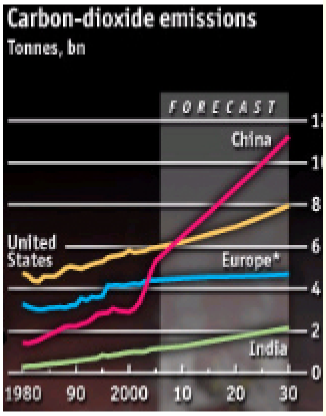
Team # 2050

In our real life, carbon dioxide(CO_2) is becoming a world wide problem. For example, global warming, unpredictable weather, rising of sea temperature and level, etc. The statistical report below(<chart 1>) shows that the amount of CO_2 has been increasing with few exceptions, and in 2007, United States has emitted *approximately 6 billion tons of CO_2*. If we keep giving off as we do today, we probably won't be able to escape from the crisis of CO_2 . Look at the <chart 2>. Even though it's a forecasted numbers, China and United States will strongly affect the world atmosphere. So The objective of our models is to reduce the amount of CO_2 in the atmosphere. So our team has come up with brand-new ideas to cut off the overflowing gas, and made a solution to use in our daily life.

First, We'll take advantage of construction waste, especially limestone($CaCO_3$). They can react in normal temperature and pressure with H_2O and CO_2 , so we can remove CO_2 in the atmosphere.



U.S. Energy-Related Carbon Dioxide Emissions by Fossil Fuel (Million Metric Tons Carbon Dioxide)

	Petroleum	Coal	Natural Gas	Total*
1990	2178	1796	1033	5013
1995	2206	1893	1192	5301
1996	2287	1976	1215	5489
1997	2309	2025	1225	5570
1998	2352	2045	1198	5607
1999	2414	2046	1198	5669
2000	2458	2140	1239	5848
2001	2469	2084	1190	5754
2002	2468	2093	1245	5820
2003	2513	2130	1216	5872
2004	2604	2155	1196	5966
2005	2621	2163	1179	5974
2006	2586	2132	1158	5888
2007	2583	2154	1234	5984

Look at the following reaction mechanism.

$$CaCO_3 + CO_2 + H_2O \rightarrow Ca(HCO_2\ (aq)$$

$$Ca(HCO2(aq) \rightarrow Ca+2HCO+H_2O$$

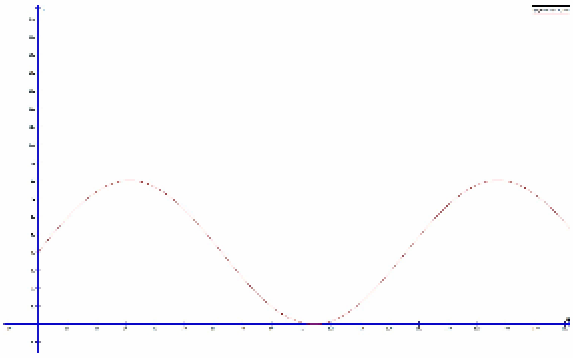
(dissolve another CO_2 into H_2O under high pressure)

$$Ca+2HCO+H_2O+CO_2 \rightarrow Ca+2HCO+H_2CO_3$$

$Ca+2HCO+H_2CO_3 \rightarrow CaCO_3 \downarrow +2H_2CO_3$ *… discard after neutralization*

At this mechanism, we can remove two CO_2 per one $CaCO_3$, and at the last step of mechanism, we can obtain another $CaCO_3$ which can be used again to remove CO_2 . So we made a model showing relationship between fluctuation of releasement of construction waste and amount of CO_2 that we can remove with the construction waste. Here are our *ASSUMPTION* to build our model.

ASSUMPTIONS :



1. $CaCO_3$ can be used for a year, and overused $CaCO_3$ will be given up.

2. All Construction waste($CaCO_3$) can be used several time, but every $CaCO_3$ can be used just the same time. (We set the amount *n days, reaction will be occur once a day*)

3. Construction market will constantly grow, never be minus grow, but there are some fluctuations according to economic depression.

4. Economic depression will appear regularly. (We set the cycle 40years)

5. Economic depression(and of course, construction depression) can be displayed *sine* function. So increasement of releasement of construction waste will be displayed *sin* function too. (We set the cycle 40years, so the function will be … *40sin(x/20)+40 :* <u>(setting x year)</u>

6. Construction waste ∝ Emission of CO_2 .

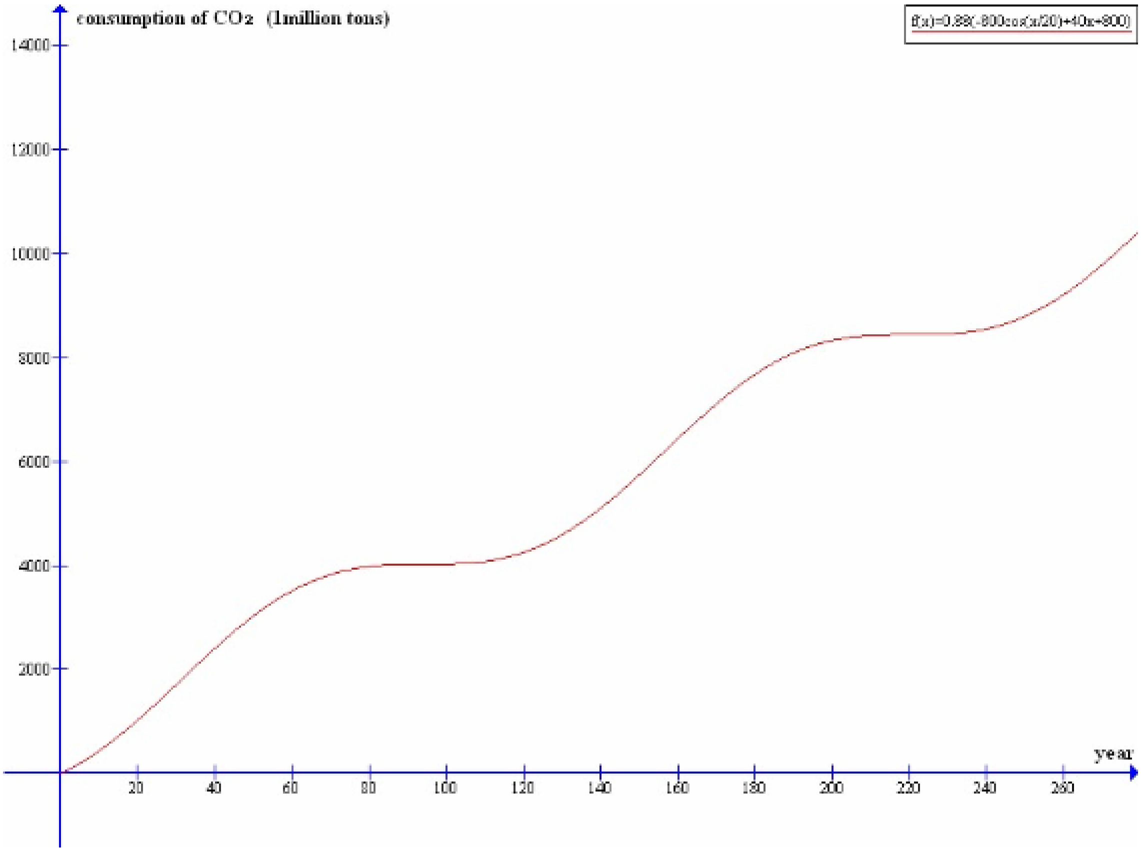
Because the molecular weight of $CaCO_3$ is 100 and that of CO_2 is 44, a single ton of $CaCO_3$ can remove 0.88n tons of CO_2 for a year.

$$(1 : r = 100 : 88)$$
$$r = 0.88$$

Setting α releasement of construction waste in 2007 and *Y annual* increasement of construction waste releasement, the annual total waste is $\alpha + \int \{40\sin(x/20)+40\}dx.$
So after x years, we can remove

$$0.88n[\alpha + \int \{40\sin(x/20)+40\}dx] = 0.88n[-800\cos(x/20)+40x+\alpha + C]$$
$$(\text{only if } \alpha + C \geqq 800)$$

We can make a graph of that formula when ***n=1***.



At this graph, if we can use $CaCO_3$ just once, to remove 6 billion tons of CO_2, we have to wait 154 years. If we do twice a year, it takes 77 years to reach the equal point of consumption and emission of CO_2. After this point, the amount of consumption will exceed the emission of CO_2, which means the CO_2 in the atmosphere will decrease. So if you want the result quicker, we must get into practice as much as possible in year.

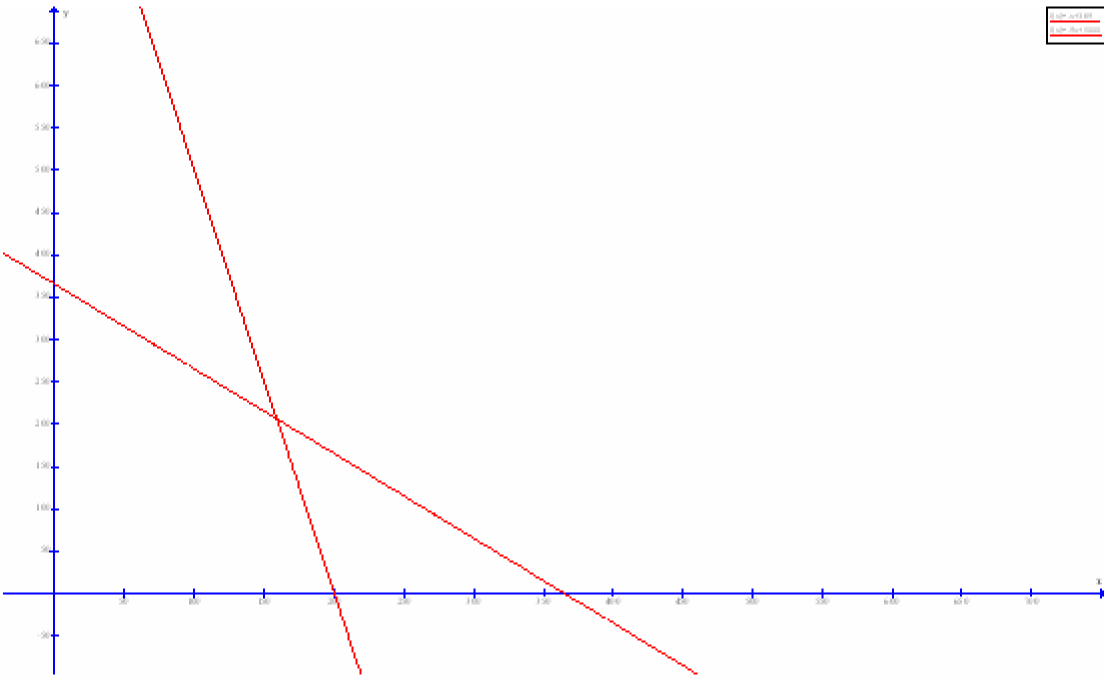
That is, if we do 'n' times a year, it will take 154/n year to reach the point.

If n is too small, we can't expect any efficiency because CO_2 removing reaction need high price. But if n is too large, it costs too much to eliminate the generated H_2CO_3 as a by-product. As a consequence, we should come up with an adequate value of \`n\`, considering efficiency and expecting cost of eliminating H_2CO_3.

Let's assume : A year contains reacting day(the day when we undergo CO_2 removing reaction) and discard day(when we neutralize H_2CO_3). The number of reacting day will be x, and the number of discard day will be y. Then we can get one formula :

$$x+y = 365$$

Concern : the cost of reacting day 500(million$), and the cost of the discard day 100. And we have 100000 of money. (all of the above are just assumption) Then, we can get another



formula :

$$500x+100y = 100000$$

Now, Let's find the point P that shows the best efficiency and cost.

From this graph, we can get a point P(158.75, 206.25). So the X(158.75) will be the 'n' which we wanted to find.

If we can get some budget, then we can find exact days that we should react them for a year.

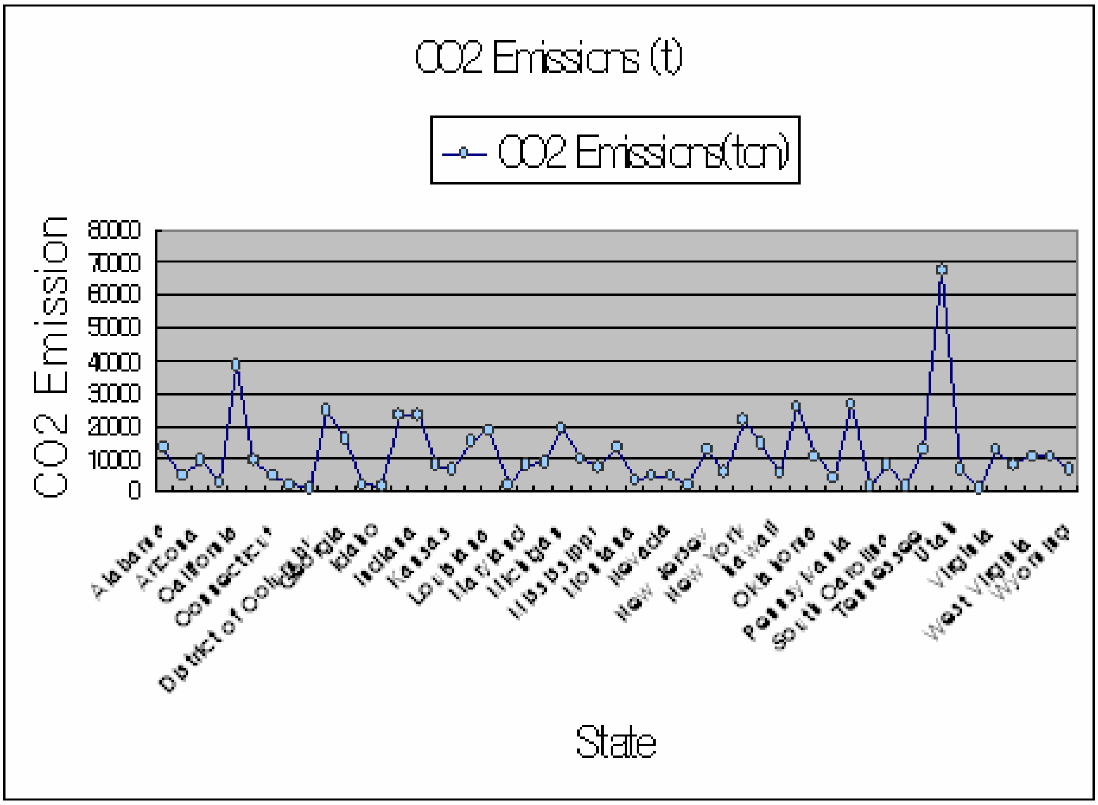
These are the real statistics that is based on a data from u.s government

With this, we can see the amount of CO_2 emission & construction waste of each states in United States.

(As we said above in *ASSUMPTION 6*, Construction waste $\propto$ Emission of CO_2.)

State	CO_2 Emissions(ton)	CO_2 Emissions per Capita(Mg/person)
Alabama	13500	3000
Alaska	4500	7125
Arizona	9000	1687.5
Arkansas	2437.5	2437.5
California	38250	1125
Colorado	9375	2062.5
Connecticut	4500	1312.5
Deleware	1687.5	2062.5
District of Columbia	450	750
Florida	24375	1500
Georgia	16125	1875
Hawaii	1875	1575
Idaho	1612.5	1200
Illinois	22875	1875
Indiana	22875	3750
Iowa	8250	2812.5
Kansas	6750	2625
Kentucky	15000	3750
Louisiana	18750	4125
Maine	2250	1875
Maryland	7875	1500
Massachusetts	8625	1312.5
Michigan	19500	1875
Minnesota	9750	1875
Mississippi	7125	2437.5
Missouri	13125	2250
Montana	3375	3750

Nebraska	4500	2625
Nevada	4500	2250
New Hampshire	1687.5	1500
New Jersey	12375	1500
New Mexico	6000	3375
New York	22125	1125
North Carolina	14250	1875
hawaii	5250	8625
Ohio	25875	2250
Oklahoma	10500	3000
Oregon	4125	1200
Pennsylvania	26250	2250
Rhode Island	1200	1200
South Carolina	7875	1875
South Dakota	1387.5	1875
Tennessee	12750	2250
Texas	67500	3375
Utah	6375	2812.5
Vermont	637.5	1125
Virginia	12375	1687.5
Washington	8250	1500
West Virginia	10500	6000
Wisconsin	10875	1875
Wyoming	6375	13125
Sum	577350	



Let's analyze this chart by graph.

In this graph, we can see the emission level of each states.

We concluded that the reactor has to be built many in the states that emit more CO_2. Namely, the states that emit CO_2 more than 20000 tons a year need four reactors in their whole states, and that emit CO_2 less than 2000tons a year need one or no reactor in their states. We made a standard :

CO_2 Emissions(ton)	number of reactor they need
more than 20000	4
10000 to 20000	3
5000 to 10000	2
2000 to 5000	1
less than 2000	1 or 0

Following our solution, we can see a high rate of CO2 reduction in the near future.

With useful information from:

- en-three-Steps-GTZ-climateneutrality

- U.S. Carbon Dioxide Emissions from energy sources 2007 flash estimate
  (Energy Information Administration U.S. Department of Energy)

- http://images.google.co.kr/imghp?ie=UTF-8&oe=UTF-8&hl=ko&tab=wi&q

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