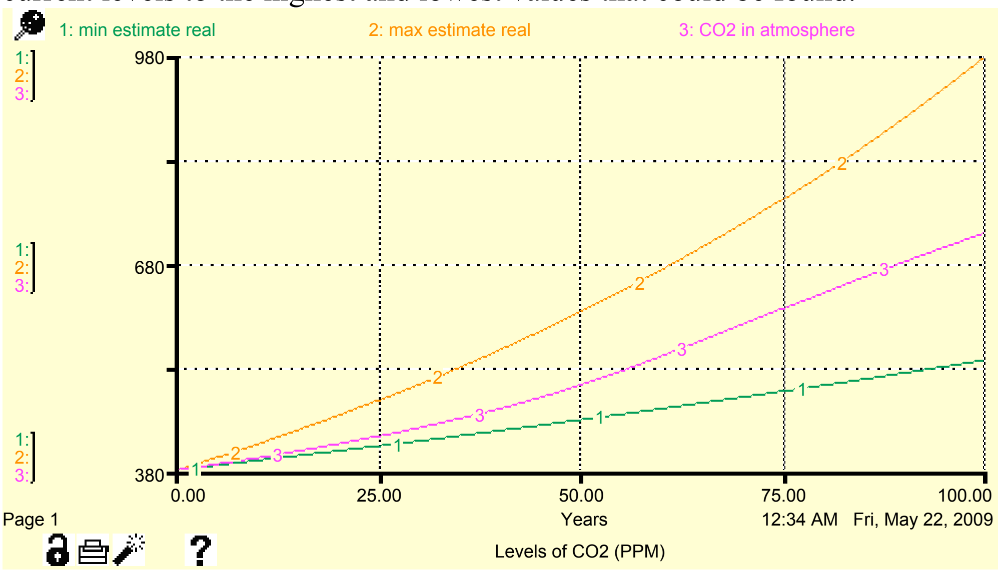
The Model Boundaries

Perhaps the biggest limitation in modeling with STELLA is that in order to incorporate all the factors required to get a full picture of a situation would require you to dedicate the rest of your life towards creating a perfect model. As a result, I had to choose what I deemed to be the most important aspect of the situation and then I had to distill those factors down into much simpler things. For instance, the upper right section of the model that contains the environments ability to remove CO_2 from the atmosphere, in that section of the model alone you could create models about oceanic warming and the chemical procedures required to remove carbon or you could add a model about deforestation. Instead I had to shrink it down into a simple estimated graphical converter. In a model that covers such a large and complex issue such as global warming the model is only as good as its estimates. All of the estimates I used are show in the documentation of Appendix A.

With that little caveat on in mind, this model really is only effective in certain ranges. It can't react if the temperature increases by more than 10 degrees and it is only supposed to be an estimate between the year 2000 and the year 2100. In fact it won't even effectively model past 2100 because of some of the graphical converter settings.

Model Testing

As mentioned above there is the serious possibility that the numbers and relationships represented by this model are completely off. I performed a few tests in order to establish that they have some grounds for reliability. First I compared it to both the most pessimistic and optimistic numbers I could find. The model ended up working fairly well. This graph shows the maximum estimated possibility of CO2 levels in the atmosphere, the bottom line the minimum CO2 level estimate. These lines were calculated by deriving equations that would move us from current levels to the highest and lowest values that could be found.



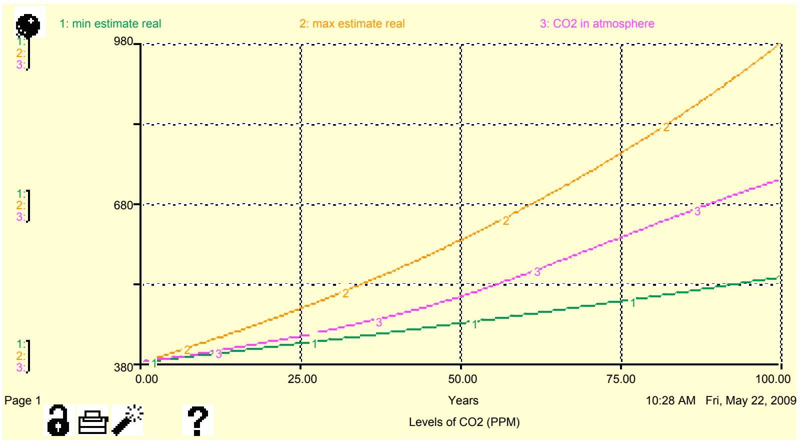
Graph 1: Shows my models results (3) compared to the min (1) and max (2)

Second, the estimate is that about 57 percent of the amount of carbons that humans produce is removed from the atmosphere by the planet. This number is only applicable for 2000 estimates because the climate is gradually changing. I compared the human generated number versus the amount that my model has being removed from the atmosphere. In my model 2.0 ppm is produced in the year 2000 and 1.18 ppm is removed. This is 59% which is fairly close to the actual number. The nearness of the values my model produces compared to the actual estimates increases the reliability of the model.

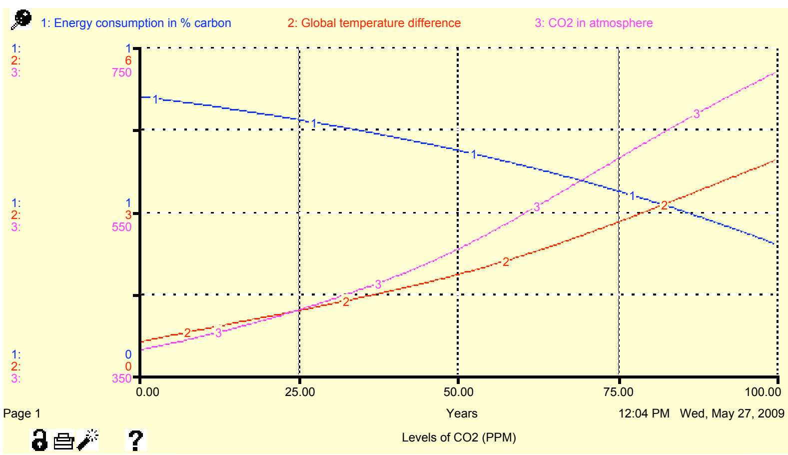
Finally, my model works to at least a reasonable degree of logic. The feedback loops make logical sense and the BOTGs from the beginning match the shape of the BOTGs that my model creates.

The model has a couple of stress points. These points represent important areas of the model that can be adjusted to alter results. Because global warming is such a complex system, there are a lot of estimates. I intend to test some of my estimates, and then test the impact that humans can have on the environment. This next graph shows the baseline results of my model, I will show divergences when I change numbers in my model.

Basic Results from the Model (no modifications):



Graph 2: shows the results of my model on CO2 levels. It shows the minimum estimate (1) and the maximum estimate (2)



Graph 3: Shows base levels all three stock values

Final temp change: 3.92
Final ppm level: 718.5
Final energy consumption level in carbon: .40

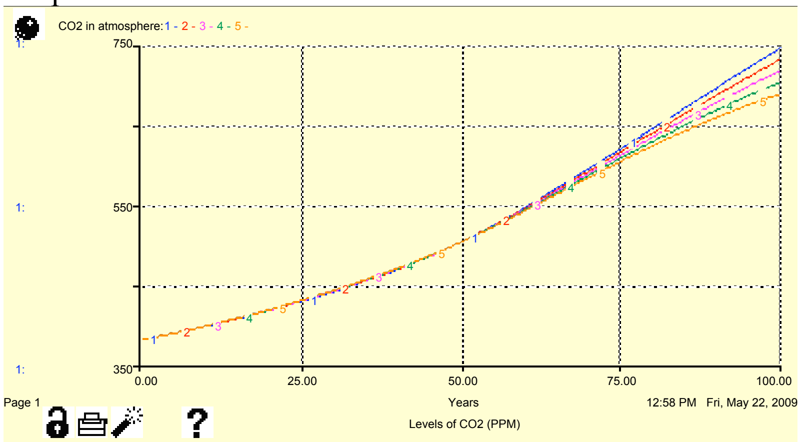
Experiment 1: Adjusting the "Change in temperature per 100 ppm"

The purpose of this experiment was to show what happens if we use different estimates for how much the planet can warm from CO2. I found both low end and high end estimates for how much the planet's climate would change. It is important to show what can happen as estimates change and what impact that has on the rest of the system. The values that I used for this experiment are shown below.

Test Run Number	Value for "Change in temperature per 100 ppm"
1	.5
2	.8
3	1.1
4	1.4
5	1.7

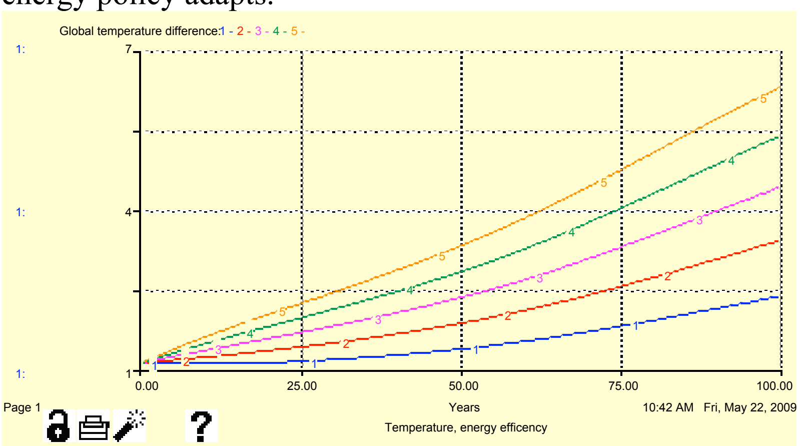
Table 1: Values for sensitivity experiment 1

Graphs:



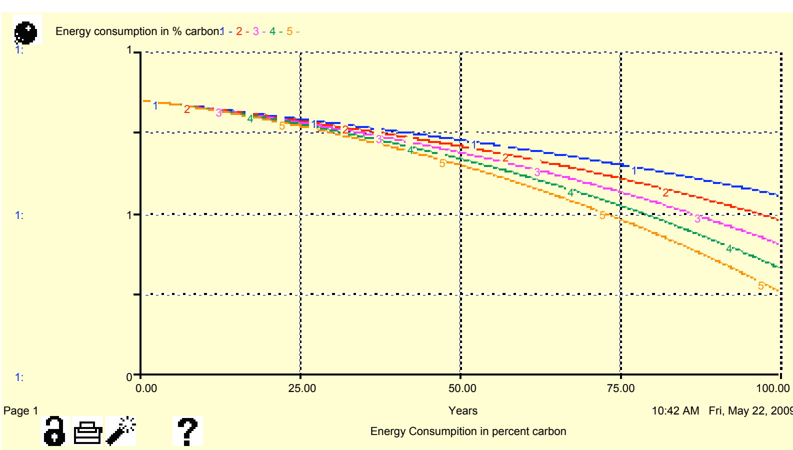
Graph 4: Shows the results of experiment 1 on CO2 levels

The results of this experiment show that as more temperature can be gained from each increase in CO2, the actual amounts of CO2 that are released decreases. This is probably best explained by energy policy. As the planet warms more, the threat of global warming becomes greater and energy policy adapts.



Graph 5: Shows the results of experiment 1 on Global Temperature changes

This graph shows that the planet temperature increases greatly as a result of this change. This is not surprising. Even though there is less CO2 in the atmosphere, it has a more devastating impact.



Graph 6: Shows the results of experiment 1 on Energy Policy

This graph shows that as the planet warms more, the system reacts accordingly and energy policy reacts strongly. The level of our energy that comes from carbon is greatly decreased.

Test Number	Final CO2	Final temp change	Final energy carbon consumption
Base	718.5	3.92	.40
1	747.3	1.86	.55
2	732.9	2.91	.48
3	718.5	3.92	.40
4	704.1	4.89	.33
5	689.7	5.81	.25

Table 2: Shows Stock Value Results for experiment 1

Despite the fact that negative feedback exists, the increase in temperature overwhelms these changes and the planet still warms at a high rate.

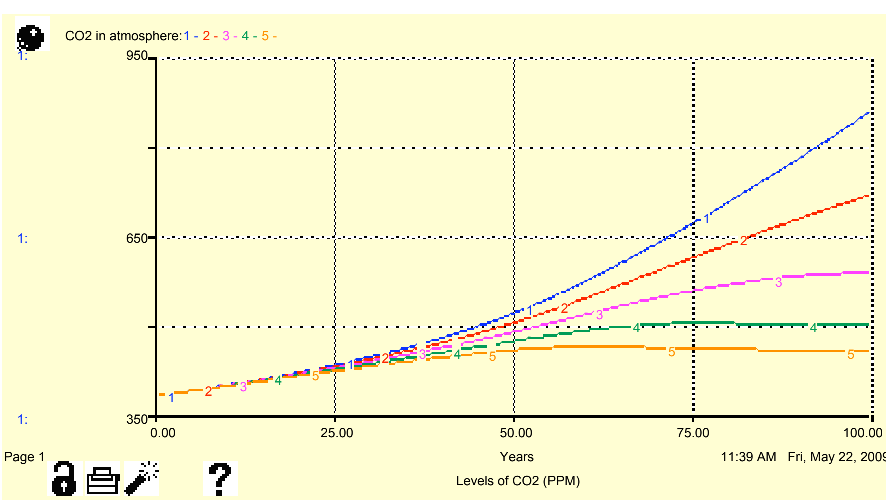
Experiment 2: Adjusting the value for "normal changes to alternatives"

The next value I decided to test was changing the energy policy base value. Every year we're trying to move away from using carbon energy; I gave a set rate for this policy based on current estimates. In this experiment, I adjust the value up and down to show the impact that energy policy can have on global warming.

Test Run Number	Value for "normal changes to alternatives"
1	0
2	.0015
3	.0030
4	.0045
5	.0060

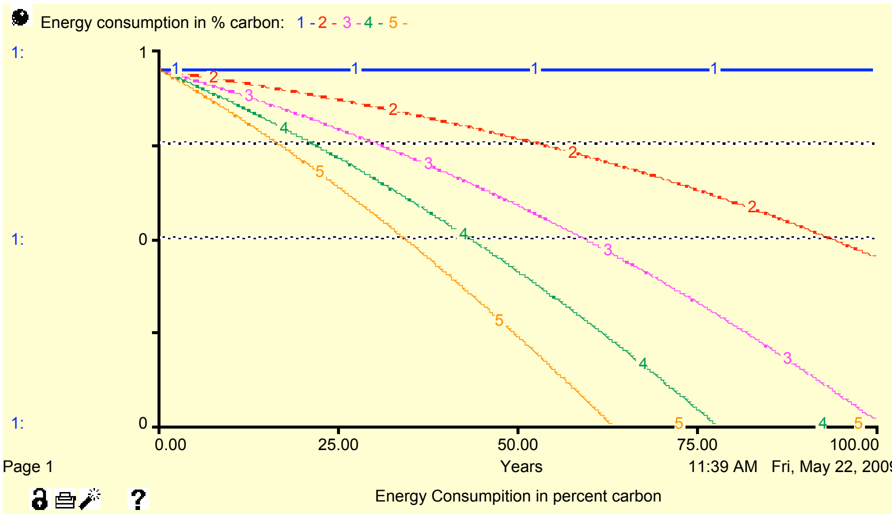
Table 3: Values for sensitivity experiment 2

For the first test run, I tested what would happen if there was no energy policy change. The second was using the baseline value. From there I tested what would happen if we doubled, tripled or quadrupled the rate at which we reduce the amount of energy that comes from carbon.



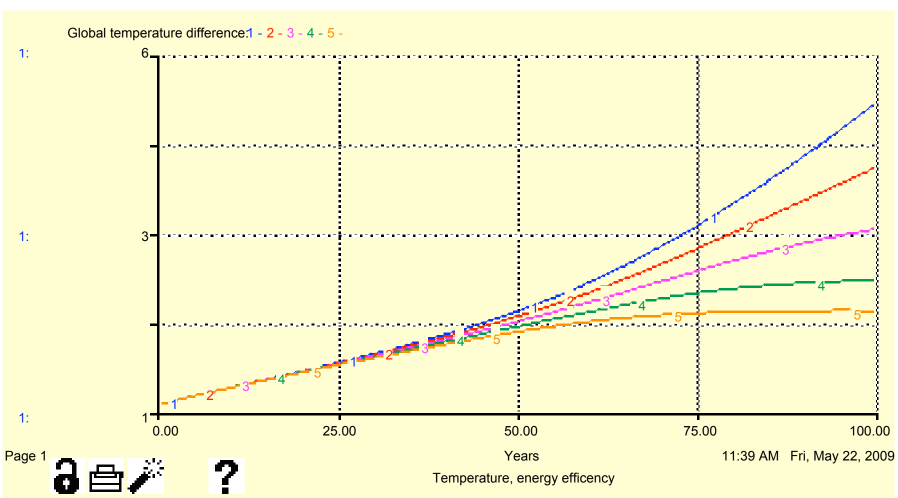
Graph 7: Shows the results of experiment 2 on CO2 levels

Obviously as our energy policy improves, the less CO_2 there is in the atmosphere. Perhaps the most frightening thing was that the only way we can achieve a CO_2 equilibrium level is by adjusting our energy policy dramatically.



Graph 8: Shows the results of experiment 2 on Global Temperature changes

The current estimate is that 67.5 % of our energy will come from carbon sources by 2050 and that 25% will come from carbon sources by 2100. Using the model I have developed, those numbers will not be powerful enough to reach equilibrium and the temperature will continue to increase unless there are dramatic changes.



Graph 9: Shows the results of experiment 2 on Energy Policy

Even a 2 degree increase could cause serious damage to the environment. Temperature increases of 4-6 degrees could be absolutely devastating.

Test Number	Final CO2	Final temp change	Final energy carbon consumption
Base	718.5	3.92	.40
1	747.3	1.86	.85
2	718.5	3.92	.40
3	587.0	3.06	.01
4	497.8	2.34	.00 (0 at 2078)
5	453.4	1.92	.00 (0 at 2064)

Table 4: Shows Stock Value Results for experiment 2

This experiment shows the powerful feedback between human energy consumption and the levels of CO2 in the atmosphere. If we could change our energy policy in a significant way we can nearly half the amount of CO2 in the atmosphere.

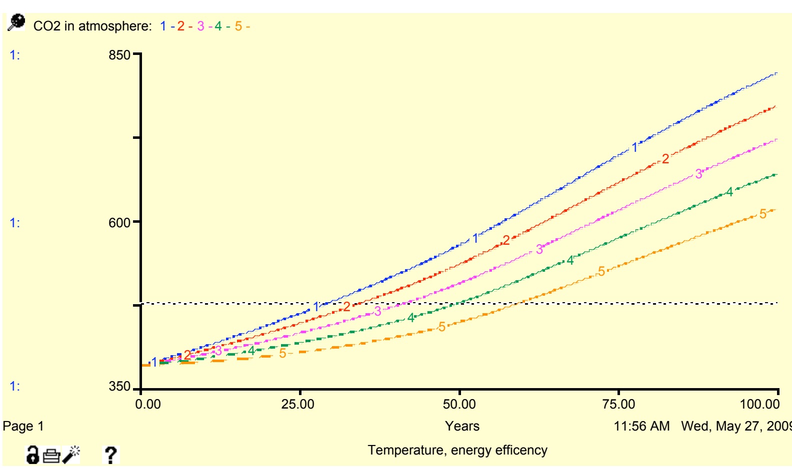
Experiment 3: Adjusting the value for "normal leaving"

The final sensitivity test I perform measured what happens when we adjust the base amount of CO2 that the planet can remove from the atmosphere. There are many estimates of the real value of this converter, I tested each common estimates to see how using different data affected my model.

Test Run Number	Value for "normal leaving"
1	0
2	.1
3	.2
4	.3
5	.4

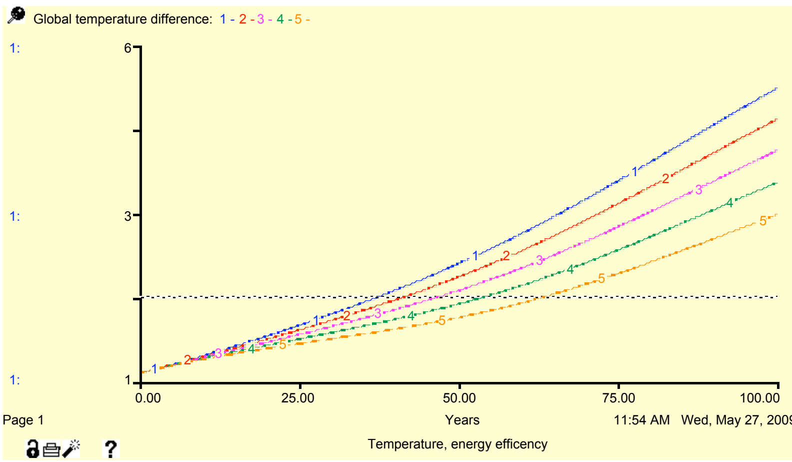
Table 5: Values for sensitivity experiment 3

The baseline value for my model was 0.2. From there I adjusted the value up or down. With all of the estimates collected about global warming, adjusting the value up and down shows what could happen to the final results if my estimates are different from the true value.



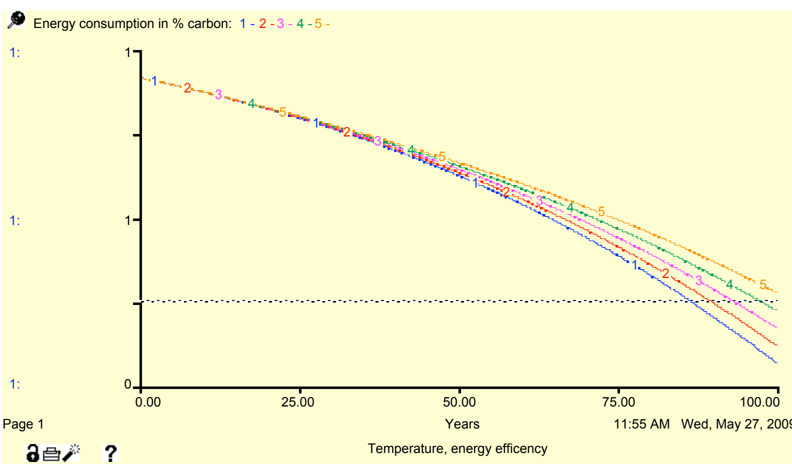
Graph 10: Shows the results of experiment 3 on CO2 levels

None of the shapes of the graphs are changed by the adjustment of the value but the result differences are still fairly dramatic. If the earth is more capable of removing the CO2 we have a much better chance of reaching a sustainable place. If we damage the earth more, than we risk the chance of creating run away behavior.



Graph 11: Shows the results of experiment 3 on Global Temperature changes

The planet could warm between 3 and 5 degrees depending on the value used. The important thing to note is that both of these values would be unacceptably high and dangerous. Even if we are optimistic about the earth's ability to protect itself, we are still overpowering that ability.



Graph 12: Shows the results of experiment 3 on Global Temperature changes

The final graph shows that no change to energy policy occurs quickly. The end result differs by as much as 0.12. Even though this is fairly substantial that difference doesn't occur until 100 years from now. Fast policy change is needed in order to radically affect the course of the planet.

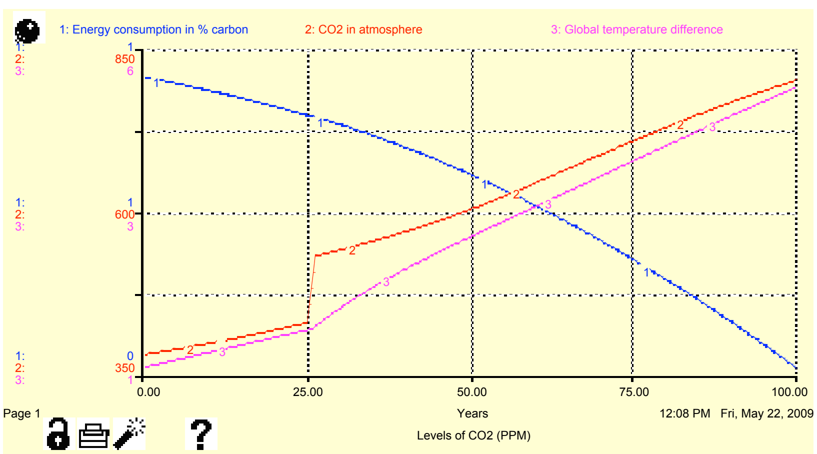
Test Number	Final CO2	Final temp change	Final energy carbon consumption
Base	718.5	3.92	.40
1	816.6	4.85	.34
2	768.9	4.39	.37
3	718.5	3.92	.40
4	667.2	3.44	.43
5	615.2	2.96	.46

Table 6: Shows Stock Value Results for experiment 3

This test makes me trust the overall results of my model more. Even though the change to this value can have a substantial impact on my model, the overall conclusions and feedback remain true. Global Warming is a complex issue and so estimates will always be fluctuating or even changing as the planet adapts to higher levels of CO2. I think the overall conclusions remain useful.

Experiment 4: Step test

For this test, I added 100 ppm at the year 25, we can say this occurred because the melting ice caps released a large amount of CO2. The model reacted accordingly:



Graph 13: Shows the results on all 3 stocks after experiment 4

The above scenario is not so unrealistic. It is estimated that ice caps contain more CO2 than all of the CO2 that humans have released. If humans melt those icecaps because of global temperature increases, we could see these spikes. The resulting change would be a spike in global temperature which would affect the CO2 increase over time creating a larger feedback where the planet produces more CO2 by itself than can be removed.

Test Number	Final CO2	Final temp change	Final energy carbon consumption
Base	718.5	3.92	.40
1	802.7	4.91	.31

Table 2: Shows Stock Value Results for experiment 4

Even a spike of 100 ppm leads to a 1 degree increase in the planet. This could be enough to overwhelm human efforts to reduce emissions and is a very real possibility.

The Key Learning from the Modeling Process

The most important thing that this model can teach us is that global warming is an incredibly complex system. Every part of global warming can have unforeseen consequences on the other parts of the model. The conclusions of my model are not the specific numbers. Many of the numbers that I had to use for my model were estimates of the average of other estimates, this means that the numerical conclusions may be off. What conclusions should be drawn from is the shapes of the graphs and the feedback loops. The shapes of the graph show the general behavior over time and the feedback loops show how factors in the model affect each other.

The results of my experiments listed above lead to one conclusion. Something needs to be done. A radical drop in Carbon emissions produced by humans needs to happen otherwise we risk permanent global climate change. The feedback loop that exists within the system is not strong enough to completely solve the problem. Despite the energy policy we are beginning to initiate, those policies will not be sufficient or in time to reduce the climate problems we are facing. In answer to my original question, in order to establish any equilibrium, even at high temperatures we need to have 50% of our energy come from alternative sources by 2050, if we hope to keep temperatures to an acceptable range than alternatives need to be reduced even more quickly.

Modeling provides a tremendous advantage when trying to understand a complex system. Listening to a lecture or watching movies on global warming only provide so much useful information. Doing the research to create a working model and then being able to play with that model by adjusting variables provides a whole new level of understanding about a system. By conducting experiments with the model I was able to look at the various impacts factors of the model had.

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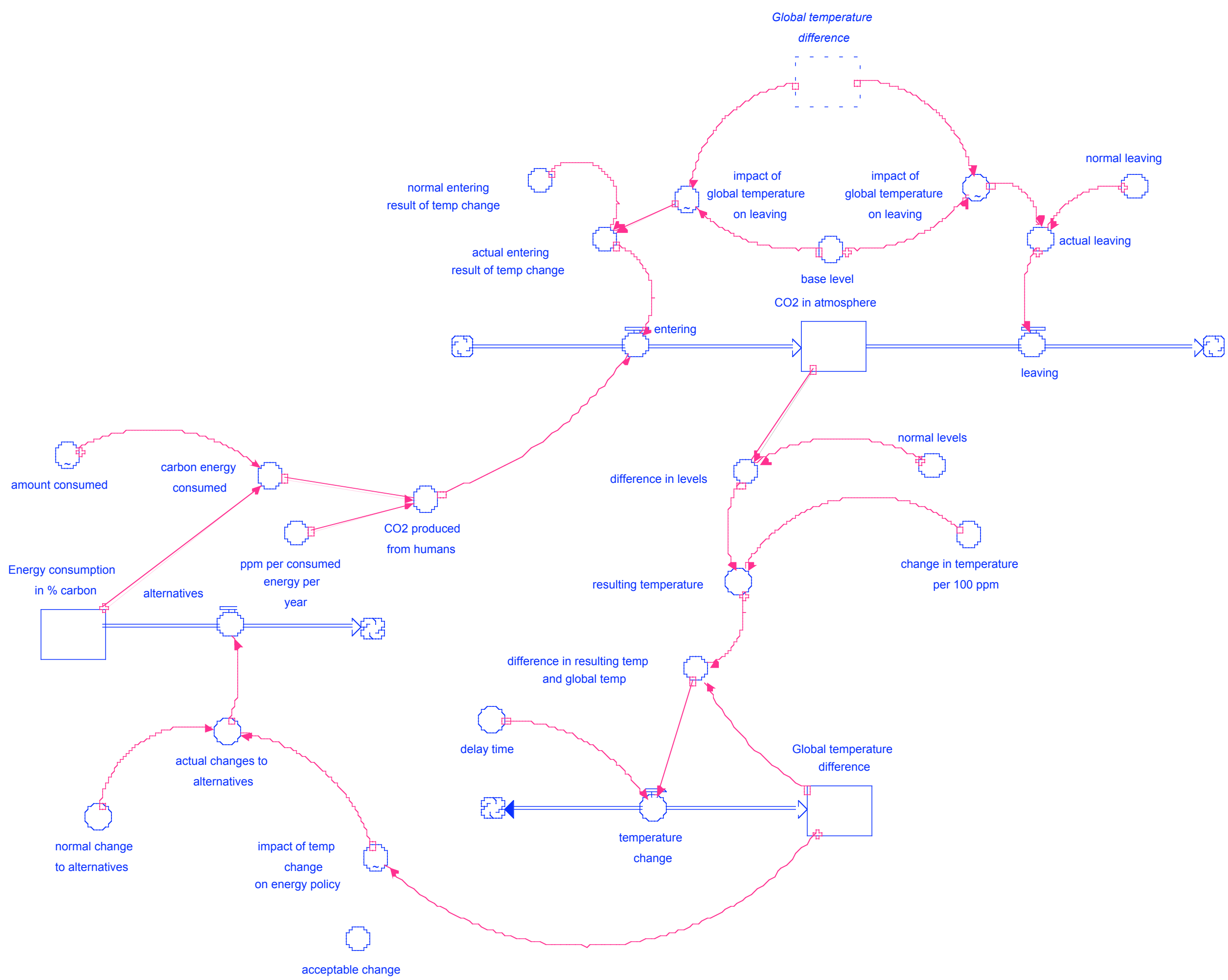
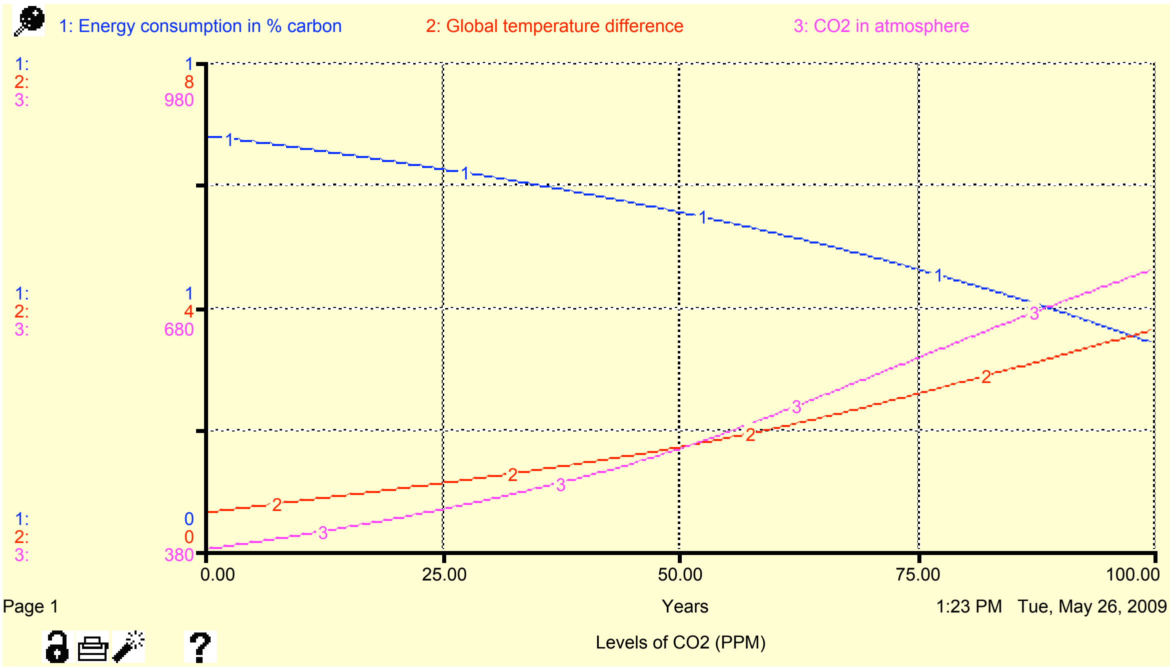
Appendix A

Final Model



Appendix B

Final Tables and graphs



CO2_in_atmosphere(t) = CO2_in_atmosphere(t - dt) + (entering - leaving) * dt
INIT CO2_in_atmosphere = 380
UNITS: ppm
DOCUMENT: 380 was roughly the level of CO2 as of the year 2000.

World Meteorological Organization. "Atmospheric Carbon Dioxide Levels Highest On Record." ScienceDaily 4 November 2006. 26 May 2009 <http://www.sciencedaily.com_
/releases/2006/11/061104084951.htm>.

INFLOWS:
entering = actual_entering_result_of_temp_change+CO2_produced__from_humans
UNITS: ppm/yr
OUTFLOWS:
leaving = actual_leaving
UNITS: ppm/yr
Energy_consumption_in_%_carbon(t) = Energy_consumption_in_%_carbon(t - dt) + (-alternatives) * dt
INIT Energy_consumption_in_%_carbon = .85
UNITS: CO2/Energy
DOCUMENT: UNEP "IPCC Special Report on Emissions Scenarios"
2001. 24 May 2008
<http://www.grida.no/publications/other/ipcc%5Fsr/?src=/Climate/ipcc/emission/045.htm>

OUTFLOWS:
alternatives = actual_changes_to__alternatives
UNITS: co2/energy-yr
Global_temperature_difference(t) = Global_temperature_difference(t - dt) + (temperature_change) * dt
INIT Global_temperature_difference = .6
UNITS: degC
INFLOWS:
temperature_change = difference_in_resulting_temp_and_global_temp/delay_time
UNITS: degc/yr
acceptable_change = 1
UNITS: degC
DOCUMENT: Used for divisor

actual_changes_to__alternatives =
normal_change_to_alternatives*impact_of_temp_change_on_energy_policy
UNITS: co2/energy-yr
actual_entering_result_of_temp_change =
impact_of_global_temperature_on_leaving*normal_entering_result_of_temp_change/2
UNITS: ppm/yr
actual_leaving = impact_of__global_temperature_on_leaving*normal_leaving
UNITS: ppm/yr
base_level = 1

UNITS: degC
DOCUMENT: divisor

carbon_energy__consumed = Energy_consumption_in_%_carbon*amount_consumed
UNITS: CO2
change_in_temperature__per_100_ppm = 1
UNITS: degC/ppm
DOCUMENT: Hansen "Target Atmospheric CO2: Where Should Humanity Aim?"
Columbia University, April 8, 2008
<http://www.columbia.edu/~jeh1/2008/TargetCO2_20080407.pdf>

CO2_produced__from_humans =
carbon_energy__consumed*ppm_per_consumed_energy_per_year
UNITS: ppm/year
delay_time = 20
UNITS: yr
DOCUMENT: Hansen "Target Atmospheric CO2: Where Should Humanity Aim?"
Columbia University, April 8, 2008
<http://www.columbia.edu/~jeh1/2008/TargetCO2_20080407.pdf>

difference_in_levels = CO2_in_atmosphere-normal_levels
UNITS: ppm
difference_in_resulting_temp_and_global_temp = resulting_temperature-
Global_temperature_difference
UNITS: degC
max_estimated_CO2 = 283*(1.0124)^TIME
max_estimate_real = 380*(1.0095)^TIME
min_estimated_CO2 = 283*(1.0065)^TIME
min_estimate_real = 380*(1.0035)^TIME
normal_change_to_alternatives = .0015
UNITS: co2/energy-yr
DOCUMENT: Normal levels of change to curve graph to predicted points of data

normal_entering_result_of_temp_change = 1.5
UNITS: ppm/year
DOCUMENT: Estimation used. See paper Experiment 3 for testing

normal_leaving = .2
UNITS: ppm/year
DOCUMENT: Estimation used. See paper Experiment 3 for testing

normal_levels = 280
UNITS: ppm
DOCUMENT: Scientific measurements of levels of CO2 contained in cylinders of ice, called
ice cores, indicate that the pre-industrial carbon dioxide level was 278 ppm. That level did not

vary more than 7 ppm during the 800 years between 1000 and 1800 A.D.

http://www.noaanews.noaa.gov/stories2005/s2412.htm

ppm_per_consumed_energy_per_year = 2.35
UNITS: ppm/CO2-year
DOCUMENT: UNEP "IPCC Special Report on Emissions Scenarios"
2001. 24 May 2008
<http://www.grida.no/publications/other/ipcc%5Fsr/?src=/Climate/ipcc/emission/045.htm>

resulting_temperature = (difference_in_levels/100)*change_in_temperature__per_100_ppm
UNITS: degC
amount_consumed = GRAPH(TIME)
(0.00, 1.00), (10.0, 1.15), (20.0, 1.35), (30.0, 1.60), (40.0, 1.90), (50.0, 2.50), (60.0, 3.10), (70.0, 3.40), (80.0, 3.65), (90.0, 3.85), (100, 4.00)
UNITS: Energy
impact_of_global_temperature_on_leaving =
GRAPH(Global_temperature_difference/base_level)
(0.00, 1.00), (1.00, 1.10), (2.00, 1.20), (3.00, 1.30), (4.00, 1.40), (5.00, 1.50), (6.00, 1.60), (7.00, 1.70), (8.00, 1.80), (9.00, 1.90), (10.0, 2.00)
UNITS: Unitless
impact_of_temp_change_on_energy_policy =
GRAPH(Global_temperature_difference/acceptable_change)
(0.00, 1.00), (1.00, 2.00), (2.00, 3.00), (3.00, 4.00), (4.00, 5.00), (5.00, 6.00), (6.00, 7.00), (7.00, 8.00), (8.00, 9.00), (9.00, 10.0), (10.0, 11.0)
UNITS: Unitless
DOCUMENT: Graph estimation used.

impact_of__global_temperature_on_leaving =
GRAPH(Global_temperature_difference/base_level)
(0.00, 6.00), (1.00, 5.80), (2.00, 5.60), (3.00, 5.40), (4.00, 5.20), (5.00, 5.00), (6.00, 4.80), (7.00, 4.60), (8.00, 4.40), (9.00, 4.20), (10.0, 4.00)
UNITS: Unitless