A GLIMPSE ON THE COAL RESERVES AND PRODUCTION IN TURKEY, ECOLOGICAL CARBON CYCLE, AND SOME NEW ERA METHODS OF LOWERING CARBON DIOXIDE LEVELS

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Introduction

It is estimated that the oil will be sufficient for us for a couple of generations of humanity. Forbes Magazine estimates we will run out of it between 2055 and 2070 (How Much Oil Does the World Have Left, 2015). Also, in an International Business Times a more specific date is given i.e. 2067 (World Energy Day 2014: How Much Oil is Left and How Long Will It Last, 2014). The numbers stand for proved reserves, of course, as new discoveries arise and technological recoverability upsurges, we may see a modification in these estimations.

And for coal, the most copious among fellow fossil fuels with proved reserves of exceeding 841 billion tons, and almost 8 billion tons of it is used in the world each year (World Energy Council, 2016). World Coal Association gives a more optimistic datum on this issue stating the proven coal reserves worldwide is 892 billion tons that would last for another 110 years whereas oil and natural gas would deplete by half this time (Where is coal found, no date). In summary, it is easy to say that coal will be above and underground for many more decades to come.

According to 2006 figures, Turkey's coal reserves are 4.2 billion tons in total and 3.9 billion tons of it are subbituminous and lignite; and, 0.3 billion tons of the reserves is anthracite and bituminous (BP Statistical review of world energy June 2007, 2007). Turkey extracts 77 million tons of coal annually (Statistical Review of World Energy 2008, 2008). A more up to date shares that Turkey's coal reserves are about 8.7 billion tons and the yearly coal production is the same as in the older report (World Energy Resources: 2013 Survey, 2013). In addition, The Ministry for Energy and Natural Resources (MENR) of Turkey states that there has a giant leap in proven lignite reserves of the country during the decade between 2005 and 2015, bringing lignite reserves from 8.3 billion tons to above 15 billion tons (MENR, 2015).

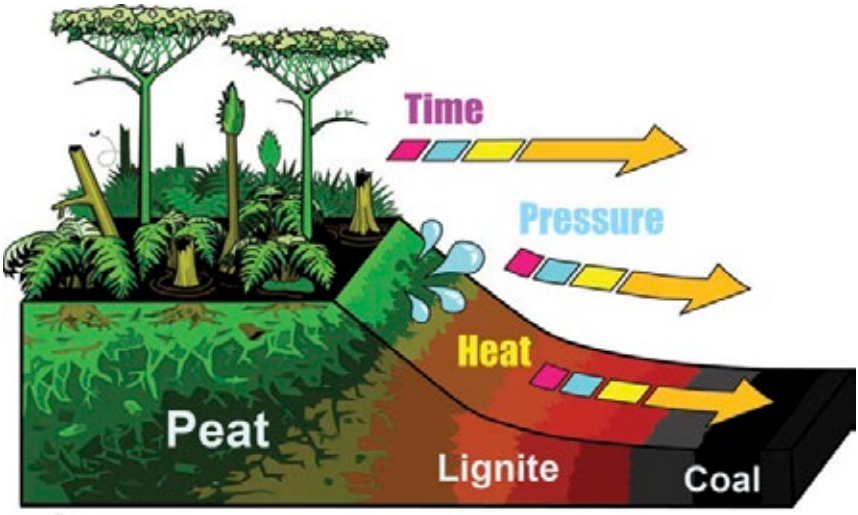

Image: Coal formation (uky.edu)

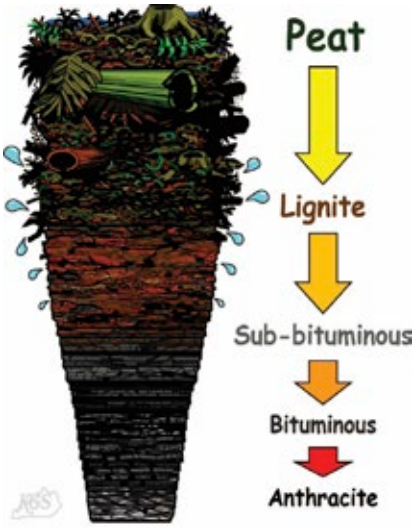

Image: Coal formation (uky.edu)

The previous and following diagrams simply show how coal is formed. The carbon-rich organic debris piling up in the swamps become peat. Next, peat goes under coalification by being affected by the heat and pressure during the process. Microbiological effects, pressure, heat and time all contribute to the transformation of peat to lignite. Bacterial decay cannot catch up with debris build up in these coal-generating swamps and the lack of oxygen limits aerobic bacterial activities. Lignite is formed if this piled up peat is buried under pressure and the water is drained away. Other elements in the pile are sequestered and given enough time we can theoretically find pure carbon in the form of graphite in these fields (How is Coal Formed, uky.edu). Given these, it can be said that Turkey's coal fields did not spend enough time underground and neither received sufficient heat or pressure.

The wetlands that generate coal are a simple laboratory that we can analyze the results of climate changes. There are limited changes to species since they are semi-closed systems (Dimichele and Phillips, 1995). Further research can be conducted in such areas in the world to give us more insights about the fate of our planet.

Ecological Carbon Cycle

Just like water in the globe, a carbon molecule finds its way in the world to and from the earth and its atmosphere. The biogeochemical cycle of carbon between the soil, the

water, and the air is called "carbon cycle" where carbon is reused and recycled in the biosphere.

This cycle gives birth to a global carbon budget, which translates to saying if a carbon molecule enters the system, it needs to go somewhere. And this "somewhere" happens to be the atmosphere where greenhouse gases reside and accumulate. With the global temperatures rising more polar and glacial ice melts uncovering barren rocks which capture heat where the ice sheet used to reflect this heat. More heat evaporates more water that in its gas form is another greenhouse gas, that brings the temperatures even further higher. The accumulation ultimately brings global climate change.

Carbon cycle is nature's way of recycling carbon. As we know, this material is essential for all living beings. The carbon in your hair might have derived from a now extinct dodo bird or even a primordial dinosaur. The carcass of the animal decomposes and the nutrients are passed to the soil, from which a plant captures it and metabolizes other molecules in its body. And the fruit of this plant is carried by some bird or it travels inside some other animal. After all, these decomposed materials accumulate and with millions of years passing under pressure and heat, fossil fuels are produced. In the exhaust gas of a car there is part of an ancient being.

However, some of the atom that was once part of the shells of marine crustaceans and mussels might become entombed inside lime rock at the bottom of the seas and oceans. These atoms are left outside the carbon cycle for long periods of time but once the water travels elsewhere they are exposed to weathering conditions, and once again become part of this biogeochemical cycle (Carbon cycle, Science Clarified). The other kind of entrapped carbon is the amount of all the fossil fuels underground waiting to be extracted to the surface. After that, also via natural occurrences like seepages etc., these carbon deposits will enter the carbon cycle once again.

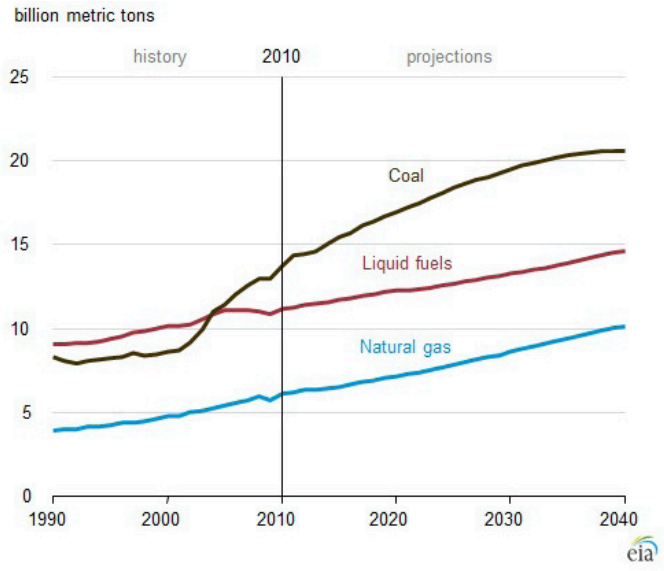

Image: World CO2 emissions by fuel type (theenergycollective.com)

Burning more and more coal and oil with the advance of industrial revolution to generate more steam power to run the mills, factories and so on, released colossal amounts of carbon dioxide into the atmosphere. As we can see in the graph above, coal is and will be the leader cause of CO2 emissions in the world. Within the last one and a half centuries, nearly 250 billion tons of carbon has been given to the air. Thankfully, soil itself, the plants and the oceans capture the bigger half of carbon dioxide released. Scientists fear that this vast input of carbon dioxide, which is a greenhouse gas that thwarts heat reflecting back to space, could alter the balance of carbon cycle (Carbon cycle, Science Clarified). Hence, we have global climate change.

Carbon capture and storage is the process of transferring the waste CO2 into storage facilities from large point sources of CO2. The Global Carbon Capture and Storage Institute published a report on the issue. Net carbon storage potentials for different industries are as follows (the Global CCS Institute, 2011):

- Mineralization of Carbonate
- Cultivation of Algae
- Enhanced Coal Bed Methane
- Enhanced Oil Recovery
- Bauxite Residue Carbonation
- Enhanced Geothermal

As we can see from the list, there can be greener approaches in a variety of fields. We will discuss algae cultivation later in the paper.

Some New Era Methods Of Lowering Carbon Dioxide Levels

In order to prevent accelerated heat building up on Earth, the natural balance needs to be restored. The budget of carbon could perhaps be balanced again. There have been implementations like banning CFCs to slow down the global greenhouse effect. Also, carbon taxation is devised in several places in the globe.

This article is listing some newer and less acknowledged methods of combatting carbon dioxide and other greenhouse gases.

Bioremediation

This method is the type of waste management strategy that include living beings in eliminating or neutralizing the wastes. United States Environmental Protection Agency defines it as "treatment that uses naturally occurring organisms to break down hazardous substances into less toxic or non-toxic substances".

Several research has been going on in this field. The fungus species of Trametes versicolor was found to be able to digest natural coal (Biodegradation of coal-related model compounds, Campbell et al.). Diplococcus bacteria can reduce coal by raising the temperature of the resource (Bacteria as agents in the oxidation of amorphous carbon, Potter).

Attempts on bioremediation will reverse the effects of coal, natural gas, and oil extraction by returning the field back to its original form and by neutralizing the excess amount of pollutants and other matter.

Reforestation

Reintroducing the lost canopy, reversing deforestation has many positive effects including prevention of erosion, introducing a milder climate and more carbon dioxide absorption from the atmosphere.

Evliya Çelebi, a famous Turkish traveler of 17th century, once wrote that in Turkey, then part of the Ottoman Empire, a common squirrel could jump from one tree to another without stepping on the ground, it could travel from Sinop in the north to Mersin in the south in that manner. This sort of "legendary" depiction of the flora of the past gives an idea of how much forest we lost through centuries. There have been several national attempts by the Turkish government and non-governmental organizations to reintroduce forests and attempting to save the ones under current threat. The Turkish Foundation for Combating Soil Erosion, for Reforestation and the Protection of Natural Habitats (TEMA) is perhaps the most widely known of the NGOs in Turkey. Another example is the Foundation for the Protection and Promotion of the Environment and Cultural Heritage (ÇEKÜL). There are a number of these foundations trying to bring public attention to this great cause.

Although not about reversing global climate change or other new era causes, New Deal Agencies during the Great Depression times in the United States, employed millions of people for public service which also consisted of planting forests in the areas which lost their fauna after unrestrained industrialization.

Image: Indian man single handedly plants 5.5 km2 of jungle (sanskritimagazine.com)

One Indian man took things in his hand and started with a sandy area near his village in India. So, in 3 decades' time, he managed to grow 5.5 km2 of jungle all by himself (Sanskriti Magazine, 2013).

In 2013, Pakistanis planted almost 850,000 trees in one day. Three years later, 800,000 volunteers in India spent 24 hours to break this record. These Indian volunteers planted 80 different species trees and exceeding 49 million trees. During the Paris Climate Conference in December 2015, India agreed to reforest 12% of her land area. Noting that, African nations promised to reforest 1,000,000 km2 of land. There is a big downside to these mass reforestation projects: these saplings of trees are quite vulnerable with 2/5 mortality rates in such attempts (Howard, 2016). Still there is optimism and with better management of upkeep and watering a copiously improved exertion can be accomplished.

Green Architecture

In the modern times, when the land is scarce and everything expands outwards, an Italian architect came up with an idea: Bosco Verticale - building forests upwards. His design skyscraper hosts as many as a hectare's worth of trees on a building.

Image: Bosco Verticale – Vertical Forest (stefanoboeriarchitetti.net)

The first project was set in Milan on two towers measuring 112 and 80 m tall that host nearly one thousand trees with addition to thousands of shrubs and flowering plants. These plants capture pollution and greenhouse gases, cool down the offices and residences with their shade, and generate a local micro-climate which is more humid than the rest of the area (dezeen.com, 2014).

The same concept is being implemented in Nanjing, China. This new project expects to produce 1,800 kg of oxygen every single month on one single project. In 2018 the two towers of Nanjing will be completed. The same architect is also planning a vertical forest in Lausanne, Switzerland (photovide.com, 2017).

Green Roofs

In the north, in Iceland, people tried surviving the harsh winters by thickly insulating their houses. The tradition goes back to Iron Age. They had earthen roofs and some houses were semi-subterranean (The Turf House Tradition, unesco.org).

Nowadays, the amount of land used for housing, commercial and industrial use is noticeable. Some buildings use their roof area to host green plants. These green roofs insulate the building, so the residents use less energy to heat or cool the spaces.

This setup also helps to reduce the heat island effect. Water that evaporates from the roof cools down the surrounding. All of this cuts down the energy need for air conditioners.

Using local plants also help the local fauna.

Image: Green roof on Penn State University (self-credit)

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Farming in the Desert

Qatar is a country known for immense heats especially in summer time. The Sahara Forest Project in Qatar came up with the idea of using seawater for the cooling of their greenhouses in the desert.

The findings are promising. They lowered their energy consumption by using solar power, and the greenhouses use less freshwater since the cooler pipes collect water vapor from the air and they fall down as drops.

With less energy and less freshwater to produce crops the future is optimistic. Also, let us not forget about the fuel needed to carry all that fruit if they were grown elsewhere (McGar, 2013).

Qatar is also implementing using hydroponics which uses less water and less land area to produce even more food than in open field. This method is good with vegetables but

cereal need an immense amount of water when compared to other crops so the Qataris may still prefer importing the latter (Fuchs, 2012).

With local farming possible, the planet's carbon dioxide production will decline even further.

Algae cultivation

These tiny creatures are humble yet prolific beings. The algae and the cyanobacteria together produce a staggering ¾ of the oxygen we inhale. Algae grow on fresh water and salt water, also on some plants when there is sufficient moisture in the system, and on some animals as well (Algae, Microbe World).

Image: The Urban Algae Canopy (inhabitat.com)

In 2015 in Milan, The Urban Algae Canopy project met the public. This design is said to produce 150 kg of biomass and generate the amount of oxygen that a 4-hectare-woods would produce in a day (Brooks, 2015). The biomass can then be converted to biofuel, or animal feed or perhaps used for human consumption – all locally sourced.

Image: Algae-Fueled Building (weburbanist.com)

This design can go under green architecture title as well. German designers put glass panels of algae reactors on their building. These panels block sound and light from the outside while providing power and heat for the dwellers – hot water and warm rooms are on the algae (Kohlstedt, Web Urbanist).

The studies on flue gas are going on. Some micro-algae which are tolerant to high temperature, NOx and Sox gases, high CO2 concentrations are selected to fix the high amount of CO2 emissions coming from flues. This bio-fixation method does not limit thermal capacity of the previous process, is environment-friendly and sustainable. However, we still do not know how to handle the big mass of biomass produced by algae – all the technologies used are altered from other food industries, yet we need algae-specific approaches. Although biofixation of CO2 by micro-algae is economically and technically feasible IEA Clean Coal Centre still consider there is more time needed for this to become widely used in their report (Zhang, 2015).

Alternative Plants

Next, a rather controversial method of combatting carbon dioxide in the atmosphere is growing hemp (We are not talking about the medically used kind, we focus on the industrial kind). It is a carbon-negative product which eliminates more carbon dioxide during its life cycle than the amount of carbon dioxide it takes to produce it.

Hemp can be used as a fiber source for textile, as an insulation material or even in concrete. The article refers to an issue of Popular Science magazine from 1937 to add on to the suggested benefits of the crop. For example, hemp concrete is a natural insulator and humidity regulator which in the end cuts down greenhouse emissions (Top 5 Most Innovative Uses for Hemp, 2013).

Furthermore, Turkey legalized growing hemp for legal issues for registered farmers who would take special permits in 19 provinces on 29.9.2016. This has been reviewed in the press in 2016. One website comments on the issue:

- One unit area of hemp produces 25 times the oxygen that would be produced by a forest in the same area
- Hemp can give 4 times more paper than trees
- 2 to 5 decades is need for a tree to be fully matured yet hemp only need 4 months
- Biofuel can be produced from hemp.

Given the list above, Turkey's approach is seen as a promising one (tarim.com, 13.10.2016).

Another example is the Barbados nut tree (Jatropha curcas) which grows in hot and arid littoral zones. This tree was found to be an alternative to carbon capture and storage. A hectare of this tree can capture more than 20 tons of carbon dioxide annually. The use of desalinized water and special minerals cost around 50 Euro per ton of carbon dioxide sequestered (Becker et al., 2013).

Summary

At the moment, we see CO2 as an end product that we treat as waste. But as we discussed earlier it can be used as a raw material in the industry and in farming. Dr. Gernot Klotz, Executive Director Research and Innovation at European Chemical Industry Council, strongly recommends that we look at CO2 as a potential not as waste (theenergycollective.com, 2014).

Turkey has more coal than oil. As a fast-growing nation, Turkey needs energy to support herself. Local coal reserves and hydropower are directed into electricity production. Natural gas is imported from neighboring regions. The country can widen the variety of energy resources used and give chance to the newly implemented methods of energy recovery.

The world has more coal than oil. Nations will use their resources. As long as we can balance, firstly nation-wide carbon budget and then a global carbon budget, with great efforts and moving towards greener ways, we can still survive this global climate change.

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