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Nuclear Carbonization/Gasification of Biomass to Produce Biochar and Biofuel for Effective Removal of CO_2 from Atmosphere

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INTRODUCTION

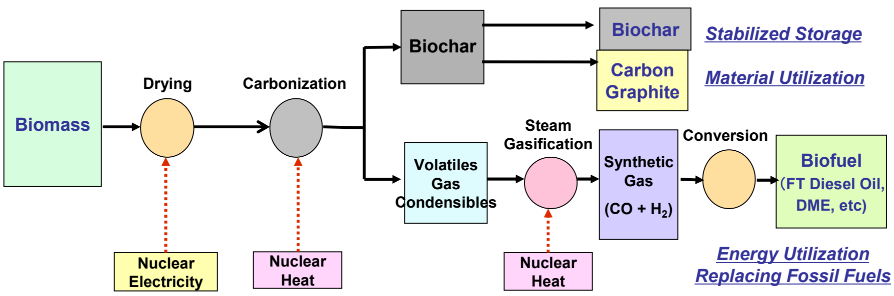
To cope with the global warming issue, it is necessary not only to reduce the emission of CO_2 to atmosphere, but also to actually remove the excessive quantity of CO_2 from the atmosphere.

For removing atmospheric CO_2, the synergistic biomass-nuclear process (Figure. 1) can be used, which consists of nuclear-heated carbonization and subsequent nuclear-heated steam-gasification of biomass [1][2][3][4][5]. Here, nuclear energy can effectively be utilized for supplying necessary energy to the process, avoiding the CO_2 emission from any biomass or fossil fuel combustion.

By the synergistic biomass-nuclear process, a portion of carbon element in biomass is stabilized as solid carbon, and the remaining portion of carbon is converted by gasification and conversion process to synthetic fuels, which can replace fossil fuels for energy supply.

Thus, biomass, which otherwise eventually decays in soil to emit the CO_2 to atmosphere, converts to stabilized solid carbon and synthetic fuels, which leads to the decrease of atmospheric CO_2 concentration in the long term.

Fig.1 Synergistic Biomass-Nuclear Process



- **Drying;**
  Vapor compression & condensation (VCC) process by nuclear electricity
- **Carbonization (where $C_6H_{12}O_6$ represents biomass);**
  $C_6H_{12}O_6$ + nuclear heat → C (charcoal) + Volatiles, Gas and Condensibles
- **Steam Gasification (where C represents carbon containing substances);**
  $C + H_2O$ + nuclear heat → $CO + H_2$
- **Conversion (Fischer-Tropsch synthesis, where CH_2 represents FT diesel oil);**
  $CO + 2H_2 \rightarrow CH_2 + H_2O$

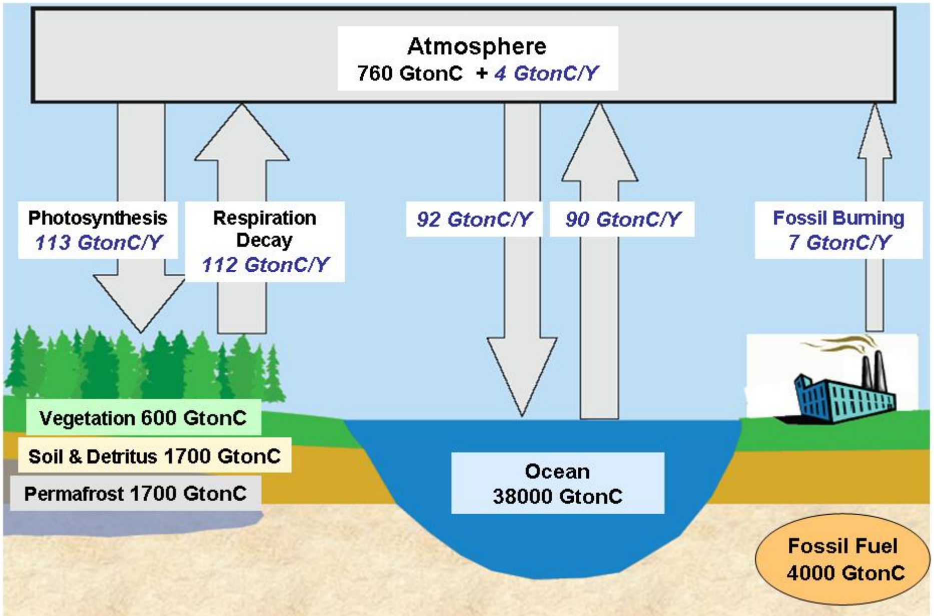
GLOBAL CARBON BUDGET

Carbon is exchanged between the Earth and atmosphere. The global carbon budget for Year 2000-2005 is shown in Figure. 2, where values on the carbon flux and the amount of carbon held in each reservoir are cited from IPCC (Intergovernmental Panel on Climate Change) [6] and other reports and are rounded by the author for approximate evaluation.

Recently, there are reports which warn that the thaw and release of carbon currently frozen in permafrost will increase atmospheric CO_2 concentrations and amplify surface warming to initiate a positive permafrost carbon feedback on climate.

According to Schaefer [7], by the positive feedback effect the cumulative permafrost carbon flux to the atmosphere by Year 2200 will 190 ± 64 GtonC (GtonC = 10^9 ton Carbon). As the thaw and decay of permafrost carbon is irreversible, it is now more urgent than before to reduce carbon emissions from fossil-fuel use and further to remove the carbon from the atmosphere.

Fig.2 Global Carbon Budget



Reference: IPCC-AR4 2007 Report & Kevin Schaefer (NSIDC)

IMPACT OF SYNERGISTIC PROCESS AND NUCLEAR SUPPLY CAPABILITY

As the reference case, processing a 1/10 amount (6 GtonC/Year) of plant growth by the biomass-nuclear process is evaluated. This case produces;

1. 2.7 GtonC/Year amount of solid carbon (biochar) which can be excluded from the global carbon cycle as the solid carbon is stable.
2. 2.2 GtonC/Year amount of biofuel which can be deducted from fossil burning flux as the biofuel is carbon-neutral.

According to the global carbon budget for 2000-2005, CO_2 increase in the atmosphere was 4 GtonC/Year. The above reference case reduces 2.7 + 2.2 = 4.9 GtonC/Year from atmosphere in the long term, so it will eventually decrease the atmospheric CO_2 by the rate of 0.9 GtonC/Year if the world consumes the same amount of carbon-based fuels as in the period 2000-2005.

All the energy required for the process is supplied by nuclear heat or electricity, which sum up to 1.7 $Gton_{O.E.}$/Year ($Gton_{O.E}$ = 10^9 ton of oil equivalent thermal unit) in the above reference case. If Plutonium-recycling Fast Breeder Reactors (or other type of nuclear reactors with efficient fertile fuel converting/burning characteristics) are adopted, then the nuclear supply capacity would becomes enough for both the world electricity demand and this biomass-nuclear process.

Nuclear energy utilization increases the efficiency of converting biomass to solid carbon and biofuel. The percentage of process yield, which is defined as the ratio of mass of carbon in the product (solid carbon plus biofuel) to mass of carbon in the feed (biomass), increases from about 50% in the case of using biomass itself as the energy source for the process by combustion, to about 80% in the case of using nuclear energy as the energy source, by rough estimation for the reference case.

If this process is used extensively, large amounts of charcoal (bio-char), carbon, and graphite materials are produced and become available abundantly. These carbon materials are presently utilized in many industries, and can be applied in the future to agriculture / forestry, building / construction (graphite structural material) and many other fields.

GLOBAL RESTORATION OPERATION

- The synergistic biomass-nuclear process can be applied not only to organic carbon in the vegetation, soil and thawing permafrost which would be otherwise decay to emit greenhouse gases, but also to green energy plants such as the switch-grass and microalgae which are cultivated on land or in water and efficiently absorb CO_2 from atmosphere.
- Nuclear energy utilization for this process makes the operation effective and efficient, and consequently helps attain the goal of removing excess CO_2 from the atmosphere as expeditiously as possible.
- Stabilizing the atmospheric CO_2 by carbonization is a restoration operation of the coal and other fossil fuels which have been mined and burned by the mankind. As the anthropogenic CO_2 emission has been global, our restoration operation will be global and massive.

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