연구논문 「환경정책」 제32권 특별호 2024. 6: 27-47
DOI http://dx.doi.org/10.15301/jepa.2024.32.S.27
pISSN 1598-835X eISSN 2714-0601

The Impacts of K-ETS Auctioning Revenues on Carbon Emissions Reduction and Economic Performance

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Abstract: This study aims to review investments of Regional Greenhouse Gas Initiative(RGGI) auctioning revenues and estimate impacts of Korean Emissions Trading System(K-ETS) auctioning revenues on carbon emissions reduction and economic performance. K-ETS will be expected to grow the auctioning revenues due to an increase in the emissions permit auction share. Specifically, the K-ETS auction share is planned to increase from 10% in the 3rd phase to 15% in the 4th phase, and the auction revenues in the 3rd phase and in the 4th phase are estimated to be $ 2,389 million and $ 3,583 million, respectively. Since the Republic of Korea does not earmark auctioning revenues, it is difficult to estimate what the proceeds are being used and how much the environmental and economic impacts of using the proceeds are. Therefore, it is indirectly estimated the impacts of reducing carbon emissions and saving energy costs for consumers by using the case of RGGI. The findings are that the lifeti me benefits of K-ETS auctioning revenues(based on scenario 3) are expected to avoid the release of 46 million metric tons of CO2 and to save $ 18.5 billion on consumers' energy bills in the 3rd phase(2021~2025).

Key Words: RGGI(Regional Greenhouse Gas Initiative), Auctioning Revenues, K-ETS(Korean Emissions Trading System), Carbon Emissions Reduction, Economic Performance

I. Introduction

Climate change causes to occur extreme weather conditions such as increasing severe flood and droughts, rising of sea levels and melting glaciers etc. In response, many countries have enacted policies to alter the magnitude or timing of climate change.(Jingchi Yan(2021)) Emissions trading system(ETS) is one of the most efficient at reducing greenhouse

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gas emissions and spurring economic growth. ETS is increasingly used to reduce greenhouse gas emissions in the worldwide and it is implemented from supernational to regional level which are 1 supernational, 8 countries, 19 states and provinces and 6 cities in force.[1](ICAP(2023))

Auctioning revenues in the worldwide ETSs are likely to increase in the future. Over time, total auctioning revenues have increased as systems have increased the scarcity of auctioned allowances and the allowances prices. Considering the growing amounts of auctioning revenues projected, it becomes ever more important to assess the use of these revenues to estimate the impacts on carbon emissions reduction and economic performance.(Wiese C. et al.(2020)) Auctioning revenues from ETS have used to tackle climate change by various categories including energy efficiency, clean and renewable energy, energy-incentive industries and direct energy bill assistance etc. The use of auctioning revenues can help to realise cost-effective emissions reduction and to reduce the energy bills to energy end-users. ETS auction revenues can be either earmarked for specific purposes, that is, further climate and energy projects, or can also go into the general budget with no earmarking. Since Korean emissions trading system(K-ETS) auctioning revenues go to the general budget, it is difficult to assess the potential contribution of the auctioning revenues to reduce carbon emissions and to improve economic performance. Therefore, it is indirectly estimated the impacts of reducing carbon emissions and saving energy costs for

1) supernational(EU member states, Iceland, Liechtenstein, Norway), 8 countries (China, Germany, Kazakhstan, Mexico, New Zealand, Republic of Korea, Switzerland, United Kingdom), 19 provinces and states(California, Connecticut, Delaware, Fujian, Guangdong, Hubei, Maine, Maryland, Massachusetts, New Hamphire, New Jersey, Nova Scotia, Oregon, Quebec, Rhode Island, Saitama Prefecture, Vermont, Virginia) and 6 cities(Beijing, Chongjing, Shanghai, Shenzhen, Tianjin, Tokyo).

consumers by using the case of RGGI, which has effectively used emissions auctioning revenues.

The study aims to examine how K-ETS auctioning revenues can help to achieve environmental and economic benefits by category after reviewing the investment of RGGI auctioning revenues. It is structured as follows; Section II introduces previous literature and status quo of auctioning revenues across the major ETSs. Section III provides how much the revenues reduce carbon emissions and improve economic performance through three scenario-based analysis. Finally, section IV concludes.

II. Previous literature and current status of ETS auctioning revenues

1. Literature survey

There are various studies on the overview of how ETS revenues are used across the major systems and how they affects on carbon emissions reduction and economic performance. The overview-related studies are Xavier le Den et al.(2017), Santikarn, M. et al.(2019), Wiese, C. et al.(2020), Borghesi et al.(2022) and Krause E. et al.(2022) etc. They showed that most of the ETS revenues were used for climate and energy purposes and played a big role environmentally and economically. Xavier le Den et al.(2017) and Wiese, C. et al.(2020) analyzed the use of auctioning revenues for EU ETS. And, Santikarn, M. et al.(2019), Borghesi et al.(2022) and Krause E. et al.(2022) provided an overview of how ETS revenues were used in EU member states, California, Quebec and Regional Greenhouse Gas Initiative(RGGI).

Xavier le Den et al.(2017) estimated that approximately 82% of the EU ETS revenues over the period 2013~2015 were used for renewable energy and energy efficiency programmes. They evaluated that auctioning revenues made an important contribution to supporting renewable energy development. Wiese C. et al.(2020) analyzed auctioning revenues to foster energy efficiency in the EU ETS. They concluded that since auctioning revenues could also be a powerful tool in the energy transition, the strategic use of revenues needed to be accelerated in EU ETS Member States. Santikarn M. et al.(2019) presented that the use of auctioning revenues from ETS delivered environmental, economic and social benefits. They used real-world examples and explored how auctioning revenues could help to fund additional climate and energy programs and compensate vulnerable groups. Borghes S. and Ferrari, A.(2022) showed that allocating even a limited share of revenues to low-income households was sufficient to compensate for the negative effects of carbon pricing. Earmarking the EU ETS revenues could contribute to strengthening the EU's own budget and to advancing the EU carbon neutrality objective by 2050. And, Krause E. et al.(2022) provided an overview of how jurisdictions that had implemented carbon taxes and emissions trading systems used the ensuring revenues. They highlighted good practise approaches to recycling carbon pricing revenue to address distributional impacts on households and citizens.

Next, there are some studies on the impacts of major ETSs auctioning revenues on carbon emissions reduction and economic performance. (Paul J. et al.(2011), Brian C. and Peter T.(2015), Choi et al.(2017), Dechezlepretre A. et al.(2018), and Jingchi(2021) etc) Paul J. et al.(2011) analyzed the economic impacts of the revenues and Brian C. and Peter T.(2015), Jingchi(2021) did the environmental impacts. And, Choi et

al.(2017) and Dechezlepretre A. et al.(2018) did both impacts. First of all, Paul J. et al.(2011) analyzed the economic impacts of RGGI auctioning revenues during the 2009-2011 period. The findings were that RGGI produced $ 1.6 billion in net present value economic value added to the ten-state region. However, the scope of RGGI's positive economic benefits varies by state and region, in large part because the states spent the RGGI allowance proceeds differently. Secondly, Brian C. and Peter T.(2015) analyzed why greenhouse gas emissions in RGGI states declined by an econometric attribution to economic, energy market, and policy factors. They concluded that RGGI states experienced a far more dramatic proportional decline in emissions in the electric power sector than the rest of the U.S. Specifically, the RGGI reduced greenhouse gas emissions by 24% without the program. Jingchi(2021) estimated the impacts of RGGI auctioning revenues on coal and natural gas consumption and measured its effectiveness for reducing carbon dioxide emissions in the electric-power industry. He found that the RGGI program decreased coal and natural gas consumption for electricity generation by 73% and 30%, respectively, within RGGI states in the regulated sectors. As a result, the RGGI program reduced carbon dioxide emissions by 4.8 million tons annually. Thirdly, Choi et al.(2017) implemented a simulation based on a CGE approach to analyze the economic and environmental impacts of K-ETS. Their findings suggested that while K-ETS has significant abatement effects which decrease 2.56% from the base case, it only has negative impacts on industry output on average falls by 0.54%, with the gas and air transport sectors most adversely affected. Dechezlepretre et al.(2019) reviewed the empirical literature combining economic and environmental performance data at the micro level. They generally found a positive and statistically significant correlation between economic and

environmental performance. In more details, the EU ETS induced carbon emission reductions to 10% between 2005 and 2012, but had no negative impacts on the economic performance of regulated firms. The results demonstrated that concerns that the EU ETS would come at a cost in terms of competitiveness had been vastly overplayed.

2. Current status of ETS allowances auctioning revenues across the major ETSs

ETS is a key market tool for cost-effectively reducing CO2 emissions and boosting economic performance. In an emissions trading system(ETS), the government can distribute emissions permits for free, auction them or combine both approaches.(ICAP(2022)) Auction is the method of the reduction opportunities for lobbying and creates a level playing field for new entrants, And, it also preserves incentives for cost-effective abatement as companies would either have to purchase their allowances or reduce their emissions. (ICAP(2019)) Most of major ETSs, such as EU-ETS, California cap-and-trade, RGGI, K-ETS etc. have risen the number of auction allowances allocated. The increase has a positive effects on revenues generated through auctioning and the auctioning revenues can be used in different ways to fund climate and energy-related programs. (Wiese et al.(2020))

The EU-ETS is the world's first and biggest carbon market. As shown in Table 1, it covers about 38% of the EU ETS GHG emissions and the revenues are $ 36,734 million in 2021 and $ 40,816 million in 2022. EU member States should use at least 50% of their auctioning revenues to energy and climate-related purposes. Around 75% of the revenues from 2013-2020 was used or is planned to be used for climate and energy purposes. With the significant share of auctioned allowances and the

carbon price increase over time, auctioning revenues increased accordingly.(EEA(2022) The auctioning revenues are used to encourage climate action and support lower-income member states, that is, renewable energy, energy efficiency, sustainable transport, R&D and other uses.(Santikarn et el.(2019))

The California cap-and-trade program began operation in 2012 with the opening of its tracking system for allocation, auction distribution, and trading of compliance instruments. The program covers about 75% of the state's GHG emissions and the revenues are $ 3,992 million in 2021 and $ 4,027 million in 2022. The California cap-and-trade's rationale for revenues furthers the objectives of California Global Warming Solutions Act and provides benefits to disadvantaged and low-income communities and households. The cap-and-trade auctioning revenues are used to fund activities that help achieve the objectives of its climate target. The revenues cover transport, clean energy, energy efficiency and waste diversion etc.

Next, the Regional Greenhouse Gas Initiative(RGGI) is the first US mandatory market-based emissions trading program to reduce greenhouse gas and the first anywhere to use the cap-and-invest model for reducing pollution. It is a consortium of northeastern states of U.S. that have agreed to limit the greenhouse gas emissions of CO2 from electric power generation through a regional emissions trading program.(Marray, B.C. & Maniloff, P.T.(2015)) RGGI states provide yearly reports as to how revenues from the ETS have been invested, The reports provide transparency and communicate revenue investments to the public to facilitate further buy-in into the RGGI program.(Krause E. et al.(2022)). The revenues are $ 926 million in 2021 and $ 1,194 million in 2022. RGGI states invest RGGI auction proceeds in five major categories, that is,

energy efficiency, clean and renewable energy, beneficial electrification, direct bill assistance and greenhouse gas abatement.(RGGI(2022))

Finally, the Republic of Korea enacted Act on the Allocation and Trading of Greenhouse Gas Emission Permits and launched the K-ETS in 2015. It also plans to gradually introduce auctioning into its ETS. The 1st phase(2015~2017) mainly focuses on the successful establishment of the K-ETS as well as providing participants with the opportunity to become familiar with the system. Therefore, all emission permits were distributed freely in the 1st phase. But the permits auction share increased to 3% in the 2nd phase and is planned to increase to 10% in the 3rd phase and 15% in the 4th phase. The revenues are $ 199 million in 2019 and $ 245 million in 2022. K-ETS auctioning revenues are used to the general fund and the revenues will be provided to participate companies to invest in environmentally-friendly facilities. They are used for supporting mitigation equipment, low-carbon innovation, and technology development of ETS-covered entities.(see Table 1)

〈Table 1〉 Overview of auctioning revenues of major ETSs

	auction share (2022)	cover-age*	current use of revenues	average price(USD)	auction rev-enues (million USD)
EU-ETS	57%	38%	At least 50% of revenues should be used for climate and energy-related purposes. Member States earmark their revenues or direct them to the general budget.(10 Member States earmark auction revenues, 11 not earmarking and 6 using a hybrid approach.	27.8(2019) 28.3(2020) 62.6(2021) 83.1(2022)	16,414(2019) 21.770(2020) 36,734(2021) 40,816(2022)
California	38%	75%	Most auctioning revenues go to the Greenhouse Gas Reduction Fund, of which at least 35% must benefit disadvantaged and low-income communities. The fund also invests the proceeds in projects that reduce GHG emissions. In addition, investor-owned utilities are allocated allowances, a portion of which must be consigned to auction. These auction proceeds must be used for ratepayer benefit and for emissions reductions.	16.8(2019) 17.0(2020) 22.4(2021) 28.0(2022)	3,065(2019) 1,699(2020) 3,992(2021) 4,027(2022)
RGGI	93%	14%	Auctions revenues are returned to the RGGI states and have been primarily invested in the follwing categories: energy efficiency, clean and renewable energy, greenhouse gas abatement, beneficial electification and direct bill assistance. The target groups are local businesses, low-income communities, industrial facilities and households.	6.0(2019) 7.1(2020) 10.6(2021) 13.5(2022)	284(2019) 416(2020) 926(2021) 1,194(2022)
K-ETS	4% (10%)	74%	The K-ETS auction provisions as for 2nd phase apply. The revenues are expected to increase since the share of auctioned allowances in the coming years and the average allowance price increase. The revenues are used for climate response fund including support for mitigation equipment, low-carbon innovation, and technology development for small and mi-sized companies covered by the K-ETS.	25.6(2019) 27.6(2020) 23.1(2021) 18.0(2022)	199(2019) 210(2020) 258(2021) 245(2022)

sources: Borghesi S. et al.(2022), ICAP(2020~2023)

Ⅲ. The impacts of K-ETS auctioning revenues on carbon emissions reduction and economic performance

1. Auctioning share and revenues by major ETSs

EU ETS, California cap-and-trade, RGGI and K-ETS etc. hold regular auction of allowances. For EU-ETS, it is driven by recent changes within the ETS framework and the revision of the EU ETS Directive. As a result, the auctioning share of EU-ETS allowances is 57% at the end of 2022 and it is expected to increase to 70% until 2026 and to 100% by 2030. California cap-and-trade program and RGGI emissions permits have auctioned 38% and 93% in 2022, respectively. And, K-ETS allowances are required to auction 3% in the 2nd phase and increase 10% in the 3rd phase and 15% in the 4th phase. Even if K-ETS allowances are required to auction 10% in the phase 3(2021-2025), K-ETS sub-sectors are considered vulnerable to international competitiveness and carbon leakage are exempted. This means auctioning system-wide currently below 10%. (see Table 2)

〈Table 2〉 Auctioning share by major ETSs

unit: %

	EU ETS	California	RGGI	Republic of Korea
2018	57	53	100	〈3
2019	57	40	100	3
2020	57	32	100	3
2021	57	37	100	4
2022	57	38	93	4(10)

Sources: ICAP(2019, 2020, 2021, 2022, 2023)

As the permit prices of major ETSs increase generally, auctioning revenues have also increased over time. By the end of 2022, the

worldwide ETSs raised a total of $ 224 billion in auctioning revenues. In 2022, the revenues raised over $ 40.8 billion in EU-ETS, $ 4.0 billion in California cap-and-trade, $ 1.2 billion in RGGI and $ 245 million in K-ETS.(see Table 3)

〈Table 3〉 Auctioning revenues by major ETSs

	total revenues cumulatively (USD billion)	EU-ETS (USD million)	California (USD million)	RGGI (USD million)	K-ETS (USD million)
2018	57	16,747	3,018	239	-
2019	78	16,414	3,065	284	199
2020	103	21,770	1,699	416	210
2021	161	36,734	3,992	926	258
2022	224	40,816	4,027	1,194	245

The use of revenues from ETS can develop the environmental and economic benefits. Auction revenues are used to depend on the jurisdiction's priorities and circumstances. ETS auction revenues can be either earmarked for specific purposes, that is, further climate and energy projects, or can also go into the general budget with no earmarking. In the case of EU ETS, some of the EU ETS member states(Belgium, Cyprus, Croatia, Germany, Greece, Latvia, Lithuania, Malta, Portugal, Slovakia, Slovenia) earmark their auction revenues to finance climate and energy projects, some members(Austria, Bulgaria, Czech Republic, Denmark, Finland, Ireland, Luxembourg, Netherlands, Poland, Sweden) do not and the rest of state members(Estonia, France, Hungary, Italy, Romania, Spain) have a hybrid system. In the case of K-ETS, there has no guidelines to use auctioning revenues. The revenues from K-ETS go to climate response fund including support for mitigation equipment, low-carbon innovation and technology development for small and medium-sized companies etc.

2. Environmental and economic impacts of RGGI auctioning revenues

The use of RGGI auctioning revenues has evaluated as successful. RGGI auctioning revenues have been used for five categories, that is, energy efficiency, clean and renewable energy, beneficial electrification, greenhouse gas abatement, direct bill assistance etc. Energy efficiency remains the largest portion of 2020~2021 RGGI investments for 43% and followed by direct bill assistance for 17%, beneficial electrification for 12%, clean and renewable energy for 11%, greenhouse gas abatement for 8%, respectively. In the average of 2020~2021, RGGI states invested $ 285 million which was composed of $ 130 million for energy efficiency, $ 43 million for direct bill assistance, $ 26 million for greenhouse gas abatement and $ 25 million for clean and renewable energy etc.(see Table 4)

〈Table 4〉 RGGI auctioning revenues investments by category

unit: $, %

	total investments (million $)	energy efficiency	clean and renewable energy	greenhouse abatement	beneficial electrification	direct bill assistance
2008~2014	1,370	780.9(57)	205.5(15)	109.6(8)	-	205.5(15)
2105	410	262.4(64)	65.6(16)	16.4(4)	-	41.0(10)
2016	436	239.8(55)	74.1(17)	48.0(11)	-	48.0(11)
2017	316	161.2(51)	44.2(14)	44.2(14)	-	50.6(16)
2018	248	94.2(38)	47.1(19)	49.6(20)	-	39.7(16)
2019	217	86.8(40)	39.1(18)	32.6(15)	-	41.2(19)
2020	196	68.6(35)	35.1(18)	9.8(5)	21.6(11)	37.2(19)
2021	374	190.7(51)	15.0(4)	41.1(11)	48.6(13)	48.6(14)
2020-2021 (average)	285	129.7(43)	25.1(11)	25.5(8)	35.1(12)	42,9(17)

sources: RGGI(2016~2023)
note: ( ) indicates share of investments by category

Investments generally benefit more than just those who directly participate in auction revenue-funded programs since money not spent direct bill assistance can be used in other ways that boost the economy. Reduced demand for energy also keeps power prices lower for everyone, and avoids investments in costly infrastructure to meet peak demand.(RGGI(2022)). Table 5 analyzes the impacts of RGGI from 2008 to 2021 to calculate the reduced CO2 tons and energy cost reduction per dollar. Using this, the environmental and economic effects were estimated by predicting the auction revenue of K-ETS.[2] Table 5 shows annual environmental and economic impacts of RGGI investments by using RGGI investment and lifetime benefits. In more details, RGGI invested $ 191 million in energy efficiency, avoiding the release of 2.09 CO2 metric tons and saving $ 418 million consumers' energy bills. Average of 2008~2021 RGGI lifetime benefits in energy efficiency per USD were 0.02 metric tons of CO2 reductions and $ 7.19 energy bill savings. And, RGGI invested $ 15 million in clean and renewable energy, avoiding the release of 1,60 CO2 metric tons and saving $ 604 million consumers' energy bills. Average of the lifetime benefits in clean and renewable energy were 0.04 metric tons of CO2 reductions and $ 14.42 energy bill savings. Finally, 2021 RGGI investments were $ 48.6 million in direct bill assistance and saved $ 29.6 million on lifetime consumers' energy bills. Converted to per USD, the lifetime benefits in direct bill assistance were $ 0.84 energy bill savings since it returns money as a rebate on consumers' energy bills.

2) Of course, there are many limitations in estimating the effect of K-ETS using RGGI, but it is judged that the effect of the rough effect can be seen.

〈Table 5〉 Environmental and economic impacts of RGGI investment by category

		investments (million $)	metric tons CO^2 avoided	per USD	energy bill savings	per USD
energy efficiency	2008~2014	780.9	11.703	0.015	3,620	4.636
	2015	262.4	2.812	0.011	1,300	4.954
	2016	239.8	2.994	0.012	823	3.432
	2017	161.2	5.944	0.037	879	5.453
	2018	94.2	1.314	0.014	1.252	13.291
	2019	86.8	1.369	0.016	554	6.382
	2020	68.6	4.165	0.061	1,179	17.187
	2021	190.7	2.090	0.011	418	2.192
	average			0.022		7.191
Clean and renewable energy	2008~2014	205.5	1.905	0.009	836	4.068
	2015	65.6	1.361	0.021	786	11.982
	2016	74.1	1.542	0.021	465	6.275
	2017	44.2	1.156	0.026	330	7.466
	2018	47.1	1.768	0.038	609	12.930
	2019	39.1	0.778	0.020	596	15.243
	2020	35.1	1.574	0.045	602	17.151
	2021	15.0	1.598	0.107	604	40.267
	average			0.036		14.423
greenhouse gas abatement	2008~2014	109.6	0.378	0.004	37.0	0.338
	2015	16.4	0.577	0.035	183.7	11.201
	2016	48.0	1.270	0.027	411.4	8.571
	2017	44.2	0.392	0.009	141.8	3.208
	2018	49.6	1.135	0.023	228.4	4.605
	2019	32.6	0.149	0.006	93.6	2.871
	2020	9.8	0.146	0.015	51.8	5.286
	2021	41.1	0.009	0.000	20.0	0.487
	average			0.015		4.571
beneficial electrification	2020	21.6	0.161	0.007	89.6	4.148
	2021	48.6	0.335	0.007	164.2	3.379
	average			0.007		3.764
direct bill assistance	2008~2014	205.5	-	-	178.2	0.867
	2015	41.0	-	-	40.4	0.985
	2016	48.0	-	-	48.6	1.013
	2017	50.6	-	-	49.4	0.976
	2018	39.7	-	-	10.7	0.270
	2019	41.2	-	-	39.5	0.959
	2020	37.2	-	-	37.6	1.011
	2021	48.6	-	-	29.6	0.609
	average			-		0.836

note: calculated by the author using RGGI data from 2008 to 2021

3. The environmental and economic impacts of K-ETS auctioning revenues

1) Analysis Method and Three scenarios

The Republic of Korea has agreed to reach climate neutrality by 2050. The investment source of financing could be the revenues from the K-ETS auctioning of allowances. The revenues are expected to further increase due to a reduction of overall emissions allowances leading to the increasing of auction share. Specifically, it is estimated to approximately $439 million in the 2nd phase, $ 2,388 million in the 3rd phase and $ 3,583 million in the 4th phase.(see Table 6)

〈Table 6〉 K-ETS auctioning share and revenues

		1st ('15~'17)	2nd ('18~'20)	3rd ('21~'25)	4th ('26~'30)
average auction shares	%	0	3	10	15
auction rev-enues(estimated)	billion won	0	558.9	3,105.0	4,657.5
	million USD	0	429.9	2,388,5	3,582.7

Source: MOFIA·MOE(2019)
Note: Based on KAU price is 27,000 won/ton(average between Jan. and Aug.) and 1,300 won per USD

Investing auctioning revenues into energy and climate related programs have an reducing CO2 emissions and saving consumers' energy bills. Most of ETSs have directed a large share of their revenues towards climate and energy programs.

Since the Republic of Korea does not earmark its K-ETS auctioning revenues, it is difficult to estimate what percentage of K-ETS revenues is spent on energy and climate purposes by category. Therefore, it is indirectly estimated the impacts of reducing carbon emissions and

saving energy costs for consumers by using the RGGI case shown in Table 5. This study set up three scenarios under the assumption that K-ETS auction revenues are used for five categories like RGGI and EU-ETS.

① The first scenario is assumed to invest by category like RGGI which the average of investment share is 43% for energy efficiency, 11% for renewable and clean energy, 8% for greenhouse gas abatement, 12% for beneficial electrification, 17% for direct bill savings.
② The second scenario is used for 36% for energy efficiency, 37% for renewable and clean energy, 8% for greenhouse gas abatement, 10% for beneficial electrification, 9% for direct bill savings.
③ The third scenario is assumed to the average of the first and the second scenario which are directed to 40% for energy efficiency, 24% for renewable and clean energy, 8% for greenhouse gas abatement, 11% for beneficial electrification, 13% for direct bill savings.

2) Findings

The findings of these scenarios are shown in Table 6 & 7. In the 3rd phase of K-ETS, the auction share is 10% and the revenues are expected to $ 2,389 million. The lifetime benefits(based on scenario 3) are expected to avoid the release of 46 million metric tons of CO2 and to save $ 18.5 billion on consumers' energy bills. In more details, the release of CO2 reductions are estimated to be 21.0 metric tons in energy efficiency, 20.6 metric tons in clean and renewable energy, 2.9 metric tons in greenhouse gas abatement and 1.8 metric tons in beneficial electrification. And, consumer energy cost savings are estimated to be $6.9 billion in energy efficiency, $ 8.3 billion in clean and renewable energy, $ 1 billion in greenhouse gas abatement, $ 1.2 billion in

beneficial electrification and $ 1.2 billion in direct bill assistance.(see Table 7)

〈Table 7〉 Environmental and economic impacts of K-ETS auction revenues(phase 3)

total estimated auctioning revenues($ 2388.5 million)			
scenario 1			
category	usage($ million)	million $MtCO^2$ avoided	energy bill savings ($ million)
energy efficiency	1,027.04	22.59	7,385.44
clean and renewable energy	262.73	9.46	3,789.35
greenhouse gas abatement	191.08	2.87	1,010.05
beneficial electrification	286.62	2.01	1,310.14
direct bill assistance	406.04	-	1,528.33
total		36.93 (7.39)	15,023.31 (3,004.66)
scenario 2			
energy efficiency	859.85	18.92	6,183.15
clean and renewable energy	883.73	31.81	12,746.04
greenhouse gas abatement	191.08	2.87	1,010.03
beneficial electrification	238.85	1.67	1,091.78
direct bill assistance	214.96	-	809.11
total		55.27 (11.05)	21,840.11 (4,368.02)
scenario 3			
energy efficiency	955.38	21.02	6,870.14
clean and renewable energy	573.23	20.64	8,267.70
greenhouse gas abatement	191.08	2.87	1,010.05
beneficial electrification	262.73	1.84	1,200.94
direct bill assistance	310.50	-	1,168.72
		46.37 (9.27)	18,517.55 (3,703.51)

note: ( ) represents for annual impacts

In the 4th phase of K-ETS, the auction share is expected to increase 15% and the total revenues are estimated to be $ 3,583 million. The lifetime benefits(based on scenario 3) are expected to avoid the release

of 70 million metric tons of CO2 and to save $ 27.8 billion on consumers' energy bills. In more details, the release of CO2 reductions are estimated to be 31.5 metric tons in energy efficiency, 31.0 metric tons in clean and renewable energy, 4.3 metric tons in greenhouse gas abatement and 2.8 metric tons in beneficial electrification. And, consumer energy cost savings are estimated to be $ 10.3 billion in energy efficiency, $ 12.4 billion in clean and renewable energy, $ 1.5 billion in greenhouse gas abatement, $ 1.8 billion in beneficial electrification and $ 1.8 billion in direct bill assistance.(see Table 8)

〈Table 8〉 Environmental and economic impacts of K-ETS auction revenues(phase 4)

total estimated auctioning revenues($ 3582.7 million)			
scenario 1			
category	usage($ million)	million MtCO2 avoided	energy bill savings ($ million)
energy efficiency	1,540.56	33.89	11,078.17
clean and renewable energy	394.10	14.19	5,684.10
greenhouse gas abatement	286.62	4.30	1,515,07
beneficial electrification	429.92	3.01	1,965.61
direct bill assistance	609.06	-	2,292.49
total		55.39 (11.08)	22,534.84 (4,506.97)
scenario 2			
energy efficiency	1,289.77	28.37	9,274.74
clean and renewable energy	1,325.60	47.72	19,119.13
greenhouse gas abatement	286.62	4.30	1,515.07
beneficial electrification	358.27	2.51	1,637.65
direct bill assistance	322.44	-	1,213.66
total		82.90 (16.58)	32,760.25 (6,552.05)
scenario 3			
energy efficiency	1,433.08	31.53	10,305.28
clean and renewable energy	859.85	30.95	12,401.62
greenhouse gas abatement	286.62	4.30	1,515.07
beneficial electrification	394.10	2.76	1,801.43
direct bill assistance	465.75	-	1,753.08
		69.54 (13.91)	27,776.48 (5,555.30)

note: ( ) represents for annual impacts

Ⅳ. Conclusion

ETS is a key market tool for cost-effectively reducing CO2 emissions and boosting economic performance. Auction is the method of the reduction opportunities for lobbying and creates a level playing field for new entrants and also preserves incentives for cost-effective abatement as companies would either have to purchase their allowances or reduce their emissions.

This study reviews the investment of RGGI auctioning revnues and estimates the impacts on carbon emissions avoided and economic performance when K-ETS auction revenues are used effectively. K-ETS will be expected to grow the auctioning revenues due to increase the share of allowances auction yearly, that is, 3% for the 2nd phase, 10% for the 3rd phase and 15% for the 4th phase. Since the Republic of Korea does not earmark auctioning revenues, it is difficult to estimate what the proceeds are being used and how much the environmental and economic impacts of using the revenues are. Therefore, it is indirectly estimated the impacts of reducing carbon emissions and saving consumer's energy bills by using the RGGI case, which has effectively used emissions auctioning revenues for energy efficiency, clean and renewable energy, greenhouse gas abatement, beneficial electrification and direct bill assistance. The findings are that the lifetime benefits for the 3rd phase of K-ETS auctioning revenues(based on scenario 3) are expected to avoid the release of 46 million metric tons of CO2 and to save $ 18.5 billion on consumers' energy bills. In more details, the release of CO2 reductions are estimated to be 21.0 metric tons in energy efficiency, 20.6 metric tons in clean and renewable energy, 2.9 metric tons in greenhouse gas abatement and 1.8 metric tons in beneficial electrification. And,

consumers energy cost savings are estimated to be $ 6.9 billion in energy efficiency, $ 8.3 billion in clean and renewable energy, $1 billion in greenhouse gas abatement, $ 1.2 billion in beneficial electrification and $ 1.2 billion in direct bill assistance.

▌References ▌

AB32, 2006, California Global Warming Solutions Act, Available at://http://www.leginfo.ca.gov/pub/05-06/bill/asm/ab 0001-0050/ab 32bill 20060927chaptered pdf.

Borghesi, Simone and Ferrari, Albert, 2022, "Social impact of emissions trading systems: Auction revenues and social expenditures in a changing world", *Policy Brief,* European University Institute. Available at://cadmus.eui.eu/bitstreem/handle/1814/75009/PB_2022_54_FSR.pdf?sequence=1&isAllowed=y.

Brian C. Murray, Peter T. Maniloff, 2015, "Why have greenhouses in RGGI states declined ? An econometric attribution to economic, energy market, and policy factors", *Energy Economics* 51, pp 581-589.

Choi, Yongrok, Yu Liu, Hyoungseok Lee, 2017, "The economy impacts of Korean ETS with an emphasis on sectoral coverage based on CGE approach", *Energy Policy,* Volume 109, pp 835-844.

Dechezlepretre, A,, Nachtigall, D., Vermans, F., 2018, "The joint impact of the European Union emissions trading system on carbon emissions and economic performance", OECD Economics Department Working Papers, No 1515, Available at: http://dx.doi.org/10.1787148196016-en.

EEA, 2022, Trends and Projections in Europe in 2022.

ICAP, 2016, 2019~2023, Emissions Trading Worldwide: Status Report 2015, 2018~2022, ICAP.

Jingchi Yan, 2021, "The impacts of climate policy on fossil fuel consumption: Evidence from the Regional Greenhouse Gas Initiative(RGGI)", *Energy Economics* 100, pp1-11.

Krause, Emma, Roth, Agustin, Schafer, Moritz, 2022, "Using carbon pricing revenues for social compensation", Guidehouse, Available at: www.guidehouse.com.

MOEF·MOE, 2019, The 3rd basic plan for carbon emissions trading system. Korea Environment Corporation, ETS Insight, Vol 44.

Santikarn, Marissa, Christopher Kardish, Johannes Ackva and Constanze Haug, 2019, "The use of revenue from emissions trading systems-delivering environmental, economic and social benefits", ICAP Secretariat, ICAP.

Paul J. Hibbard, Susan F. Tierney, Andrea M. Okle and Pavel G. Darling, 2011, "The Economic Impacts of the Regional Greenhouse Gas Initiative on Ten Northeast and Mid-Atlantic States: Review of the use of RGGI auction proceeds from the first three-year compliance period," Analysis Group. Available at://https/www/ourenergypolicy.org/wp-contnent/uploads/2018/04/analysis_group_rggi_report_april_2018-3.pdf.

RGGI Inc, 2016~2023, The Investment of RGGI Proceeds in 2015~2022, Available at http://www.rggi.org.

Wiese, Catharina, Cowart, Richard and Rosenow, Jan, 2020, "The strategic use of auctioning revenues to foster energy efficiency: status quo and potential within the european emissions trading system." *Energy Efficiency,* 13(8), pp1677-1688, Available at://doi.org/10.1007/s12053-020-09894-0.

Xavier le Den, Edmund Beavor, Samy Porteron, Adriana Ilisescu, 2017, Analysis of the use of auction revenues by the member states, Ramboll. Available at://http://auction_revenues_report_2017_en.pdf(europa.eu).

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Received: 04 January 2024
Revised: 04 June 2024
Accepted: 16 June 2024