Planet Hacking

Ahmed Abd-Elbaset, Ahmed Abbas, Mohammed Tarek

Hassan Amer, Mohammed Adel, Mohammed El-Messiry

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STEM SCHOOL FOR BOYS

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Abstract

Nowadays, our earth encounters a great increase in the temperature causing what is called Global Warming. This beast has a catastrophic intervention in our lifestyles, and threatens our future. Moreover, it could destroy our current communities and put an unexpected end to the world that we know. The overuse of fossil fuels for industrial purposes has resulted in wide emission of greenhouse gasses. Among theses gases is CO2 which is considered the main factor causing negatively global warming. Our suggested solution targets these emissions by the means of Carbon capture and storage. The capture stage is based on sequestration of co2 particles, in flue gas resulted from post-combustion technique, using a chemical absorption process. Then, the products are transported to the nearest water source and are directly injected on the surface. These sequences are figured out through a mathematical model describing the results after applying our solution based on testable equations, relations and graphs. By testing our model, we concluded that our solution can prevent an increase rate of temperature by 0.02 Celsius by 2100.

Introduction

Global warming represents a real challenge to the world. This problem is controlled by many factors and the major participants can be addressed in terms of greenhouse gases concentrations in the atmosphere, especially CO_2. The increase of temperature will lead to global problems, including for example: biological environment deterioration and malfunctioning and some physical problems related to the polar ice melting. The latter part in particular, will have destructive effects on our coastal regions as the rise in sea water level will submerge them. It is estimated that quarter of the Nile delta will be a part of the Mediterranean Sea by the end of this century.

As stated before, the effect of CO_2 on temperature is the most significant among the other factors. By increasing the concentration of CO_2 in the atmosphere by 100 ppm, the temperature will increase by 1degree Celsius. As a matter of fact, CO2 emissions are in a continuous annual increase and they have reached Unprecedented levels within the past 15 million years and if they continue on the same approach, the amount of emissions will reach 638.208 PPM in the year 2100 causing about 3 degrees Celsius increase in the global temperature. (fig. 2)

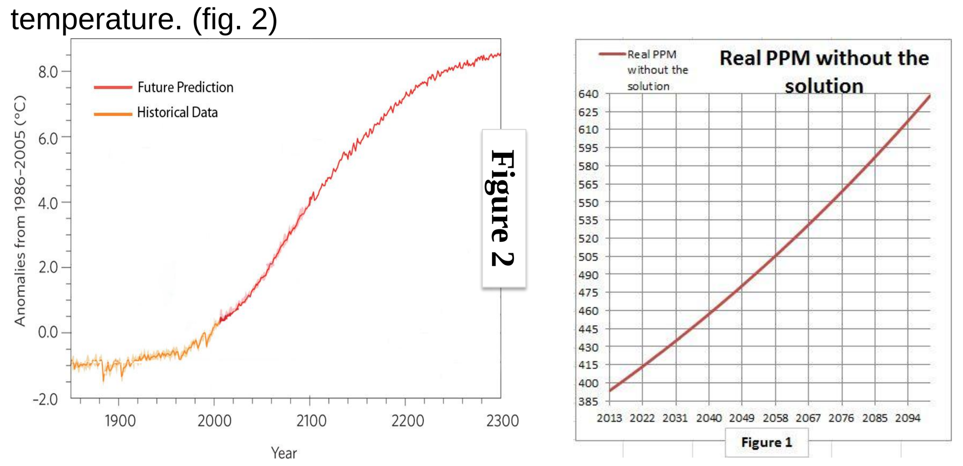

Figure 2

Based on this perspective, many scientists and researchers have made many attempts to deal with the uprising problem trying to cut off the emissions. They tried: The use of electric cars (green cars), and using renewable energy resources. We have proposed carbon capture and storage (CCS) and have compared it to the other solutions. We have made a table to evaluate the possible solutions to choose the optimum one based on the scores each of them got in its success to fulfill our design requirements. We worked on five main requirements: its cost, capability of reducing emissions by a minimum of 50%, doesn't have many side effects, effective on the short range and can be applied to any already existing plant or factory without the need to redesign our production assembly lines. Finally, we chose CCS as our optimum solution because it meets the minimum requirements and more than that. For example; it reduces the emissions by 79.1% not only 50%. In addition to this, it is fully capable of stabilizing temperature rates of increment.

Methods

We have chosen to apply Carbon, Capture, and Storage (CCS). First, we will mimic the natural process, based on a chemical absorption techniques relying on carbonate-based absorption.

Carbonate-based absorption:

Basic idea (natural process):

1- When the rain is formed, it reacts with Carbon Dioxide gas,CO_2, previously existing in the atmosphere, from flue gas, as the following chemical reaction:

$$H_2O + CO_2 \rightarrow H_2CO_3 \qquad (1)$$

2- When carbonic acid is formed, it briefly exists, in the form of H_2CO_3. Then, it is carried by the air to one of the carboxylic rocks, located in the band of the rivers. These rocks are full of silicate, and carbonate salts. One of the most important carbonate salts is Calcium Carbonate ($CaCO_3$).The reaction occurs:

$$CaCO_3 + H_2CO_3 \rightarrow Ca^{2+} + 2HCO_3^- \qquad (2)$$

3- Then, Calcium Bicarbonate, $Ca(HCO_3)_2$, is drained into the river in its ionic form, Ca^{2+}, and $(HCO_3)^-$. Then, Bicarbonate ion moves along the river to the ocean. There, the buffer capacity of the ocean, to uptake Carbon Dioxide from atmosphere, will increase due to the increase in CO_3 in the water. These processes occur naturally as a carbon cycle and lead to the reduction of CO_2 emissions.

Industrial process:

Our idea to capture the CO_2, is by simulating the natural process. In addition, we can stimulate the reactions using AWL, accelerating weathering of limestone. Also, this process can be applied to any plant, using post-combustion techniques. The mechanism of the process is as simple as it occurs naturally.

AWL Process (figure 3):

1. A gas stream rich with CO_2 (1) enters the reactor vessel (5) by one or more entryways (e.g., 2, 3, and/or 4). The gas stream then passes over or through a wetted porous bed of limestone particles within the reactor.
2. This carbonate mass, $CaCO_3$, is sprayed (6) and wetted with water/carbonic acid solution, which is unsaturated with respect to bicarbonate ion. This arrangement exposes the incoming gas to a large surface area of water/solution in the form of droplets and wetted carbonate particle surfaces in (5).
3. To facilitate the hydration of the entering CO_2, to form carbonic acid solution within the reactor, CO_2-depleted gas exits the reactor (7).
4. The formed carbonic acid solution reacts with the carbonate to form calcium and bicarbonate ions in solution, which is either recirculated or bled from the reactor and replaced with unreacted water within the reactor at a rate that maximizes cost and benefit.

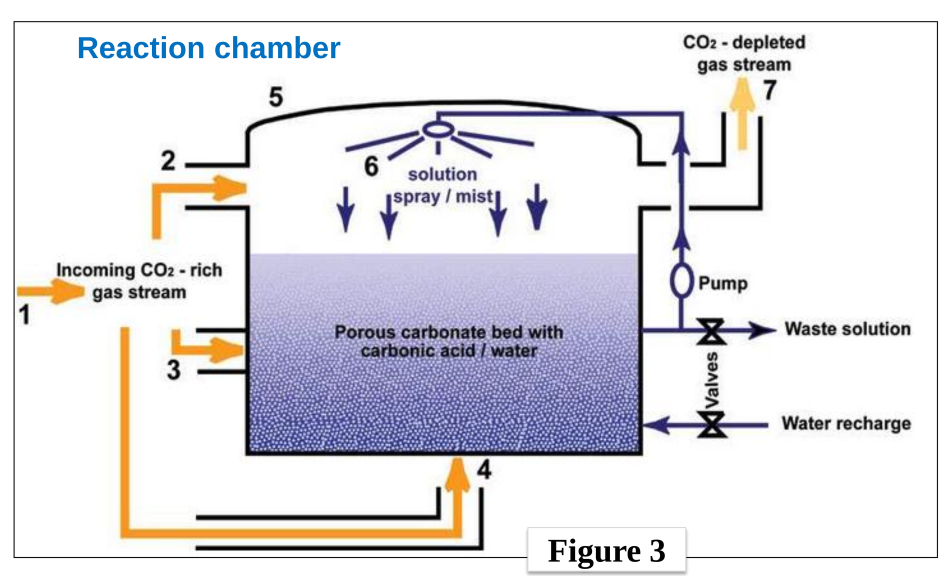

Figure 3

Flue Gas Desulfurization (FGD):

SO_x emissions in flue gas, is taken into consideration as it can form sulfuric acid, H_2SO_4, when reacting with water in the reactor chamber. This will make corrosion in the pipeline system, and cause a disturbance in the oceanic biological life when it is injected in. The products can be filtered using a membrane *(7).*

$$SO_{2(g)} + H_2O_{(l)} + CaCO_{3(s)} \dashrightarrow CaSO_{3(aq)} + CO_{2(g)} + H_2O_{(l)}$$

$$CaSO_{3(aq)} + 0.5O_2 \dashrightarrow CaSO_{4(s)}\downarrow \qquad (3)$$

Results

After applying our solution, we extracted results by using our mathematical model , these results predict how our solution can affect the future of our life on the earth. By these results, we can predict some quantities that changed after applying our project like the amount of CO2 emissions through the next 100 years, number of ppm and its amount in the atmosphere, and the relation between that amount and the expected temperature due to this changing. Some of these results :

1- Graph that represents the amount of CO2 emission (Kt) before, and after applying the solution :

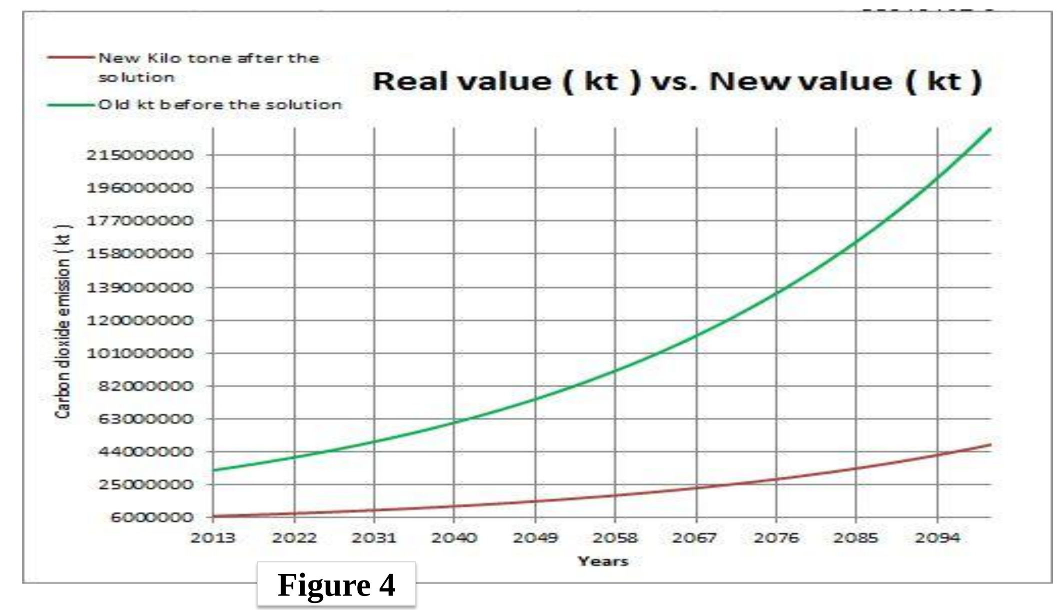

Figure 4

2- Graph that represents the relation between the amount of CO2 particles (PPm) in the atmosphere before, and after applying the solution :

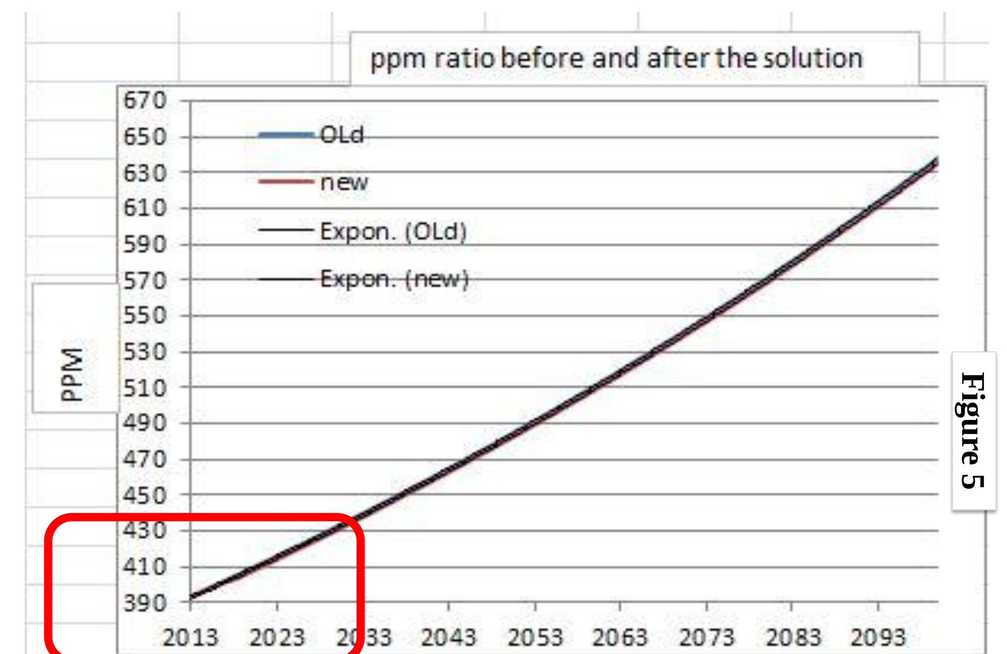

Figure 5

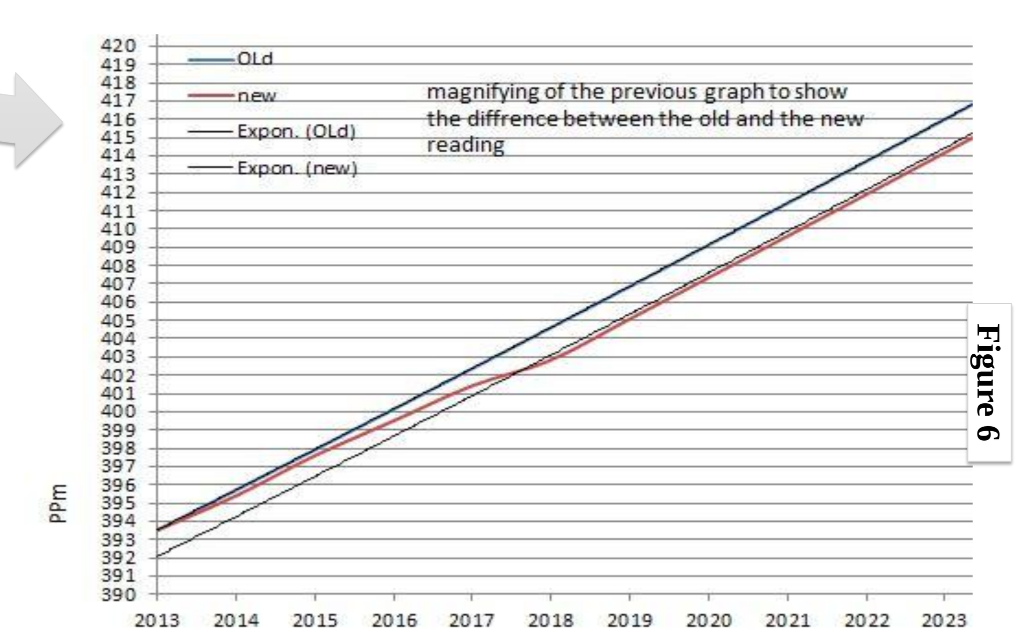

Figure 6

Discussion

1- Our model will show the effects of applying (CCS) by comparing the expected temperature, based on IPCC scenario, to our forecasted temperature, based on what we predicted. Our model is characterized by its accuracy as it is supported by many graphs and equations. Also, it works by applying a complete series of equations that starts by giving it the number of energy plants complying and ending with the change in temperature.

$$(Y)\ \% = \left(\frac{0.81\,a + 0.64\,b + 2.8\,c + 0.936\,d}{0.9\,a + 0.8\,b + 3.5\,c + 1.3\,d}\right) \times 100 \qquad \textit{(eqn. 1)}$$

Where;

a: refers to the number of power plants complying

b :refers to the number of cement factories complying

c: refers to the number of steel factories complying

d: refers to the number of oil refineries complying

(Y)% : refers to the percentage of reduced from CO_2 emissions

2- The reduction percentage, we will get from the previous equation, will be interpreted into the graph of the forecasted carbon dioxide emissions. The new value of the carbon dioxide emission, we get from multiplying it by the forecasted one, will be substituted in this equation

$$F(x) = (5.0999)x^{0.250803475} \qquad \textit{(eqn.2)}$$

This equation will help us to convert the value of CO_2 presented in kilo-ton to PPM (parts per million). The results will be involved into a relation so that it can give the amount of change in temperature based on the given change in carbon dioxide concentration in PPMs.

$$100\ PPM = 1\,^{\circ}C \qquad \textit{(eqn.3)}$$

The equation states that if PPM of CO_2 has increased to 100 the temperature will increase 1celesius. After that, we will figure out the new values of the temperature as a graph versus the time, and this how our mathematical model will work , Figure 7.

Future study:

We will make an enhancement as it was more than our desirable cost. By applying the solution, the cost will be 5 trillion dollars for the next 10 years in the world. ***F(x) = {[(2.3 ton) ($4) (x ton)] + [($0.06)(x ton)(a K.M.)] + [($2.5) (x ton)] + [($7.57) (.04 ton) (x)]}***

Where;

x: refers to CO2 emissions (kt)

a: refers to distance.

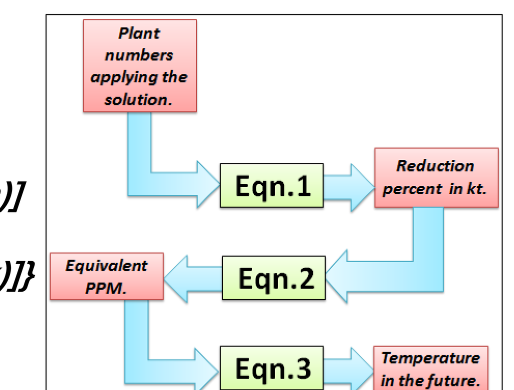

Figure 7.
Mathematical Model paths

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