

Mitigating Carbon Lavishness by multiple Carbon Re-Use

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Overview

The world uses annually 13bln tonnes of fossil plus bio-gene Carbon, being the backbone of fossil- or bio- energy carriers, as if it were a one-way package, by merely disposing it into the atmosphere. Over the last 50 years a doubled population having 3-folded its clean water consumption to 120% of natural availability has 11-folded its Carbon consumption to 160% disposal rate of the planet's metabolism^[1]. Carbon consumption having reached 57% of all resource consumptions is barely recycled today.

Nature forms Carbohydrates, having been the ancestors of fossils, from the basic elements of Carbon, Oxygen and Hydrogen, the latter being delivered mostly by water. And Nature decomposes Carbohydrates into Carbohydrates, Carbon oxygens and or from water again^[2]. And as we know from refineries, Carbon is the core building block in the processes of upgrading Hydrocarbons to increased Hydrogen per Carbon Ratios. So this obtrudes the question, why the rationale of recycling paper, saving the number of fresh trees needed to be cut when producing new paper, is not applied for Recycling Carbon to safe fresh crude resource exploration when wanting to refine new Hydrocarbons. After all crude oil is just Carbon for 83% of its mass and coal just a more or less contaminated pure form of Carbon.

Generally scoping today's total anthropogenic managed Carbon, 45% could be recycled and replace fossil crude oil at a rate of up to 2 litres per kg physically captured Carbon for multiple Re-Use^[3].

Methods

As having been said in the overview Nature lives from perpetuated decomposing and re-synthesizing organic matter, namely carbohydrates. Over the last two decades Technologies have been developed, mainly for purposes of energy recovery only, to accelerate the decomposition of carbonaceous matter into energy rich gases^[4]. Even Substitute Natural Gas Synthesis from such product-gas yields has already been demonstrated industrially Gothenburg Bio-Gas from wood at an energy efficiency of ~ 67%^[5], not to mention fermentative Bio-Gas achievements.

However, targeting for energy recovery only, these efforts do not contribute much Carbon Efficiency^[6] improvement as the Carbon usually gets disposed into atmosphere by combustion to generate heat, usable for further transformations. When we take electricity as an example, the overall efficiency from fossil or synthetic Natural Gas may be 35% plus whatever CHP of waste heat may be usable.

If in contrary producing the electricity from Hydrogen derived by physical Carbon Capture from fossil or synthetic Natural Gas by dry thermo- catalytic splitting^[7], in a state of the art Fuel Cell, the electricity yield per cubic meter of Methane would be almost equal as if the Methane was burned for heat to produce motion energy in the form of steam to mechanically propel a generator – in other words, replacing a 3-step transformation into a single step electro-chemical energy transformation. By doing so, per cubic meter Methane representing most part of Natural Gas, the same electricity could be produced under retention of the Carbon as a fossil Carbon source substitute of 1 litre crude oil equivalent (per m³) for synthesis of new Hydrocarbons.

Results

Synthesizing Hydrocarbons from Carbon requires available corresponding rate of molecules of Hydrogen to result in the desired Hydrogen to Carbon Ratio of the aspired output product. On the one hand this may come from water, either for Hydrolysis or Steam Reformation. Alternatively it might also be provided from water electrolysis using Carbon emission free excess electricity like for example Hydropower, Photovoltaics, or Wind-turbines. Today so called Power-to-Gas new renewable energy storage configurations have demonstrated Methane synthesis from such Hydrogen with CO₂ from flue gases or biogas plants, needing four molecules of Hydrogen per Methane molecule output plus not generally definable energy for the CO₂ provision from a mixed source of flue- or bio- gas.

Combining electrolysis Hydrogen with physically Captured Carbon for multiple Re-Use required number of Electrolysis-Hydrogen molecules can be halved – meaning, storage efficiency for Renewable Energy can be doubled, as a steam reformation of the recycled Carbon could deliver one Carbon monoxide plus one Hydrogen molecule, needing only two additional Hydrogen molecules for the Methane synthesis. Happens, physical Carbon Captured by dry thermo- catalytic Methane Splitting can be tailored to at a high specific surface and morphologies providing high electron mobility. Both can be used to optimize chemical reaction regimes for growing or cannibalizing the Carbon under the mitigation of unwanted equilibrium chain reactions.

Even if there was not enough Hydrogen from electrolysis available, half the captured graphene like Carbon could be sacrificed into CO₂ to achieve the molar ratio required for a Methane synthesis from the remaining 50% Carbon monoxide. In that case synthetic Natural Gas net-output energy efficiency would be 90% of Carbon Energy Input. Overall Carbon Efficiency improvement would still be 1.4 times higher than using Hydrogen Fuel Cell Utility from Methane Steam Reforming in the first place, already representing a bisection of Methane combustion's Carbon intensity. However, Steam Methane Reforming requires about 1.8 times the transformation energy per mole Hydrogen dry thermo- catalytic splitting of Methane does.

At adequate scales Carbon Recycling can compete with fossil Carbon replenishment starting from a crude oil price level of US\$ 30 per barrel. Due to the cannibalization of Recycled Carbon in downstream chemical reactions required catalysts are getting recycled as a by-product, usually being a huge cost factor in such kind of chemical vapour deposition processes. Further, not using the Carbon as a high-tech graphene material, for which the process had originally been developed, intricate cleaning procedures can be skipped, representing the second predominant cost factor of nano Carbon fabrications.

Conclusions

Today's practices of lavishly squandering Carbon from energy carriers, organic waste treatment and biomass use drive prices for Carbon replenishment, stress global resources and require tapping into ever new reserves. If policies would tax usage of carbonaceous matter by the replenishment equivalent price of discharged CO₂, the game would dramatically change. First of all, Carbon would be recycled to minimize atmospheric discharge. Secondly primary feedstock would be chosen by its Hydrogen to Carbon ratios being a direct key to Carbon Efficiency, so that the most appropriate feedstock and methods would be used for energy productions or chemically and materials synthesis only. The local closed loop multiple Carbon Reuse would generate significant local employment from the economics of money no more needing to be sent out into foreign oil wells, never returning again for local value adding.

Carbon Recycling as well as New Renewable Energies as well as biomass and waste to energy Technologies all together share appropriateness for decentral scales only. Therefore in conjunction with the local closed loop economic uplift by Carbon Recycling appropriate hybridisation among the aforementioned Technologies could eradicate Energy poverty without burdening societies with the cost of subsidies. Just imagine, one tonne of ultimate organic residue of municipal solid waste represents ~ US\$ 150 per tonne fossil Carbon substitute value! For biomass it would even be more than double. But citing that, it must also be clearly stated that replenishment of agriculturally used soil should always prevail energy exploitation, as soil ligated Carbon currently deteriorates 100 times faster than it can be rebuild by Nature – representing the real Climate Change Challenge!

Apart from Carbon Recycling contributions to Climate Change mitigation it should be primarily also considered in terms of Security of Energy Supply. It can leverage the potentials of renewable and alternative sources of energy by multiples if applied in the right hybrid configurations.

References

- 1 Global Footprint Network (WWF); "In 2016, Earth Overshootday fell on August8"; Oakland USA / Geneva CH
- 2 Denny K.S. Ng, University of Nottingham, Malaysia; "Synthesis of an integrated biorefinery via the C–H–O ternary diagram"; Article in Clean Technologies and Environmental Policy; January 2010
- 3 Yong Cao, Carbotopia™, Austria; "Increasing Carbon Efficiency of Coal Power Plants by Carbon Capture Use"; EREC-2016 Nanjing, China; May 2016
- 4 S. Kern, C. Pfeifer, H. Hofbauer; Vienna University of Technology, "Gasification of Low Grade Coal in SD-DFB Gasification"; Energy Technol. 2013, 1, 253 – 264
- 5 Åsa Burman; "The GoBiGas-project", SGC 2013, Gote-borg, Oct 2013, Sweden
- 6 Guobao Zhang; Specialist Committee for National Energy Commission & former Minister of National Energy Administration, "New Requirements to Energy Re-searchers (Opening Remarks), 4th Asian and 1st China IAEE Conference, Beijing China; August 2014
- 7 K. Mauthner; BMVIT Report 1/2011, Factory of the Future, EU-FP5