Suggestion for Engineering Cost of Carbon

Deokjin Kim
EnTEs Institute, Korea. E-mail: entes@outlook.kr

March 31, 2022

Keywords: Carbon credits, Carbon tax, Climate change, Right of nature, Social cost of carbon

Abstract The question of how much reasonable carbon tax should be set in each nation is the biggest problem that cannot be calculated in climate change. In previous study, we have proposed environmental thermoeconomics. From thermodynamics, the minimum electricity required to remove carbon 1 ton from the air is calculated as minimum 424 MJ/tonCO2. The medium that connects nature and human is a power plant, and the unit price of industrial electricity in Korea is about $0.066 / kWh. Multiplying the above two values, the cost required to remove carbon 1 ton from the air is calculated as minimum $7.77. In Korea, 80% of carbon emissions are free, and carbon credits are set for 20% of excess. Therefore, the engineering price of carbon 1 ton for 20% excess is calculated as minimum $38.9. Currently, the trading price of Korean carbon market is about $16.5 ~ $33.0. Judging from the uncertainty of climate change, it can be said that the above calculated unit price and trading unit price are similar. Carbon credits are not a means of profit creation through trade, and it is the cost of human obligations through engineering calculation.

1. Introduction

In this study, from environmental thermoeconomics [1], the engineering cost of carbon is calculated.

2. Current cost system for carbon credits

2.1 Carbon tax

The carbon taxes in developed countries are set at average about $33 from $0.08 to $102, which is very different from country to country. This means that no one knows what a reasonable carbon price should be.

2.2 Carbon emission trading system

Carbon reduction due to climate change is the duty of all mankind. Carbon emission trading system is contrary to the duties of mankind. Does it make sense that the duty of mankind is to be bought and sold in the market? Can student understand this? Obligation is what government must strongly push forward. Carbon credits are not a means of making a profit for humans, but the cost of rights of nature [2].

2.3 Social cost of carbon, SCC

SCC is the economic cost that society must bear for one year due to climate change when 1 ton of carbon is emitted. The calculated value is about US 50$, UK 310$, French 90$, and German $200 ~ $710. This method has disadvantages in that it is very complicated and uncertain. This is being pushed strongly in the United States. However, although this can be an excellent reference for climate change policies, this value cannot be set as a reasonable carbon cost.

2.4 Marginal Abatement Cost, MAC

MAC is the cost to remove 1 unit of pollutant. We learn how to calculate MAC in high school. However, in case of carbon, the cost depends on the removal system and storage mechanism, the cost is bound to vary greatly.

3. Theoretical Marginal Abatement Cost

3.1 Core of the problem

Existing methods focus on the numerical size of the carbon cost. Finding a reasonable basis for setting a carbon cost is at the core of the problem. Rationality must start with the laws of thermodynamics.

3.2 Laws of thermodynamics

The laws of thermodynamics are born from the truth of nature, and carbon emissions are also a part of natural phenomena.

3.3 Current removal VS. Future damage

It is quite natural that carbon that is not removed now will cause damage to society in the future. Therefore, carbon emissions are subject to a penalty cost. Here, should the penalty be imposed on current removal or future damage? It is quite natural that a penalty should be imposed on the cost of carbon removal.

3.4 Minimum electricity for removing carbon

The theoretical minimum work w_{min} required to remove 1 kg of carbon from the air is thermodynamically as follow:

$$w_{min} = R_{CO2} \cdot T_0 \cdot \ln (y_{CO2} / 100\%) = \mathbf{424}\ \text{kJ/kg} \quad (1)$$

Where,
R_{CO2} 0.1889 kJ/kgK, Carbon dioxide gas constant
T_0 288.05K, Absolute temperature of ambient 14.9℃
y_{CO2} 0.041%, Mole fraction of carbon dioxide in air

It should be understood that in Eq. (1), the calculated value is the minimum value. That is, the actual value is several times larger than the calculated 424 kJ/kg. Thermodynamically, work w_{min} of Eq. (1) is equivalent to electricity.

3.5 Medium of nature and human, Power Plant

Power plant is where the natural resources of nature are transformed into the human economy. That is, power plant is a medium between the environment and the economy. The unit price of industrial electricity in Korea is about \$0.066 / kWh. This value is a conversion factor that can convert energy into money. Because the conversion factor has been discovered, the carbon cost can be calculated. From this factor, all the values of nature can be converted into human money. If it is not acknowledged, the carbon cost cannot be engineered.

3.6 Theoretical Marginal Abatement Cost, TMAC

Therefore, the theoretical marginal abatement cost required to remove 1 ton of carbon is calculated as minimum \$7.77 / tonCO2 (= 424 kJ / kgCO2 · \$0.066 / 3600kJ).

3.7 Absolute \$7.77 VS. Permit \$39 in Korea

\$7.77 is the theoretical minimum cost of electricity required to remove 1 ton of carbon. In Korea, 80% of carbon emissions are free, and carbon credits are set for 20% of excess. Therefore, the cost of permit system for 20% excess is calculated as minimum \$39.

3.8 Cost of Korea trade market

Currently, the trading price of Korean carbon market is about \$16.5 ~ \$33.0.

3.9 Reasonable cost in euro market, about \$80

The unit price in the euro market was below \$20 by 2021. As of 2022, it has reached \$100. An estimate of the future carbon price of \$200 has been announced. Who can explain the change of the cost? In general, the unit price of electricity in Euro is about twice that of Korea. Therefore, the reasonable carbon cost in Euro is calculated as about \$78.

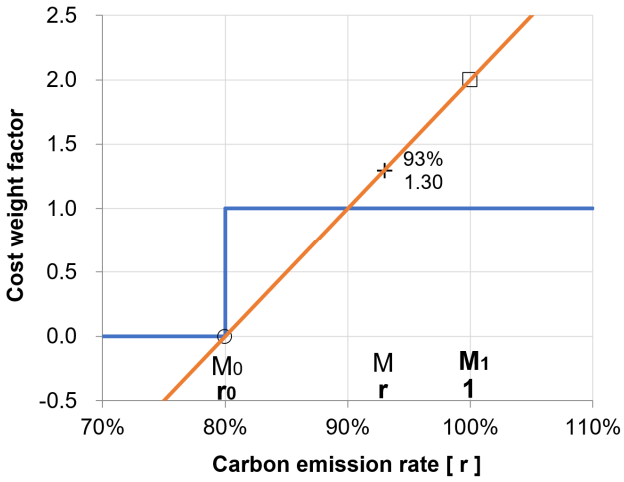

Fig. 1 Cost weight factor

3.10 Cost of carbon emission in 2020

In 2020, 31.5E9 tons of carbon were emitted. When converted to the unit price of electricity in Korea, the cost is calculated as minimum about \$244 billion.

3.11 Cost of from 1850 to the present

From 1850 to the present, about 2400E9 ton of carbon have been emitted. When converted to the unit price of electricity in Korea, the cost is calculated as minimum about \$18.7 trillion.

4. Engineering Cost of Carbon, ECC

4.1 Equation for ECC

We propose the following formula and Fig. 1.

$$\text{Cost} = G \cdot M_1 \cdot (r-r_0) \cdot C_{min}/(1-r_0) \cdot 2 \cdot (r-r_0)/(1-r_0) \quad (2)$$

Where,
M_1 Standard Emissions
r Current Carbon Emissions / Standard Emissions
r_0 Carbon Reduction Target

4.2 Amount of excess emission carbon $M_1 \cdot (r-r_0)$

As an example, the carbon target ratio in Fig. 1 is 80%. Therefore, $M_1 \cdot (r-r_0)$ is the amount of excess emission carbon.

4.3 Minimum carbon cost $C_{min}/(1-r_0)$

The theoretical unit cost of carbon removal C_{min} is calculated as about \$7.77 in Korea and \$15.5 in Euro of twice. However, the cost does not important. It is important that the engineering basis for the carbon unit price is presented.

The absolute value of C_{min} is presented to all countries as a constant by international organizations, such as \$10.0. In Fig. 1, the target is 80%. Therefore, this value is converted

to relative value of $C_{min}/(1-r_0)$ such as $50.

4.4 Cost weight factor $2\cdot(r-r_0)/(1-r_0)$

In Fig. 1, the blue line is stepwise weighting factor, and the orange line is linear weighting factor. It is easy to remove a little carbon, but it is even harder to remove a lot of carbon. Therefore, the constant weighting factor of the blue line is not reasonable. The orange weighting factor are suggested by author. An international organization should develop various weighting functions to find the optimal weighting line for climate change mitigation. The optimal function should be presented to all countries by an international organization.

4.5 Government will factor G

The above calculation method applies equally to all countries. Here, G is the will factor of each government. Underdeveloped countries will have a G value less than 1.0, and developed countries will have a G value greater than 1.0.

5. Who owns the money?

5.1 Cost in 2020 year, $244 billion

Who owns $244 billion in 2020? What is the engineering basis that the person or the company have ownership of the money?

5.2 Cost from 1850 years, $18.7 trillion

Why do not the countries that have been emitting carbon since 1850 pay the money?

5.3 Who is suffering from climate change?

If humans are suffering from climate change, that money is money for the advancement of human rights. If nature is suffering from climate change, that money is money for nature's rights improvement. Who is suffering from climate change?

5.4 What is the purpose of carbon credit policy?

Is that correct for the present values of mankind? Is the current policy direction the current human values? If that is, it means that the current values of mankind only need to earn money. If the future human values are also like this, the hope of the earth will disappear.

5.5 Labor cost of nature

Nature has worked hard for 4.5 billion years to create natural resources and is still working hard to remove carbon from the air. Carbon credit money is the labor cost of nature.

6. Right of Nature

6.1 Engineering proof of the existence

In previous study [2], the existence of the rights of nature has been proven by engineering.

6.2 Root Causes of Climate Change

Which of the following is the root cause of climate change?

(1) Because factories emit a lot of carbon
→ Let's blame the factory owner.

(2) Because the carbon unit price is too low
→ Let's make money by raising the cost

(3) Because humankind disregards the rights of nature
→ It is the duty of all mankind

6.3 Judgment of Law

Since the law deals only with humans, the rights of nature in law are not subject to judgment. Also, nature has no hands, no feet, and no mouth.

6.4 Birth of natural intelligence

In previous study [3], the birth of natural intelligence has been proposed. The environmental ministries of each country will have to create natural intelligence from the cost of carbon. Natural intelligence, born from the cost of carbon, can legally represent the nature. In other words, hands, feet, and mouth were created in the nature.

7. Conclusions

It does not important what the reasonable cost of carbon should be. It is important to find a rational methodology for the calculation. It can be found from the integration of the environmentology of nature conservation, thermal engineering of resource saving, and economics of human development. The reasonable price of carbon was calculated from the integration of the three disciplines in this study.

International organizations should integrate their calculation methodologies and distribute them to all countries. Each country will reflect its government's will to the carbon cost.

The root cause of climate change is human disregard for the rights of nature. we propose that “the rights and duties of nature, human and natural intelligence are the same” as Article 0 of the nation constitution.

References

[1] D. Kim, 2022, Suggestion of Environmental Thermoeconomics, https://vixra.org/abs/2203.0159

[2] D. Kim, 2022, Proof of Thermodynamic Existence on the Rights of Nature, https://vixra.org/abs/2203.0164

[3] D. Kim, 2022, Discovery of Theory of Everything by Natural Intelligence, https://vixra.org/abs/2203.0144