Clean up after yourself: the optimal pricing mechanism for the creation of a world carbon neutral energy economy

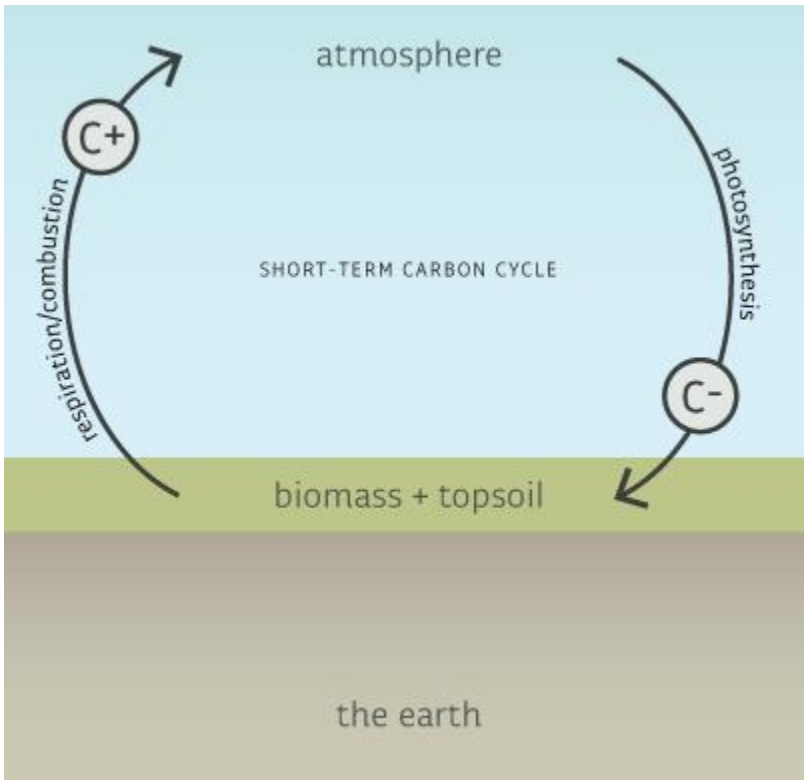
Problems to be addressed:
1) The increasing atmospheric concentration of carbon dioxide caused by unabating human activity is one of the greatest threats facing the planet and 2) soil is a living ecosystem and our actions are significantly and perhaps dangerously, and unnecessarily depleting them.

A note to the biochar community
I have been a peripheral member of the biochar community since 2009. No practical manifestation of what follows will be possible without the 100% involvement of this community, in particular the membership of the international biochar initiative. In the following I introduce a new jargon and a new perspective on biochar. I do this because it facilitates the clarification of distinct commodity markets that I believe may generate the revenue necessary to finance a biochar revolution. Some may find this presumptuous. It is farthest from my intention to insult the very people without whom none of these ideas will ever see the light of day. I think if you read and give consideration to what I have written here, my reasons for doing so will become evident and I think justified. At any rate, I mean no offense to those who have broken the ground. I am one of you.

A note on anthropogenic global warming due to humanity's use of fossil fuels
I am not trying to change any minds about global warming. If you don't believe the science, then there is nothing that I am going to say that is going to change your opinion about the implications of humankind's current use of fossil fuels. The point of departure taken here is that the increase of atmospheric concentration of carbon dioxide is creating a crisis. The paper presents various necessary and sufficient conditions for equilibrating the atmospheric concentration of carbon dioxide. If you don't believe in global warming don't read on. If you do believe in it then I hope you do read on.

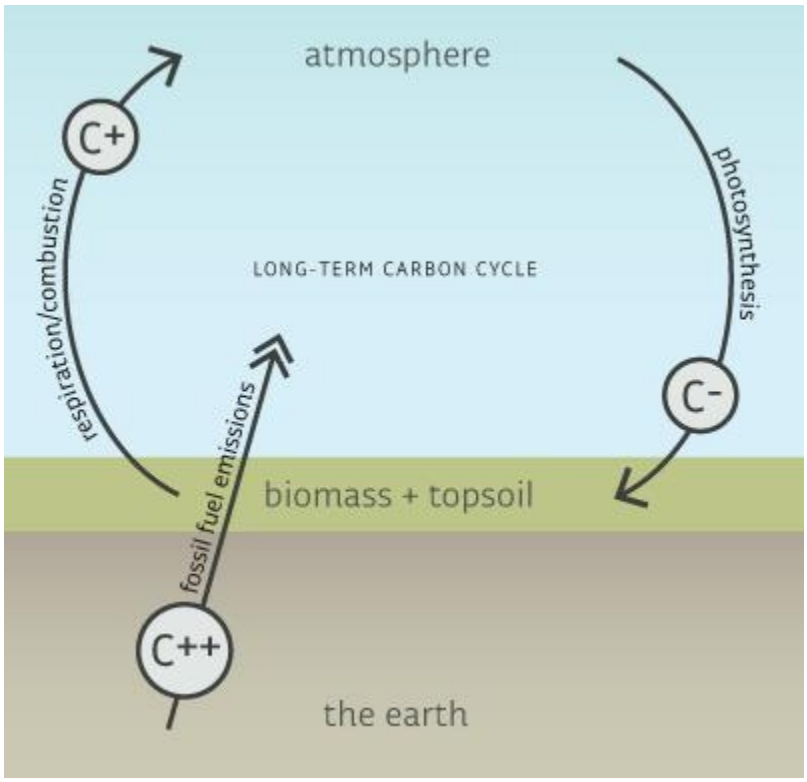
Background: a different way of conceptualizing certain carbon flows.
Prior to the industrial revolution and the associated introduction of fossil fuel emissions, the flow of carbon through the biosphere was largely characterized by the short term carbon cycle. This cycle is characterized by photosynthesis and combustion and/or respiration. Photosynthesis is carbon negative [C-] because it transfers carbon from the atmosphere to biomass. Combustion is carbon positive [C+] because it transfers carbon from biomass to the atmosphere. Over a reasonable period of time, the short term carbon cycle is in equilibrium (carbon neutral) [C=]. See illustration 1, the short term carbon cycle.

The short term carbon cycle



Fossil fuel emissions (emissions = combustion plus use in industrial agriculture) are carbon positive positive [C++]. They are [C++] because they transfer carbon from the long term carbon cycle into the short term cycle, and in particular into the atmosphere. See illustration 2, fossil fuel emissions superimposed on the short term carbon cycle.

Illustration 2, fossil fuel emissions superimposed on the short term carbon cycle



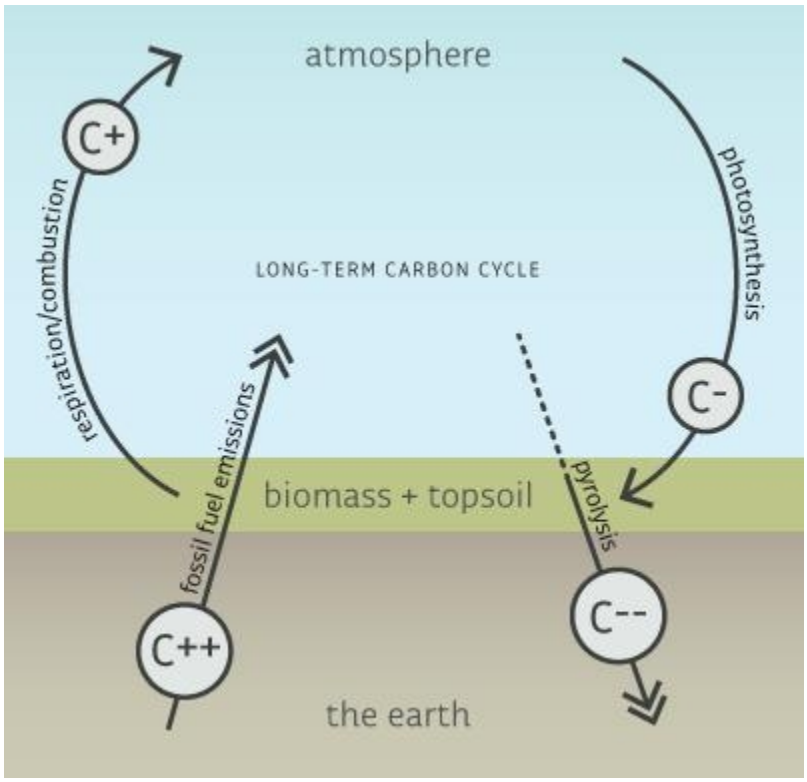
It is clear that this system cannot be in equilibrium without a carbon negative negative [C--] process. [1]

If the atmospheric concentration of carbon dioxide is to be equillibrated, both the short term carbon cycle must be in equilibrium (carbon neutral) [C=] , and the long term carbon cycle must be in equilibrium (carbon neutral) [C==].

The challenge of global warming will be met when the 2nd illustration of today becomes the 3rd illustration of tomorrow. If and only if. It should not be a stretch of the imagination to envisage massively constructive economic activity associated with this development.

1 This paper does not address the very substantial problem stemming from net deforestation of the earth's forests.

Illustration 3, long and short term carbon cycles in equilibrium



The purpose of this paper is to introduce (1) a candidate [C--] process, (2) a candidate [C--] product, (3) a constraint that would result in their creation, (4) some characteristics of resulting carbon neutral ([C=] and [C==]) energy markets (5) some candidate starter projects that if successful could have far reaching implications for economic development of the bottom billions.

(1) pyrolysis, a candidate [C--] process and (2) [char as C--], a candidate [C--] product

Combustion and respiration are the heating of biomass in the presence of oxygen. The products are water and carbon dioxide. Pyrolysis is the heating of biomass in the absence of oxygen. The products of pyrolysis are liquids, gases and a solid. The liquids and gases are biofuels or their precursors. The solid is charcoal or char. Char is largely carbon. If the char is combusted then this carbon returns to the atmosphere and remains in the short term carbon cycle. If not combusted, than the carbon in a lump of char has effectively been transferred from the short term carbon cycle to the long term carbon cycle. This is measurable. Pyrolysis is thus a candidate [C--] process, and char a candidate [C--] product. Call this [char as C--].

If the production of [char as C--] is going to equilibrate the atmospheric concentration of carbon dioxide, then a lot of it must be produced. At the present time not one of the 7 billion of us is carbon neutral. At the point in time that we equilibrate the atmospheric concentration of carbon dioxide, all of us will be carbon neutral. Cleaning up after oneself is the principle for "the optimal pricing mechanism for the creation of a world carbon neutral energy economy".

If we are going to produce enough [char as C--] to equilibrate the atmospheric concentration of carbon dioxide, there will be some very large piles of [char as C--] lying about. Here is a most remarkable virtuous non-sequitur. There is substantial evidence, both long term anecdotal and current academic soil science that the addition of char to agricultural soil, in particular depleted agricultural soil, fundamentally increases soil health and productivity. This char is biochar or [char as biochar].

It is critical to understand [char as biochar] does not diminish the simultaneous use of char as [char as C--]. The same lump of char can simultaneously be both [char as C--] and [char as biochar]. Although the number of atoms of [char as C—] and [char as biochar] will be equal, these are separate and independent commodities, and the markets that will develop for them are independent of one another.

It must be emphasized that the increase in soil health is due to the physical, not chemical properties of [char as biochar]. It may not be immediately intuitive as to why the inert substance [char as biochar], should radically improve soil health and biodiversity. Long term historical evidence is to be found in terra preta dos indios, "black earth of the Indians", an almost magically productive soil found along many banks of the amazon and its tributaries, a relic of the efforts of long ago pre-Columbian inhabitants. Additionally there is an increasingly substantial body of academic soil science supporting the claims of increases to soil health and biodiversity resulting from the application of [char as biochar] to agricultural soil. [char as biochar] acts as a buffer, a biological sponge. It absorbs moisture and nutrients in times of plenty, releases them in times of want. Biological activity takes place on surfaces. The structure of [char as biochar] is all about surfaces where biological activity is facilitated. It releases its mineral content over time, not instantaneously as ash by slash and burn, which blows away. But is not add char and stir, soil is alive, living things need to be nurtured, one must expect it to take time and nurturing to bring soils to greatest health.

There currently exists a vital biochar community which is a critical resource in the realization of the vision outlined in this paper. This community possesses the soil and crop science expertise necessary to determine the effects of biochar on soil, the ability to perform reasonable assessments of carbon recalcitrance, the ability to measure the purity of biochar, the ability to perform the carbon life cycle analysis that is essential for process integrity to form the basis for development of the [char as C--] market.

To repeat for emphasis: if not combusted, char produced by pyrolysis may simultaneously have two complementary uses, [char as C--] and [char as biochar]. Two uses, two sources of economic value, and two separate and independent commodity markets.

Illustration 4. Is a simple example of illustration 5. It just shows biomass -> char which is [char as C--] and [char as biochar]. Illustration 5 introduces the constraint, but it does it by way of the dilemma.

Illustration 4 is missing

(3) Clean up after yourself: The optimal pricing mechanism for the creation of a world carbon neutral energy economy.

The single necessary and sufficient condition for the creation of a carbon neutral energy economy is: "Clean up after yourself". For each atom of carbon that an agent is responsible for transferring from the long term carbon cycle into the short term cycle, the obligation must be to transfer an atom of carbon from the short term carbon cycle back into the long term carbon cycle.

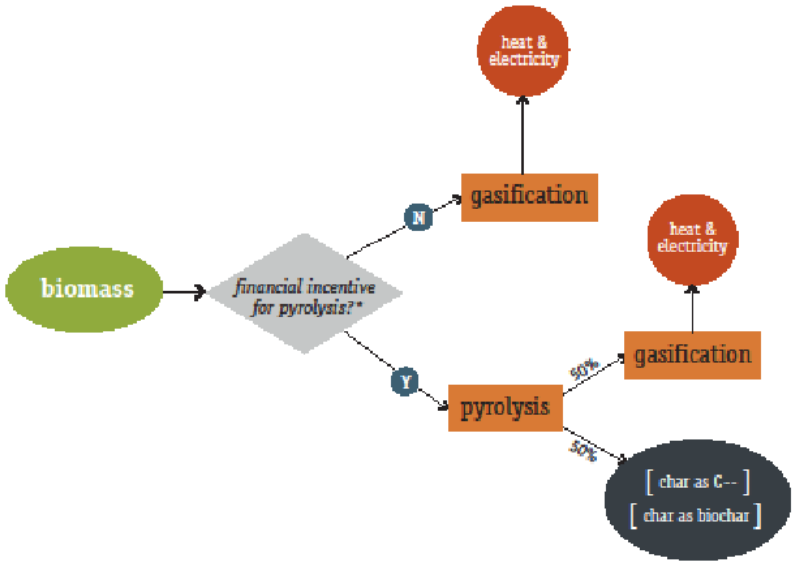
Call this not a carbon offset which is currently used in an ambiguous and gameable fashion but a carbon [equal and opposite].

A characteristic of this constraint is that no one is net [C--] and no one is net [C++]. Everyone must be [C==]. An implication of this is that irrespective of one's historical carbon footprint, the current obligation is the same. I have given no thought to how to address this inequity which is clear and unambiguous. The single immediate recompense is likely to be that the low cost producers of sequestered carbon are those who historically have had the smallest carbon footprints.

The inequality, the dilemma and the development of a voluntary [char as C--] market

Consider the following: imagine an economic actor, motivated by reasonable self-interest who is in the business of thermo chemically processing sustainably produced biomass and selling the end products. The end products will either be (1) 100% heat and electricity or (2) in the order of 50% heat and electricity and 50% char. in (2), the char may be retained as char, as [char as C--] AND [char as biochar, or if alternatively used as [char as heat and electricity] (2) is the same as (1). See illustration 5.

Thermo-chemical Processing of Biomass with Alternate Outputs



*Consider an economic actor, motivated by reasonable self interest who is in the business of thermo-chemical decomposition of biomass[1] and selling the end products. These end products are either 100% heat & electricity or 50% heat & electricity and 50% char, which can be used as both [char as c--] and [char as biochar]. Their rational choice will be determined by the following inequality:

$[char as heat and electricity] >=< $[char as c--] + $[char as biochar]

Because there is a market for heat and electricity, the left hand side of the inequality is greater than zero.
Because there are no markets for [char as c--] and [char as biochar], the value of the right hand side is $zero and so there will be no char produced.

1. The biomass must be sustainably produced and sustainable is subject to robust characterization.

The inequality
The choice between (1) and (2) above will be determined by the following simple inequality:

$ [char as heat and electricity] >=< $[char as C--] + $[char as biochar]

This may be read as "is the dollar value of [char as heat and electricity] greater than, equal to or less than the sum of the dollar value of [char as carbon negative negative] plus the dollar value of [char as biochar]?

Because there are markets for [char as heat and electricity], the left hand side of the inequality is greater than zero. Because there are to all intents and purposes no markets for [char as C--] or [char as biochar] the right hand side is zero.

The dilemma
Therefore under the existing economic incentives and constraints, economic activity, motivated by reasonable self-interest will produce no significant amounts of [char as C--]. Any char produced for [char as C--] and/or [char as biochar] will be produced largely for altruistic or research purposes, neither of which is scalable. This is the dilemma.

If we are to produce [char as C--] and [char as biochar] then the right hand side of the inequality will have to be greater than or equal to the left hand side.

Markets need producers and consumers. There is a chicken and egg question about markets, which comes first, the supply or the demand? If I produce carrots and no one wants carrots then my carrots are going to rot and I am going to be out of business. But if I want to eat carrots and there is no one producing carrots, then if I am willing to pay enough to cover a potential producer's costs of production plus a reasonable profit, then production will come into existence. So I will largely discuss the potential development of demand for [char as C--] and [char as biochar] before discussing development production of char for these purposes. The discussion is complicated because char is not one product, but both [char as C--] AND [char as biochar], not [char as C--] OR [char as biochar]. It is further complicated because [char as C--] is a public good.

It is informative to briefly compare the approach of "clean up after yourself" to the approaches of carbon taxes and "cap and trade". Carbon taxes effectively increase the price of the consumption of [C++] energy. This will decrease the relative demand for [C++] energy and increase the relative demand for [C=] energy. So it will decrease the rate of increase of the atmospheric concentration of carbon dioxide, but it will not, cannot reverse it. So if we are currently going to hell, then it will decrease the rate at which we get there, but it is not going to change our destination. Cap and trade is a means of ostensibly setting a maximum total quantity of emissions allocated among a set of emitters, and allocating to each of the group an individual emission allocation. The emitters are then free to trade their allocations among one another so

that one who takes steps to become more efficient and therefore has an excess of emissions allocations can sell them to an emitter who is relatively less efficient. As with the taxation of carbon emissions, "cap and trade", when optimally implemented, can reduce the emissions in the jurisdiction in which it is employed, but to the best of my knowledge it has never been effective, and at best it will change the rate of increase of the atmospheric concentration of carbon dioxide, but cannot equilibrate it under anything approaching a reasonable scenario.

One often hears about the need for a "price for carbon". Here for example is a recent (2013/10/09) conversation between the World Bank Group President Jim Yong Kim and the managing director or the IMF, Christine Lagarde about the "Economic Case for Climate Action"[2] in which Ms. Lagarde implores the finance ministers of the world to "get the pricing (of the negative externalities of carbon right)". In particular she emphasize the need to 1) set a price for carbon and 2) remove the subsidies for energy, in particular the subsidies for fossil fuels. The principle of clean up after yourself that is the single basic principle of this essay is nowhere mentioned as an approach to this challenge. When I say nowhere mentioned, I am unaware of it being raised in discussion in any serious economic or policy arena. Dr. Kim further makes the point that agriculture is the single way of "putting carbon back into the earth". Although he is referring to living biomass, he is just one step away from the concept of [char as biochar] that will truly sequester carbon from the atmosphere in a quantifiable way.

Implementation into policy of the principle of "clean up after yourself" does not "set a price for carbon". It creates new markets in the existing commodity markets for carbon and more generally energy and agriculture in their various forms. So rather than set a price, it creates new markets which are pricing mechanisms that will affect certain changes in economic behaviour and achieve various environmental, financial, economic, economic development, health, social and educational aspects of human individual and collective life.

You get the price right not by setting the price by fiat, but by creating markets.

Four characteristics and a question about the principle of "clean up after yourself'

1) **it is conceptually sound:** The science is unequivocal. Almost without exception, humanity now agrees that our use of fossil fuels, is creating a crisis of epochal proportions. Unlike carbon taxation and "cap and trade", "clean up after yourself" certainly addresses, and could conceivably solve this problem. It does this by the permanent removal of carbon from the short term carbon cycle, unlike carbon taxes and "cap and trade" which at best can decrease the rate of increase of the atmospheric concentration of carbon dioxide.

2) **It is understandable:** The principle of "clean up after yourself" or "leave no trace" is universally understood. It is so easy to understand that all parents attempt to teach the principle to their children.

3) **it is fair:** I will clean up after myself. You clean up after yourself. What could be more reasonable or more fair? But it is not fair if one of us cleans up and the other does not. You and I are strangers, we are unlikely to ever meet, our children and grand children are unlikely to ever meet, but we have a mutual obligation: we must agree to clean up after ourselves.

2" http://live.worldbank.org/economic-case-climate-action-webcast-live-blog

4) it is scalable: Consider 2 jurisdictions, each of whom agrees that the increasing atmospheric concentration of carbon dioxide is creating a crisis. One of the jurisdictions adopts a policy of cap and trade, and the other carbon taxes. But to each the other's choice seems arbitrary and not optimal. So a third jurisdiction will have no obvious approach. However if the 2 jurisdictions each agree to clean up after themselves, then the fairness of the approach is clear and the third jurisdiction has an obvious path to follow. Hence "clean up after yourself" is scalable.
Question: is it feasible? primary production is basically the total product of photosynthesis in a year. Net primary production refers to the primary production that remains after the primary producers consumer some of the gross primary product through cellular respiration. Human appropriable net primary product refers to the total annual product of photosynthesis that is available for human use. If we are to equilibrate the atmospheric concentration of carbon dioxide using pyrolysis and char, then we must have sufficient sustainable production of biomass as feedstock. I make no attempt to address this question at this time, however there is a short appendix at the end of this article which will demonstrate very crudely the effect on the demand for fossil fuels that would result from the implementation into law of this principle.[3]

Motivations for the development of the early [char as C--] market
It is not unreasonable to say that there are 6 possible motives for human activity, 1) altruism, 2) ethical imperative which is likely related to altruism, 3) reasonable self-interest, 4) unreasonable self-interest, 5) government coercion and 6) irrational behaviour. To be an altruist one must at a minimum be privileged; you cannot be an altruist if your child is hungry. It is therefore not scalable. Ethical imperative is surely a reality for any and all who are aware of the implications on the planet of their carbon footprints. Early adopters of truly carbon neutral footprints will be motivated primarily by altruism and ethical imperative. By early adopters, I am referring to the demand side of the market for [char as C--]. I will subsequently outline some early projects for the production of char, both [char as C--] and [char as biochar] who are in no position to act out of altruism, and the incentives can be created such that they act in their own reasonable self-interest. Unreasonable self-interest is a measure of (poor) quality of governance. Because [char as C--] is a public good, its market will be characterized by the free rider problem[4]. Let us say that the equilibrating the atmospheric concentration of carbon dioxide is favoured by those motivated by reasonable self-interest, and not favoured by those motivated by unreasonable self-interest. In this context if there is a sufficient mass of reasonable self-interest in a political forum to prevail over the mass of unreasonable self-interest, then government policy will act to implement laws resulting in the equilibration of the atmospheric concentration of carbon dioxide. This is a massive task; clean air is an international public good, the governance challenges that must be overcome to implement this effort with a reasonable chance of success are unprecedented in the history of human affairs.

It is almost trivial to argue that there is an ethical imperative to clean up after yourself.

Together, 7 billion of us whom we must assume are largely motivated by reasonable self-interest,

3" http://www.pnas.org/content/110/25/10324.full

4" http://en.wikipedia.org/wiki/Free_rider_problem

have created a set of economic constraints that are now have the surreal outcome of potentially catastrophically changing the world that humanity has inhabited from earliest times. If we introduce into law the principle of cleaning up after yourself, we will still be the same group of reasonably self-interested people, but no longer will our collective actions create a surreal outcome.

7 billion of us will not have changed, but now a constraint of behaviour has changed, and soon it will be normal and fully incorporated into one's normalcy, but no longer will we be creating a surreal outcome. Our energy markets will now all be carbon neutral, whether inherently [C=] as in solar, wind and nuclear, or net carbon neutral as in the short term carbon cycle, [C+] + [C-] = [C=] or the long term carbon cycle [C++] + [C--] = [C==].This future market for energy becomes a far purer market; with the surreal characteristics excised, no longer will good (and expensive) [C=] energy have to be subsidized to compete with bad (and inexpensive) [C++] energy; all energy will be either [C=] or [C==].

It is instructive to think of markets in general as physical or virtual locations where consumers and producers come together to buy and sell private goods. A private good is a good that "yields positive benefits to people". (Wikipedia). But the markets for fossil fuels are markets not just for private goods, but also for public bads. A public bad is a good that negatively affects public welfare. Fossil fuels are public bads because their consumption increase the atmospheric concentration of carbon dioxide. The market for [char as C--] is a market for a public good. Such a commodity market is unprecedented. But at the point in time that we equilibrate the atmospheric this market for a public good will be the largest commodity market in the world, traded in London and new York and Singapore and shanghai, equal in numbers of atoms of carbon to the sum of the markets for oil and natural gas and coal. So a market that today does not exist will come into existence and become the largest commodity market in the world.

A consumer of fossil fuels is motivated to purchase a private good which allows him to drive his girlfriend around the block. The consumption of this private good necessitates the production by the consumer of a public bad. This public bad is measureable, not directly in environmental damage, not directly in a dollar value, but directly in terms of the numbers atoms of [C++] emitted. And so the constraint of cleaning up after yourself, of causing to come into existence one [C--] [equal and opposite] for each [C++], causes to come into existence one unit of public good for each unit of public bad and so the overall consumption of fossil fuels becomes:

1 unit private good + 1 unit public bad + 1 unit public good = 1 unit private good.

So the consumption of fossil fuels becomes a carbon neutral [C==] process,

Likely characteristics of the early markets for [char as C--] and [char as biochar]

There will likely develop a single global commodity market for [char as C--]. Producers of char will sell their [char as C--] into this commodity market. It does not matter where it is produced it, its consumption is geographically indifferent to location. If I emit 100 million atoms of [C+

+] into the atmosphere by my consumption of oil or natural gas or coal, then I can purchase a carbon [equal and opposite], 100 million atoms of [char as C--] and so be [C==]. Because of the logistics of the materials management of both biomass feedstock and [char as biochar], it is reasonable to assume that the use of the physical char as [char as biochar] will be very proximate to the location where the biomass feedstock was produced. Further, it is a reasonable assumption that the [char as biochar] will be most effective as soil amendment where the feedstock was grown. The producer of the char will therefore with high frequency also be the consumer of the [char as biochar] to nurture its own productive plant, its soil, or sell it into a local market. The market value of [char as C--] is likely to be much greater than the market value of [char as biochar]. $[char as C--] >> $[char as biochar].

The demand for labour that will be associated with the char markets is not currently conceivable. Consider the percentage of the world working population that is involved in the energy industry or those related to it. The markets for char could conceivably create a sufficient demand for labour to address unemployment chronic among the young in the developing and to a lesser degree developed worlds, mitigating the danger of the unemployed as a source of violent unrest and lost lives.

A future paper should address the reasonably imaginable economic implications of the implementation of this principle, but I imagine them to be substantial and positive, both for employment and income.

Developed world market for pyrolysis equipment and char production

Current pyrolysis equipment in the developed world is largely for high temperature pyrolysis for the production of biofuels such as diesel. The producers of pyrolysis equipment for low temperature biochar production struggle. These characteristics of this market correspond to the logic expressed in the dilemma of the inequality. So despite the fact that char making is one of the oldest industrial processes known to mankind, you can't easily get the stuff in the developed world.

In the developing world, however, wherever there is available woody biomass there is a market for the [char as charcoal]. [char as charcoal] is in this instance synonymous with [char as heat and electricity]. The industrial equipment that is used in the production of [char as charcoal] is minimal. In general it is not more than piles of dried wood that is covered with green biomass, reeds for example and then covered again with soil. The smoldering of pyrolysis is started and the process continues for a number of days at which point the char has been produced. It is certainly not optimal, but very effective and ubiquitous.

For char to be acceptable for [char as C--] and [char as biochar] it must meet various constraints. [char as biochar] must be free of toxins, which means that the feedstock must be free of toxins and the means of pyrolysis must not create toxins, in particular dioxins and polycyclic aromatic hydrocarbons. An important new release of the International Biochar Initiative is the ibi "standardized product definition and product testing guidelines for biochar that is used in soil"[5].

5" http://www.biochar-international.org/characterizationstandard

A test measuring the recalcitrance of the [char as C--], based upon the molar ratio of hydrogen to organic carbon determines the suitability of a given batch of char as [char as C--]. Pyrolysis optimised for char processes about 50% of the biomass as char and the other 50% as liquids and gases. These should be used as combined heat and power. Detroit could perhaps regain the engineering supremacy it had in its heyday if it could lead the world in the development of pyrolysis machinery and combined heat and power.

Development of market

A beauty to be found in the developing world is that the existing market for [char as charcoal] sets local prices for char. This is a basis that allows the first market price for [char as C--]. The benefits that could accrue to the bottom billions could conceivably write tomorrow's history of economic development.

Initial projects
By the end of 2013, I will have spoken to groups in Uruguay, Ghana, Vietnam and the United States about char related projects.

Uruguay has a very sophisticated left leaning, rule of law, property rights based, agricultural economy. In February of 2013 I crisscrossed the country by car. Cargill and other agricultural giants are to be seen throughout the country .which seems one continuous field. Sorghum, maize, soybean, wheat, rice, pine and eucalyptus plantations, millions of sheep and cattle are produced throughout the country. It has no domestic sources of fossil fuels. I was offered one thousand hectares with which to make biochar. I do not at present have the skills needed to spearhead a project at that scale and sophistication, but it is waiting to happen. I believe a local market for [char as charcoal] exists and would create a base price for [char as C--] and [char as biochar]. It will be interesting to collect international local prices for [char as charcoal] and compare them. Without robust life cycle accounting, not just for carbon, but for other organic elements, prices will not be directly comparable. I have spent considerably more time thinking of the nascent economics of the market that would come into existence in Ghana than the likely more complicated Uruguay. Uruguay must become a producer and consumer of renewable energy. They have massive land for agriculture.

There is an entirely different flow of biological materials through an industrial agricultural means of production and a subsistence farm. Industrial agriculture largely treats land as part of a production line. Sow into the soil not just seeds that are the product of industrialization, but chemicals and fertilizers and herbicides and pesticides and all of the ingredients of the green revolution. On a road trip from southern Saskatchewan, south of the great lakes to my home in Toronto, I remember a small rural agricultural town, grain silos guarding its entrance and on a rail siding tankers of anhydrous ammonia. I can distinctly remember the eerie sense that we are just widgets, we are not humans any more, our humanity has been sacrificed, we are now industrial products. At any rate we funnel all of the stuff of industrial agriculture into the soil and then we harvest the crop, and the fruit is spread far and wide, and I am not certain what happens to the vine, but when the land is again fallow, there is no natural regeneration of the soil

to compare to that which should happen in a likely more community and organic based agriculture in the developed world, and the developing world. The fossil fuel footprint of industrial agriculture must be immense.

I am not arguing in favour or against industrial or organic agriculture. I am arguing that all agriculture should be carbon neutral, both [C=] and [C==].

The history of economic development is a history of substantial social disruption associated with internal migration of low cost labour from rural to urban. This is accompanied by the concentration of capital, creation of infrastructure and formation of factories and the use of this low cost labour to produce cheap manufactured goods for export to the rest of the world. This is as true of China today as it was of England during the industrial revolution.

I believe that the bottom 1 or 2 billion people can become the low cost producers of sequestered carbon and in so doing, become vital contributors to the world economy. And I believe that they can do this without the social dislocation, concentration of capital, factory formation or infrastructure development associated with the historical precedent. The basic unit of production is not the factory, but the small subsistence agricultural village. The manufactured product for export is [char as C--] which is exported by an entry in a double entry carbon accounting system. There is no physical product to be exported.

In the bottom billion or two of the developing world, the market for [char as heat for cooking] is universally present in any village that has access to woody biomass for feedstock. The technology for char making is universally available; it is reasonable to say that any subsistence farmer is able to produced char. This market for [char as heat for cooking] sets a point of departure price of the markets for [char as C--] AND [char as biochar]. To whatever degree the market for [char as heat and electricity] exists in a village, it should remain in parallel to any new market for [char as C--] and [char as biochar]. Now consider the agricultural growth cycle. The following is more or less true about the agricultural practices of much subsistence agriculture. At the beginning of the planting season a farmer comes to a fallow field and plants a seed. At harvest time the farmer harvests the fruit and throws away the vine, and then eats the fruit and throws away the night soil. At the beginning of the next planting season the farmer will sow his seed in a depleted fallow field. He may engage in slash and burn or some variant of it.
A new market can be created using the lowest cost labour in the world, and a technology, that however imperfect is universally available. Not only is the technology available but it is in the hands of the same people who are best able to use its physical product, that is [char as biochar]. So if the farmer now collects the vine and the night soil and uses a known technology to produce a product that will facilitate the return to the soil everything that has been removed, and in particular through the vector of biochar, then I would hypothesize that (1) this would be the most productive use of the [char as biochar] that is produced from the feedstock from that land and 2) that this would greatly facilitate the determination of optimal production and application of [char as biochar], complications of experimental design will be substantially reduced as the number of variables shrinks.
Commodities are generally private goods, but the commodity markets for oil, coal and natural gas are markets for both private goods and a public bad. The public bad is the transmission of

carbon from the long term carbon cycle into the short term carbon cycle and in particular into the atmosphere. The lowest cost labour in the world, will simultaneously become exporters to the world of the public good [char as C--] and producers and consumers of [char as biochar] and in doing so increase their primary means of generating income. Of course the economic benefits from these should go directly to the farmers, but there are many players who will attempt to corrupt the process, these are those motivated by unreasonable self-interest.
In the town of Gbigli in northern Ghana, the farmers are excited about the prospects of increasing their productivity. There must be 100,000 or a million subsistence villages like Gbigli in the world; I am hoping that it can become a prototype for a developing world producer of char, [char as C--] for sale to the world, and [char as biochar] for local use. Associated with this effort must be the introduction of both optimal pyrolysis facilities and combined heat and power for local electricity production, and optimal cook stoves.

The International Biochar Initiative is already doing a certain amount of biochar related research in the Tamale area of northern Ghana. I believe that the biochar is being sourced from residue of the [char as heat and electricity] market.

I am proposing that subsistence farmers employ known methods to produce char from their sustainably produced "vine and night soil" and apply [char as biochar] increasingly beneficially to their land. I am further proposing that I will pay them an amount of money for this which is based upon the existing market for [char as charcoal]. By effectively creating equality between the left and right sides of the inequality, the producer will be indifferent whether they sell into the markets represented by the left or right hand sides of the inequality and so the markets will remain distinct. What am I buying for my money? I am emphatically not buying [char as biochar]. No, a constraint of my purchase is that the [char as biochar] returns to the soil from which it originated. But I am, effectively buying "a sack full of [char as C--] at wholesale prices". And with that I will attempt to create a voluntary market for [char as C--], which will be a truly carbon neutral marketplace. The integrity of this marketplace must be absolute. At first I will sell to family and friends. But over time, if this is successful, when the voluntary marketplace that has been created has 1 million of 100 million customers, then we will be able to effect public policy, and then perhaps we will constrain the energy marketplace such that all forms of energy are either inherently or net carbon neutral, and the energy market will thus not inherently subsidize fossil fuel consumption by an amount that is quantifiable, not in terms of price, but in terms of numbers of atoms of carbon.

The method of production is not optimal for a number of reasons, in particular because about 50% of the potential from the process is wasted and should be power.
This scenario could conceivably write the future history of economic development. Low cost labour will not have had to undergo the massive social dislocation of internal migration. There will be no concentration of capital, factory formation or infrastructure development necessary to facilitate the use of low cost labour to manufacture the production of physical goods to the rest of the world. The production will be done in existing rural communities and the product to be exported will physically remain in the village, to be returned to the soil from which it came, the export will be a certificate indicating to the purchaser the number of atoms of [char as C--] that have been created.

Critically important considerations with respect to the char that is produced.

In introducing these possibilities to the bottom billions, the question that must be addressed is, "Do you skip the "land line" generation of technology, do not pass go and go directly to "cellular"?" Do we encourage the use of already existing methods of preindustrial processing of biomass to create char, or do we go directly to a more modern technology? My guess is that we should start with the existing means of production, but move as quickly as possible to introduce a superior technology. There will be many cultural and managerial and other teething problems that must be overcome before this idea on paper becomes a real means of production. This assumes however, that existing means of production, dos not result in the creation of dioxins or polycyclic hydrocarbons, and that it effectively sequesters carbon as indicated by the ratio of hydrogen to carbon as mentioned earlier. Even if the char produced by these pre technology widely known methods of production, for certain the carbon content that is represented by the liquids and gases is not being exploited. An optimal village project would capture this and make use of small scale combined heat and electricity to among other things, perhaps provide the introduction of electricity to the village. It seems clear that if the barriers to the introduction of a superior pyrolysis production technology with combined heat and electricity, if feasible is a better prototype.

In Vietnam I think, but as of writing am not certain that there is already a sophisticated biochar production facility already active. I will be visiting Vietnam in late November 2013 to observe this.

The inequality revisited

It is almost trivial to conclude that the qualitative effect the incorporation of biochar into agricultural soils is beneficial, but variety of soil types and biochars make the quantitative determination of soil quality very time consuming, expensive and locally accurate.

Integrity of [char as C--] market:
http://www.biochar-international.org/protocol, biochar carbon offset protocol has been submitted for validation
Integrity of [char as biochar] market:
http://www.biochar-international.org/sites/default/files/IBI_Biochar_Standards_V1.1.pdf
Google's carbon offsets:
http://static.googleusercontent.com/external_content/untrusted_dlcp/www.google.com/en//green/pdfs/google-carbon-offsets.pdf

Conceptual difference between a carbon offset and a carbon [equal and opposite]
What is a carbon offset? A carbon offset is a reduction of carbon dioxide equivalent emissions to offset an emission made elsewhere.[6] Its intent is to increase [C++] efficiency and thereby reduces overall carbon emissions. This is very different from a carbon [equal and opposite]. An offset

6" http://en.wikipedia.org/wiki/Carbon_offset

will reduce 10 units of C++ to say 8 units of C++. A carbon [equal and offset] doesn't directly reduce the production of C++. An [equal and opposite] produces [char as C--]. An offset changes the rate of increase; an [equal and opposite] facilitates an actual decrease. So is there a difference between the net effect of reducing 10 units of C++ by 2 units or leaving it at 10 units and producing 2 units of C--. Arithmetically the first is 10 -2 = 8 and the second is 10 + (-2) = 8. So they add to the same thing. But conceptually these are entirely different. If you want to equilibrate the atmospheric concentration of dioxide using offsets, you will have to reduce the 10 units to zero which means that you have to put an end to fossil fuel use, which is not a reality. But the creation of a new agricultural and industrial C—and biochar sector is revolutionary, but very reasonable. Offsets leave untouched the fundamental dilemma of fossil fuel consumption and that is there remains 2 types of energy, good energy (such as solar and wind nuclear) that are inherently carbon neutral, and bad energy that is fossil fuel based and it is carbon positive positive. When you introduce the [equal and opposite] fossil fuel can become net carbon neutral. This means that all energy becomes carbon neutral and so no longer do we have good, clean, expensive energy and bad, dirty, cheap energy. And the price of carbon neutral energy will be set by the paired costs of fossil fuel production and [char as C--] production. This is a profound difference between carbon offsets and carbon [equal and opposites].

An implication for the demand for fossil fuels under the "clean up after yourself scenario"
Assume 1) that for each atom of C++ emitted, the emitter is constrained to sequester on atom of carbon, equivalently, purchase or produce one atom of [char as C--], and .
Imagine a user of fossil fuels who is currently using 100 units of C++ energy and whose consumption is now constrained to be 100 units of C== energy. Very, very simplistically, 100 units of biomass produces 50 units of C= energy and 50 units of [char as C--]. 50 units of C++ energy and 50 units of [char as C--] gives 50 units of [C==] energy. In particular:
1) 100 units C++ energy
2) 50 units C++ energy + 50 units [char as C--] + 50 units [C=] energy => 50 units [C== energy] + 50 units [C=] energy = 100 units carbon neutral energy.
Implications of this are that 1) demand for fossil fuel has decreased by 50% and 2) market for energy is now carbon neutral.
ethics for carbon managers: http://ghginstitute.org/2013/03/28/ethics-for-carbon-managers/?utm_source=March+2013+Newsletter&utm_campaign=Monthly+newsletter&utm_medium=email
transparency international: global corruption report:climate change
http://www.transparency.org/whatwedo/pub/global_corruption_report_climate_change
collective intelligence: http://www.co-intelligence.org/CollectiveIntellTakesOff.html