Carbon Emission Trading for Community Contribution

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***Abstract*—The reduction of greenhouse gas (GHG), including CO_2 , has been recognized as the task to be solved by the world. This paper presents an approach to enable citizens to use carbon emission credits or allowances for community contribution, e.g., schools and non-profit organizations. It assigns a small amount of carbon emission credits or allowances to RFID tags or barcodes attached to specific products and show how must credits that tag is worth like coupon for mitigating GHG emissions. People, including students, who want to support communities, including schools, collect these tags or barcodes and then redeemed the credits assigned to them to offset the GHG emitted from their communities. The approach was constructed and evaluated with real customers and real carbon credits with real communities.**

***Keywords*-Carbon emission credit; Carbon emission allowance; RFID tag; Barcode.**

I. Introduction

The reduction of greenhouse gas (GHG), including CO_2 , has been recognized as a common task to be solved by the world. Public organizations, e.g., schools, museums, civil halls, community centers, and local governments, are required to work for public purposes, but they are not avoid to emit greenhouse gases for their activities like commercial activities. For example, schools need to consume energy for lighting and heating in their buildings. Although they should reduce their GHG emissions as much as possible, their missions are to provide people, including local communities and students with services as much as possible. In public sectors, approaches to reducing GHG emitted from communities may be different from those from commercial sectors. This paper proposes an approach to helping public communities, e.g., schools and non-profit organizations, to offset their GHG emissions. The approach assigns a specified amount of carbon emission credits to RFID tags or barcodes attached to specific products and show how must credits that tag or barcode is worth like coupons. People, including students, who support public communities, including schools, collect these tags or barcodes and then redeem the credits assigned to them to offset the GHG emitted from their communities.

This paper proposes an approach to enable citizens to use carbon emission credits or allowances for community contribution, e.g., schools and non-profit organizations, where carbon emission credits or allowances are economical values and can be traded [6]. The key idea behind it is to assign a small amount of carbon emission credits or allowances to RFID tags (or barcodes) attached to specific products by using RFID-tags [8][9], which was a scheme for reducing GHG emissions from the home and individual sectors and offsetting GHG emissions from public sectors, so that tags or barcodes can be worth like coupon for mitigating GHG emissions. People, including students, who want to support communities, including schools, collect these tags or barcodes and then redeemed the credits assigned to them to offset the GHG emitted from their communities. The approach was constructed and evaluated with real customers and real carbon credits with real communities.

The rest of the paper is organized as follows. Section II states the problems that the paper addresses and the requirements of the approach. Section III surveys related work. Section IV presents basic approach outlines the basic ideas of the approach. Section V describes the design and implementation of the approach and Section VI presents our experiences with the approach. Section VII discusses on the approach and Section VIII gives some concluding remarks.

II. Problem statements

We briefly outline conventional *carbon emission credits* before explaining our approach. Carbon emission credits are not carbon emission allowances, which are limits on emissions that are lowered over time. A government sets limits on the amount of CO_2 that companies are allowed to emit CO_2 . If a company emits an amount of CO_2 due to their activities below its limit, it can sell the excess capacity, which is the difference between the limit and the amount has emitted, to companies whose emissions are over their limits. They represent a certain volume of absorbed or reduced emissions by different people or organizations that have reduced excessive amount of GHG in the atmosphere in the short- or long-term. For example, developed countries or companies financially or technically support projects that aim to reduce GHG emissions in developing countries. They can, in turn, offset their emissions by credits generated from the projects. These projects might involve installing

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renewable energy technologies, implementing energy efficiency measures, or removing CO_2 from the atmosphere through carbon sequestration. Emission credits can be traded in voluntary markets to reduce overall GHG emissions while still allowing countries or companies that may have difficulty doing so to have outlets for transition. However, existing carbon emission credits and their trading have several problems:

- Carbon trading is usually provided through electric commerce systems, but existing trading systems are too complicated and difficult for end-users to sell or buy carbon credits for reasons unique to carbon credits. Since carbon credits are tradable, the systems must authenticate whether the creditors that demand credits to be transferred to them are the credits' current owners or their certificating agents. Carbon credits also have specified expiration dates, e.g., one or two years, for institutional reason for carbon credits. The price of the credits is based in part on the validation process and the sophistication of the fund or development company that acted as the sponsor of the carbon project. Therefore, fees for trading carbon credits tend to be expensive, where in Japan, a fee of 6,200 yen (about 72 US dollars) is charged for one carbon credit trading independently of the number of credits. Existing systems allow professional carbon traders to sell or buy large amounts of emission credits.
- The minimal units of existing trading credits are more than one hundred or one thousand tonnes of CO_2 . However, the amount of CO_2 an average person emits throughout his/her life for one year is less than one tonne. Each end consumer product should have less than one kilogram of credits. However, there are currently no approaches to trading small amount of carbon credits, e.g., one gram or one kilogram except for ours. However, each final settlement process in existing approach needs time and effort, because the process needs receive RFID tags, which are physical certificates for carbon credits. The approach proposed in this paper needs to reduce the cost of settlement process.
- Carbon credits can already be traded through e-commerce, but existing trading systems have been designed of professional traders, called *carbon providers* or *carbon agencies*. Since credits are virtual values, it is too difficult and complicated to authenticate whether the stakeholders that claim the credits are the credits' current owners or their certificating agents. Therefore, it almost impossible for communities and end consumers, in additions to small companies and NPOs/NGOs to sell or buy credits. Furthermore, current personal-level carbon emission trading has not been designed for communities. To support communities, carbon emission credits should be easily exchanged within communities.
- Carbon offsetting has gained some appeal mainly among end-consumers in western countries who have become aware and concerned about the potentially negative environmental effects of energy-intensive lifestyles and economies. However, existing schemes for carbon offsetting products assume they only support end-consumers so that they experience problems at companies. They lack any mechanism for transferring the carbon credits linked to the products to the consumers. Instead, dealers or manufacturers, who assign the credits to products, offset the credits on behalf of the consumers of the products. Therefore, the consumers have no chance of owning the credits and they do not know whether the credits have been properly offset by the dealers or manufacturers.

III. Related Work

There have been several attempts for trading small amount of carbon emission allowances instead of carbon emission credits. So, we survey carbon allowances. The notion of carbon emission allowances has been useful in existing schemes such as the European Union (EU) Emissions Trading Scheme (EUETS) for EU countries or similar schemes elsewhere [1]. Several countries, e.g., the U.K. and Ireland, have proposed schemes for carbon emission trading in the home/end user sector to Conferences of the Parties (COP) of the United Nations Framework Convention on Climate Change (UNFCCC). *Personal Carbon Trading* (PCT) is a general term referring to personal versions of *carbon emission trading* in the home/end user sector. The original notion of *Carbon emissions allowances* is an economical approach to reducing the amount of GHG emissions in industrial sector. The allowances are limits, often called *carbon emission caps*, where a government authority first sets limits on the amount of CO_2 that companies are allowed to emit. If a company emits an amount of CO_2 below its limit, it can sell the excess capacity, which is the difference between the limit and the amount of CO_2 that has really emitted, as carbon allowances to companies whose emissions are over their limits. If a company emits an amount of CO_2 beyond its limit, it must pay a penalty or buy carbon allowances from someone so that it can comply with its allowances.

On the other hand, PCTs support carbon emissions allowances allocated to individuals rather than companies. If individuals emit at a level above that permitted by their initial allocation, they need to purchase additional carbon emission allowances from those using less, creating a profit for those individuals who emit at levels below those permitted by their initial allocation. Several researchers and organizations have proposed different kinds of PCT in the last five to ten years.

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- *Cap and Share* was originally developed by the Foundation for the Economics of Sustainability (Feasta) [2] and supported the use of fossil fuels. Individuals received certificates from the government and fuel suppliers required corresponding certificates equal to emissions from the use of fossil fuels to sell fuel.
- Personal allowance (PCA) was proposed by Hillman [4] and it was a proposed downstream carbon cap and trade policy instrument suggested for the U.K. There represented a mandatory policy whereby all individuals received an annual carbon emissions budget for their personal use. The PCA scheme only covered emissions under direct personal control, e.g., household energy use (electricity and gas) and private transport (not including public transport).
- Tradable Energy Quotas (TEQs)[3] assumed that individuals would receive certificates and if they used fewer certificates, they could sell their surplus. All fuels and electricity had *carbon ratings* in units. When individuals buy energy, their certificates are deducted according to the amount of CO_2 emitted from the use of that energy.
- Household carbon trading [5] was a yearly carbon emission cap to set for residential energy use based on emissions reduction targets. Allowances are allocated to each household on an equal per household allocation basis via utility service providers who place the allowances in each user's account.
- Tradable transport carbon permit [7] was a cap that was set for emissions from private transport. Allowances were allocated to all individuals to comply for free, but these were not any equal basis. Allowances are transferred to the regulating authority for every purchase of fuel to cover the CO_2 equivalent of a liter of fuel and cancelled. Participants bought and sold permits through intermediates like banks or buy them at gas stations.

Although the concept of PCT was expected to reduce the GHG emissions from homes and individual sectors, existing PCT have several serious problems that must be solved before applying schemes can be applied to the real world.

Since existing PCT has aimed at reducing GHG emitted from energy, i.e., their spending electric power from thermal power plants and refuelling their private cars, they have mismatches with existing carbon emission trading and carbon emission reduction schemes in companies, although reducing GHG emissions is a global issue. For example, suppose that a supermarket sells beverages or mineral water from room temperature shelves in addition to refrigerated shelves to reduce the amount of GHG emitted from electricity for the latter and to obtain surplus carbon emission allowances. When customers intentionally select and buy beverages or mineral water from normal temperature shelves, they should share the surplus allowances with the supermarket. Nevertheless, there is no way to share surplus allowances with supermarkets in existing carbon emission trading schemes, including PCT. Furthermore, existing approaches aimed at personal-level or company-level trading but not community-level.

IV. Basic Approach

Our previous paper [9] enabled a small amount of carbon emission credits or allowances attached to products or services to be transferred to consumers who buy these products or products. The approach proposed in this paper is to enable people to donate their own carbon emission credits/allowances to communities and the communities to mitigate their GHG emissions with the credits/allowances.@It provides communities with a method to collect a volume of RFID tags or barcodes as credits for the rights to claim credits with low costs in addition to the key ideas of our approach.

- The previous approach introduced RFID tags or barcodes as a certificate to claim carbon emission credits or allowances attached to products in in supply chains. It could directly use the RFID tags or barcodes that had already been attached to products.
- The approach proposed in this paper supports a donation of carbon emission credits or allowances to communities to mitigate their GHG emissions by giving the RFID tags or barcodes that are certificates to claim carbon emission credits or allowances.

A. RFID tags/barcodes as certificates in donating carbon emission credits

Whereas the previous approach introduced RFID tags (or barcodes) as certificates for carbon emission credits [8][9], the approach proposed in this paper is designed for certificating carbon emission credits. The former is assigned by the government, but the latter is voluntarily generated by certificated projects to reduce GHG. Therefore, the latter is essentially various. To claim credits dominated by RFID tags (or barcodes), we need to return these RFID tags (or barcodes) to the stakeholders that assigned credits to the tags (or barcodes). RFID tags (or barcodes) can be used as certificates for carbon emission credits. For example, when sellers want to attach carbon offsetting credits to products, they place RFID tags (or barcodes) on them that represent the credits for the products. Therefore, purchasers, who buy the products, tear the RFID tags (or barcodes) from them and return the tags to the sellers (or the stakeholders of the credits). When the sellers receive the RFID tags (or barcodes) from the purchasers, they transfer the credits to any accounts for payments that the purchasers specify. It is difficult to replicate or counterfeit RFID tags (or barcodes) whose identifiers are the same, because their identifiers are

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unique and embedded into them on the level of semiconductors.

B. Community-based collection/lump-settlement for certificates for carbon credits

When a purchaser has peeked an RFID tag (or barcode) from a product, which might have been attached to a product that he/she purchased, our approach permits the purchaser to resell the tag (or barcode) to others. Instead, the new holder of the tag can claim the credits attached to the tag from the stakeholder of these credits or resell them to someone else. Note that trading or donating RFID tags (or barcodes) corresponds to trading or donating carbon emission credits that can offset GHG emitted from the receivers. To offset GHG emitted from a community, e.g., school and council, according to the Kyoto protocol, holders of tags donate certified credits to the community by giving the RFID tags (or barcodes) assigned to credits to the community. Next, the community donate a volume of credits to the government via a complicated electronic commerce system or carbon agency.

C. Procedure

Figure 1 explains our approach to attach carbon credits to products with RFID tags (or barcodes), which involves seven steps:

1. A seller places an RFID tag (or barcode) on a product (or a volume of products) if the product has no tag.
2. It sets a certain amount of credits for offsets for a product and registers the amount and the identifier of the tag in a database.
3. It sells the product with the RFID tag to a purchaser.
4. The purchaser tears the tag from the product that it has bought.
5. It only gives its tags to a community, e.g., school and non-profit organization.
6. The community collects tags and sorts tags according to the sellers that their credits should be paid to, because the identifiers of the tags discover the sellers.
7. It returns the tags to their sellers.
8. The seller receives the tag and then finds the amount of credits coupled to the tag in the database.
9. It transfers the amount to the account specified by the community and removes information on the identifier from the database so that the tag can be reused.

Note that in our approach RFID tags can be reused even when their identifiers are static because the database removes information on the identifiers after the tags are returned.

V. Design and Implementation

The proposed approach enables sellers at steps in a supply chain to sell their products with RFID tags (or barcodes) coupled to carbon emission credits to customers, including raw materials and components. Anyone can access information about the credits attached to the products, because the credits are transferred to purchasers who return the tags themselves to the sellers. The sellers should provide information about the credits, e.g., their amounts, expiration dates, and sources. When customers can read RFID tags (or barcodes) with web-enabled terminals, they see information on the credits attached to the tags.

- Our approach requires each RFID tag (or barcode) to have its own unique read-only identifier. Most RFID tags (or barcodes) used in supply chain management already have such identifiers.
- To support carbon offsets, the amount of credits attached to a product need to be equivalent to the total or partial amount of CO_2 emissions resulting from the use or disposal of the products.

This approach assumes to have agents, called *carbon credit agents*, to enable customers to access the information. They have two databases. The first maintains credit accounts and the second maintains information about assigned credits. They can only be connected to certain RFID agents and other account agents through authenticated and encrypted communications.

Some readers may worry that returning RFID tags (or barcodes) to their stakeholders is more costly than returning the identifiers of tags (or barcodes) via a network. There are two flows that are opposite to each other between sellers and purchasers at each stage in real supply chains: the flows of products and the flows of receipts or containers for the products. Our approach can directly use the latter flow to return tags (or barcodes) from purchasers to sellers. Therefore, our cost and extra CO_2 emissions are small. Actually, returnable containers, which deliver parts or components from sellers and then return them to sellers, are widely used in real supply chains.

VI. Experiences

The proposed approach was already evaluated through a social experiment with real retailers, end consumers, local communities, e.g., elementary school, local government, and non-profit organizations. We asked an elementary school, called Kita-sunamachi, in Kouto-area of Tokyo. The school announced students that several beverage cans are sold in a super market, supermarket (Kitasuna branch of Ito-yokadou), which is one of the biggest in Tokyo area, with seals assigned with 300, 500, or 700 g carbon emission credits. It was carried out for two weeks from 9 am to 10 pm and more than five thousand goods were sold with carbon. Figure 2 shows beverage cans with barcodes in a showcase at the supermarket. In this experiment, the credits are called Japan Verified Emission Reduction (J-VER), where J-VER credits were generated from thinning

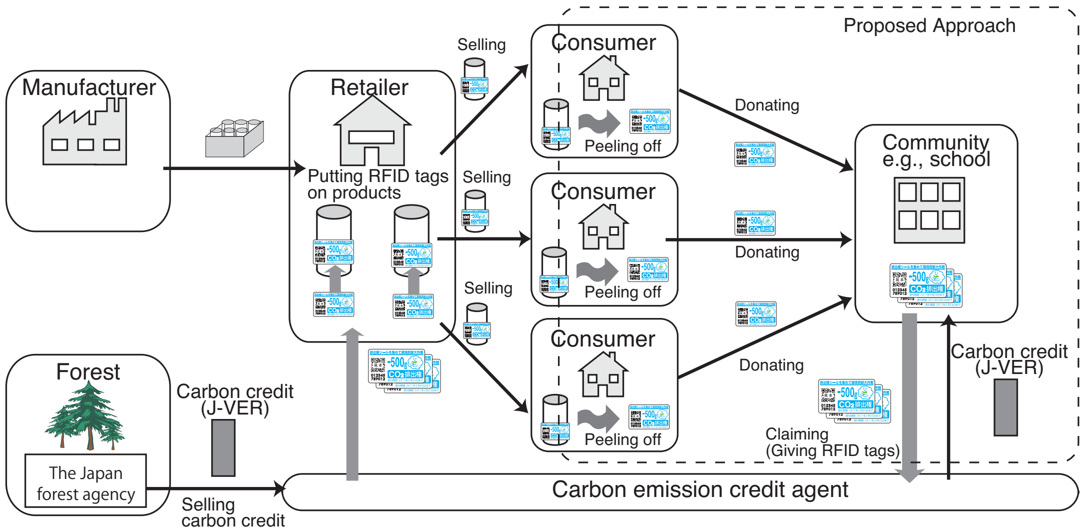

Figure 1. Community-based carbon credit attachment and settlement

forest and were traded on the domestic market and managed by the Forestry Agency.

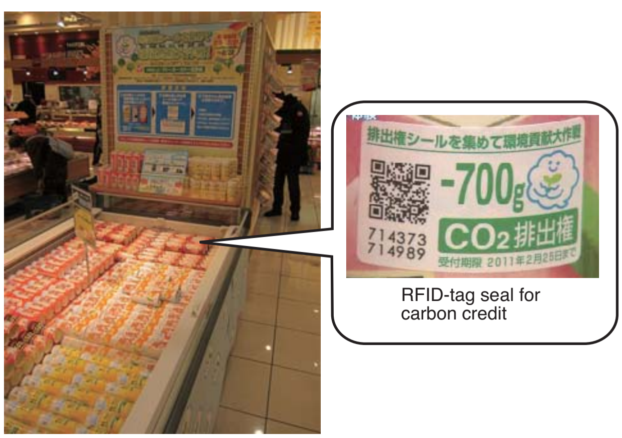

Figure 2. Beverage with RFID tag (or barcodes) seal for carbon credits

When students bought the beverage cans, they should tear off the seals from cans and put them collecting boxes located at the school as shown in Fig. 3.

- The supermarket attached RFID tag seals on cans and sold them to real consumers, where each seal displayed small amount of its carbon emission credits.
- The customers bought cans with RFID tag seals like other items.
- They peeled the seals from the cans that they bought, where the seals could easily be unattached from products by them.
- Students, who had the seals, attached the seals on certain mount papers and return the seals on the mounts to boxes located at the school.
- The school collected seals from about three hundred students and returned to the supermarket and informed its carbon credit account.
- The supermarket read the identifiers of the seals and then transferred the carbon credits to the accounts.
- They could see the balances of their carbon account through a web site for carbon account management.

Figure 3. RFID tag/barcode seal collecting box

The supermarket totally sold 5320 cans, where the sales volumes of cans with carbon credits in two weeks was three times more than usual at the supermarket. Thirty-five percent of RFID tags or barcodes were returned to the supermarket by customers who claimed the credits. About 750 tags among them were donated to the school through our approach. There were many lessons learned from the experiment, but most problems in the experiment were not technical. For example, many consumers asked us about the notion of carbon credits so that we spent a lot of time to dealing with their questions. We could considerately reduce the cost of settlement of RFID tags, because the school collected many tags from students and returned a volume of the tags to the supermarket in comparison with our previous approach [8][9], which lacked any techniques for donations to third parties like the approach presented in this paper.

VII. Discussion

Our approach intended a supermarket to use carbon credits as an incentive to sell products. We expected end consumers to explicitly select products with more credits, which were in proportion to the amount of reduced CO_2 emissions. The approach also allowed existing RFID tags for logistics to be directly used as certificates for credits so that its environment cost was minimal. The approach had to be as simple as possible so that participating parties could easily understand how the approach worked and what they should to. The trading of RFID tags in the approach corresponded to the trading of credits. RFID tags could be used as monetary values, where money is generally considered to have three functions, as a medium of exchange, as units of accounts, and as stores of values. RFID tags in our approach could be exchanged because they were physical and tradable entities in the real world. The tags could be coupled to a certain number of credits. The tags were durable and able to be stored and the information stored in the tags could not easily be erased. The approach restricts sellers to assign more carbon credits to RFID tags than the amount of credits that they have because assigned credits are withdrawn from their carbon accounts. The approach permitted anyone to access information about credits, e.g., their amount, expiration dates, and sources via RFID tags and only the holders of the tags could claim the credits. The approach allowed purchasers, including end consumers, to claim credits by returning the tags coupled to them to the stakeholders of the tags without any complicated authentication mechanisms. End consumers did not need to read the RFID tags, because they could sell the tags to others, including sellers. The buying and selling of products is often done where networks and electronic devices may not be available, i.e., in warehouses, on streets, and in stores. Account agents need to be always connected to the system, but sellers and purchasers do not. The reader may worry whether the accuracy and correctness of carbon credits attached to products can be ensured at the supplier level. Consumers can select products according to the amount of carbon credits attached to them and they can know information about the credits through our identifiers assigned to small amounts of carbon credits.

VIII. Conclusion

We proposed a scheme to bridge the gap between personal- and company-level carbon emission credits or allowances and trading by using information technology, in particular RFID tags, barcodes, and telecommunication. The key idea underlying our approach was to combine offline and online approaches. The former was to introduce RFID tags (or barcodes) as physical certificates for the rights to claim carbon allowances, including carbon emission allowances and caps. The latter was to support the transfer of small amounts carbon emission allowances via e-commerce. When purchasers buy products with allowances for carbon offsets, they can claim the allowances by returning the RFID tags (or barcodes) coupled to the allowances to stakeholders, e.g., sellers or agencies, without the need for any complicated authentication. The approach could collect small amount of carbon credits by using communities, e.g., schools and non-profit organizations. The approach was designed to help communities to offset their GHG emissions. Finally, we would like to identify further issues that need to be resolved in the future. We plan to carry out more public experiments on the approach in other supply chains. We need to estimate the social cost in implementing and operating the approach.

References

[1] A. Brohe, “Personal Carbon Trading in perspective: potential pitfalls and compatibility with the EU ETS Framework,” International Energy Agency Workshop, Paris, 2008.

[2] “The Foundation for the Economics of Sustainability (festa): Cap & Share: A fair way to cut greenhouse emissions,” festa, 2008.

[3] D. Fleming, “Energy and the Common Purpose (Descending the Energy Staircase with Tradable Energy Quotas (TEQs)) ,” The Lean Economy Connection, 2005.

[4] M. Hillman, “Carbon budget watchers,” Town and Country Planning, Vol.67, No.9, 1998, pp. 305.

[5] D. Niemeier, et al., “Rethinking downstream regulation: California’s opportunity to engage households in reducing greenhouse gases,” Energy Policy, Vol.36, 2008, pp. 3436-3447.

[6] “Personal Carbon Trading,” Y. Parag and T.Fawcett (eds), Routledge, 2010.

[7] C. Raux and G. Marlot, “A System of Tradable CO2 Permits Applied to Fuel Consumption by Motorists,” Transport Policy, Vol. 12, No. 3, 2005, pp. 255-265.

[8] I. Satoh, “RFID-enabled carbon offsetting and trading,” Pervasive and Mobile Computing, 2013, Vol. 9, No. 1, pp. 149-160.

[9] I. Satoh, “IT-enabled Personal-level Carbon Emission Allowance,” in Proceedings of the 5th International Conference on Ambient Systems, Networks and Technologies (ANT 2014), the 5th International Conference on Sustainable Energy Information Technology (SEIT-2014), 2014, pp. 665-672.