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Viewpoint

CO_2 credit or energy credit in emission trading?

Eric Hu*

School of Engineering and Technology, Deakin University, Geelong, Victoria 3217 Australia

Abstract

Emission trading is a good concept and approach to tackle global warming. However, what "currency" or "credit" should be used in the trading has remained a debatable topic. This paper proposed an "Energy Credit" concept as an alternative to the "CO_2 credit" that is currently in place. From the thermodynamic point of view, the global warming problem is an "energy balance" problem. The energy credit concept is thought to be more thermodynamically correct and tackles the core of the global warming problem more directly. The Energy credit concept proposed can be defined as: the credit to offset the extra energy trapped/absorbed in the earth (and its atmosphere) due to the extra anthropogenic emission (or other activities) by a country or company. A couple of examples are given in the paper to demonstrate the concept of the Energy credit and its advantages over the CO_2 credit concept.

Keywords: Energy credit; CO_2 credit; Emission trading

1. Introduction

A key feature of the Kyoto Protocol is the free market approach to the greenhouse gas issue: the endorsement of international emissions trading, i.e., countries are allowed to obtain credits toward their (CO_2 reduction) targets through project-based emission reductions/offsets in other countries. The CO_2 is proposed to be used directly as the "currency" in the trading, although its political (and technical) acceptance is still in doubt (Boom, 2001). Generally speaking, the so-called CO_2 credit is that if a company or a country wants to emit extra CO_2, it needs to take some measures (e.g. planting trees or buying credit forest somewhere in the world) to reduce or offset/absorb CO_2 emission somewhere. From the thermodynamic point of view, the cause of global warming is the heat (energy) accumulation in the earth and its atmosphere. This accumulation is mainly due to the imbalance of (solar) energy reaching the earth and the energy leaving the earth, which is caused by "green house effect" in which the CO_2 and other green house gases play a critical role. In another words, the global warming problem is an "energy balance" problem. So, an "energy credit" concept is proposed in this paper, which is basically to use "energy" rather than CO_2 as a measure in the emission trading between parties. The energy credit proposed in lay language is defined as: to emit extra CO_2 or conduct any other activities contributing to global warming, you need to send the energy out of the earth's atmosphere, which equals the energy trapped due to the extra CO_2 you emitted.

2. Energy credit or CO_2 credit

The main argument related to the CO_2 credit idea is that the CO_2 credits obtained especially by carbon sinks i.e. planting trees are temporary (i.e. it is not a real credit) and any benefit may be countered by reducing surface albedo (Betts, 2000). The carbon sink (forest) may become a CO_2 generator when the forest is matured or in case of bushfire. There is an even argument that the CO_2 level/concentration increasing in the atmosphere has a positive effect on the life on the earth as CO_2 is the food for plants.

The global warming ultimately is an energy (balance) problem. The green house gases or CO_2 just play an important role in it. So using "energy" as the "currency" directly in the emission trading sounds more reasonable. The concept of "energy credits" proposed by the author can be defined as: the credit to offset the extra energy trapped/absorbed in the earth (and its atmosphere) due to the extra man-made (anthropogenic) emission (or other activities) by a country or company. The energy credit can only be obtained

*Tel.: +61-3-5227-2828; fax: +61-3-5227-2167.
E-mail address: erichu@deakin.edu.au (E. Hu).

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through the anthropogenic process or activities. In other words, any country or company that wants to emit more green house gas or to conduct any other activities which would trap an extra amount of energy in the earth, needs to get the same amount of energy which would be otherwise trapped in the earth naturally, out of the earth by some means.

At the conceptional level, the "energy credit" concept has the following advantages:

(1) It will not limit nor retard the development in all countries. Namely, all countries are allowed to develop their carbon based industry as long as they get sufficient energy credits. In most of the cases, direct reduction/limiting of CO_2 emission would retard the development so that it is not easily to be accepted politically. The USA's pull out of Kyoto Treaty was an evidence of this fact. The energy credit concept avoids the reduction or limitation of CO_2 emission directly, but instead provides a compensating way, i.e. reject "extra energy" that is the core of the problem, out of earth. It should be more easier to obtain the political acceptance, at least theoretically.
(2) It is thermodynamically correct. From a thermodynamic point of view, CO_2 is not the core of the problem but energy is. Only energy focused measures (e.g. energy credit) are capable of ultimately limiting (or even solving) the problem. As long as we keep consuming (at the current rate if not more) the fossil energy, the CO_2 focused measure is not a real solution to the global warming problem. How can you compensate the CO_2 released from the fossils that are the result of "carbon sink" over million years, with any CO_2 mitigation/sink measures in our life time?
(3) The energy credit concept can be extended to measure and guide other human activities which contribute to increasing radiative forcing (and so global warming). All human activities related to release energy from fossil and nuclear (and other activities like decrease in the surface albedo by construction etc.) should be treated same as the emissions. These activities may not be a concern now, but may be a problem in future.

The technologies and measures to gain energy credits may include anthropogenic change/increase of the albedo of local earth surface, shading the earth from outer-space and cloud control etc. The feasibility especially the large scale feasibility of these ideas is beyond the scope of this paper. The following hypothetical examples do not promote any particular measure i.e. "change local albedo" nor endorse its feasibility, but demonstrate the practical application of the principle of "Energy Credit" and compare it with the "CO_2 credit".

Example 1. *Question*: if Australia wants to increase its annual CO_2 emission by 5%, how much energy credit does it need? To gain these energy credits by installing man-made reflector in its central desert areas, how much land area is required as compared to the land requirement for forestation to absorb (sink) the 5% of CO_2?

Solution:

Australia's annual CO_2 emission in mid-90s is about 0.5 Gt = 114 Million of Metric Tons Carbon Equivalent (MMTCE). 5% of this is 0.025 Gt CO_2, i.e. Australia wants to emit 0.025 Gt more of CO_2.

The correlation between the CO_2 concentration in the atmosphere and the energy absorbed can be calculated by the radiative force (at the tropospheric level) (Lupis, 1999)

$$F = 5.35 \ln (C/C_0) = 5.35 \ln (1 + \Delta C/C_0)\, \mathrm{W/m^2},$$

where C_0 is the base concentration of CO_2 in atmosphere = 363.9 ppmv (in 1997) which is equivalent to 2815.4 Gt CO_2 in the atmosphere.

If CO_2 concentration doubled (i.e. $\Delta C = C_0$), $F = 3.7\,\mathrm{W/m^2}$ on the earth surface. This rough estimation agrees with the calculation in Myhre et al. (1998).

Assume earth is a round ball, its surface area is about $5.2 \times 10^{14}\,\mathrm{m^2}$. This means double CO_2 (i.e. another 2815.4 Gt CO_2 in the atmosphere) will be equivalent to extra heating at the rate of $3.7 \times 5.2 \times 10^{14} = 19.24 \times 10^{14}\,\mathrm{W}$. This gives that per Gt CO_2 in atmosphere would equivalently gain earth 6.83×10^{11}W heat/Gt CO_2. This is the energy credits needed to emit an extra Gt of CO_2. So, in this example, Australia needs to have 1.7×10^{10} W energy credits to emit an additional 5% (= 0.025 Gt) CO_2.

To gain the energy credits by installation of reflector: Assuming that the 1 $\mathrm{m^2}$ reflector (in central Australia) can reflect 300 $\mathrm{W/m^2}$ solar energy back to space and that the reflector works effectively 8 h every 24 h, that gives that the 1 $\mathrm{m^2}$ reflector has 100 W energy credits (daily average). For Australia to emit 5% more CO_2, it needs to install $1.7 \times 10^8\,\mathrm{m^2}$ reflector working in the above assumed conditions.

If trying to absorb the 5% CO_2 by forestation: The production of a hectare ($100 \times 100\,\mathrm{m} \times \mathrm{m}$) pine plantation is about 22 $\mathrm{m^3}$ wood (carbon) per year at a density of 0.6 $\mathrm{T/m^3}$. This gives that per $\mathrm{m^2}$ plantation would be able to absorb 4.84×10^{-3} T/CO_2 per year. Namely, to absorb 0.025 Gt CO_2, one needs to plant $5.16 \times 10^9\,\mathrm{m^2}$ pine trees.

The land use figures seem big in both cases, but plantation needs 30 times more land than installation of the reflector. If Australia wants to emit 5% more of CO_2 every year, it needs to install these areas of reflector every year.

This example shows that there are other (than plantation) measures that exist when a party has to