A Comparative Study on the F-Gas Control Laws and Systems of EU and Korea*

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[Abstract]

This paper reviews and compares the legal and institutional structures of EU and Korea regarding the control of F-gas. Various directives and regulations, programs and initiatives to reduce F-gas emissions in EU are scrutinized. Korea's related laws and government initiatives are examined and compared with EU's directives and programs. The authors attempt to characterize both countries' laws and institutions from the viewpoints of integration, enforcement, and incentives. It is observed that Korea's micro-level policy tools have followed EU

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with a time lag. However, despite the recent amendment of CACA, ARCEEV and other related laws and regulations, F-gas control laws and system in Korea still lack integration. The recent amendment of CACA extended the coverage of those who are subject to the refrigerants management standard .and introduced the specialized refrigerants recovery agent system. Despite this amendment, there are still some F-gases, equipments and sectors that are not effectively controlled by the Korean legal system. It is questionable whether there is any meaningful economic incentive to diligent recovery activity of the business owners or the recovery agents. Korea's enforcement mechanism is not yet seriously examined, and the effectiveness is questioned. A comprehensive F-gas control measure, including a new legislation with separate reduction target and strategies, deserves a serious consideration.

Ⅰ. Introduction

F-gases, or fluorinated greenhouse gases which include SF6, PFC, and HFC, are powerful greenhouse gases, with a global warming effect up to 23,000 times greater than carbon dioxide (CO_2), and their emissions are rising strongly. By 2050, F-gas emissions are expected to account for 6.2% (GWP 100yr) or 8.6% (GWP 20yr) of the total direct greenhouse gas emissions in the world. In Korea, the share of F-gases in GHG emission increased from 0.4% in1990 to 2.5% in 2015 and it is expected that the share will increase in the future. The share of F-gas in GHG emissions in Korea, 2.5%%, is higher than the share in EU, 2%. Since the shares of F-gas in GHG emission are rising, most countries, particularly the European Union, are taking more efforts to control F-gases. Furthermore, it is discovered that there is a large and less costly abatement potential for F-gases, compared for other GHGs.[1] Considering the rising emissions and large and less costly abatement potential, it is a logical consequence to have a program to reduce more F-gas emissions.

However, there are considerable barriers to get F-gas emission to be reduced

1) Schaefer et al (2006).

significantly. The main obstacle is the technical properties of F-gas use and disposal that makes it difficult to reduce F-gas emissions. F-gases are emitted from non-energy sources, so have distinctive nature in its emission/leakage behaviors. Emissions of F-gases mainly occur by means of leakage of gases contained in products or equipment, or at the end of the lifetime of the product/equipment, where contained F-gases are not fully recovered and destroyed or re-used. Refrigerant (HFC), among others, is used in various small units such as automobiles, buildings, refrigerators, etc. This makes the collection and recovery of HFC difficult. In addition, F-gases are characterized by a significant time lag between the supply of F-gases to their industrial uses and their emissions.

Therefore, the institutional design and implementation of F-gas control is of crucial importance. A well-designed control system, such as reporting, licensing, and some enforcement measures are essential. However, many cases are observed where people ignore regulations when there is no strong enforcement or incentives to reduce the emission of F-gases including HFC. One of the problems is the lack of legal and institutional integration. Laws and regulations are scattered across various sectors and industries, in parallel with the emissions of F-gases themselves. For energies, even when energies are used by various sectors and industries, the quantities are easily measured and monitored. However, F-gas emissions occur at various stages of F-gas using products' lifecycle, and the emissions are not regularly measured or monitored.

Despite the large and potentially less costly abatement potential, F-gas abatement is a big challenge because of high transaction costs including the costs for legislation and enforcement. Due to scattered nature of F-gas emissions, integration in legislation and enforcement is the crucial element. It will work best if the people involved in F-gas have incentives to reduce emission.

It is reported that EU has been fairly successful in cutting F- gas emissions with more stringent and efficient control measures. Furthermore, EU is the leader in

emission trading system, and Korea is also carrying out the similar greenhouse gas emission trading system. We can observe that many traits in Korea's greenhouse gas control policies are borrowed from EU's laws and practices. Since F-gases are GHGs, it is .logical to refer to EU system rather than other advanced countries without national level emission trading system. In addition, the EU is also the leader in international standards such as REACH and other. This paper attempts to review the EU's efforts to reduce F-gas emission.[2] Korea's legal and institutional arrangement is reviewed and the comparison with EU is provided. The reviews are conducted with emphases on integration, enforcement, and incentives, which we believe the three essential elements to the efficient and effective legislation and enforcement for F-gas control.

Ⅱ. Trends and Characteristics of Emissions of F-Gases

Hydrofluorocarbons (HFCs) account for 85 % of present F-gases supply. They are used primarily as refrigerants in refrigeration, air conditioning and heat pump equipment. Foam blowing and aerosols are other important uses of HFCs. The other F-gases are perfluorocarbons (PFCs), mainly used as a protective gas in electrical equipment and as etching agents in electronics manufacture, as well as sulphur hexafluoride (SF_6) and nitrogen trifluoride (NF_3).

1. F-Gas Emissions in EU

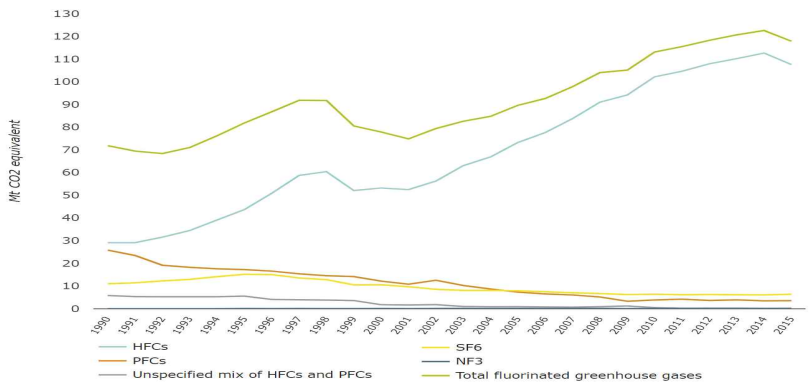
As part of its actions to fight climate change and reduce greenhouse gas

2) This is confined to the European Commission's directives and regulations level, excluding member states' legislation via transposition.

emissions, the European Union is phasing down the use of HFCs. The supply of F-gases to the EU, measured in CO2-equivalents, has been overall decreasing since 2010 (HFC imports were extraordinarily high in 2014, prior to the EU-wide HFC phase-down coming into effect in 2015). Since 2015, the EU has complied with its annual targets under the EU F-Gas Regulation 517/2014 and is approaching the HFC consumption limit, which comes into effect in 2019 under the Montreal Protocol.[3] For the first time in 2015, a decrease in the EU emissions of fluorinated greenhouse gases (F-gases) reported under the United Nations Framework Convention on Climate Change (UNFCCC) was observed, following 13 years of increases.[4]

In Europe, large scale reductions in F-gas use and emissions are expected to result from a new phase-down measure, which will progressively cap sales of HFCs allowed on the EU market, bringing maximum sales down to 21 % of baseline levels by 2030. Reductions are also expected to result from bans on the use of F-gases that have high GWPs.

Figure 1. Emissions of F-gases (CO_2eq.) in EU



Source: EEA(2018)

3) EEA (2018).
4) EEA (2018).

2. F-gas Trends in Korea

Korean government has a plan to reduce 20 million ton CO2e by securing world top level technologies in reducing N20, CH4, PFC, HFC, and NF3 by 2020.[5)]

Korea's total GHG emission in 2015 was 690.2 million ton. Korea introduced emission trading from 2015, which includes 65% of national emission of GHGs. In Korea, another regulatory scheme called Target Management System is in operation applied to less sized emitters. Within Korea's GHG emissions, CO_2 was 633 million ton CO_2e, comprising 91.7%. Shares of Non-CO2 emissions are CH4 3.8%, N2O 2.0%, HFCs 1.1%, SF6 1.2%, and PFCs 0.2%. F-gases (HFC, PFC, and SF_6) have total share of 2.5%. The change rate from 2014 for CO_2, CH4, N_2O were 0.7%, -0.4%, 0.7%, while those for HFCs, PFCs, SF6 were -7.1%, -37.5%,- 0.8% respectively. Comparing emissions in 2015 with those in 1990, PFC and SF6 increased by 14,900.0% and 4.000.0% respectively, due to the increase in semiconductors and LCD productions. HFC emissions are increased by 690.0% from 1990 due to increase in the use of refrigerants.

Although F-gas' share in GHG emission is low, considering high growth rate, high dependency of Korean economy on F-gas intensive industries and relatively loose management framework, regulation systems on F-gas deserves a special attention. It is necessary to review regulatory laws and regulations relating to industrial production and waste management of F-gas related industries. In 2015, the trend of increasing F-gas emission is reverted to decrease, though it is not certain this negative growth rated will be norm after 2016.

GIR (2017a) refers to several initiatives in F-gas related industries as follows. Semiconductor industry in Korea adopts and runs PFC decomposition facilities for all plants constructed or retrofitted after 2011.[6)] Display industry also runs

5) Lee and Kim (2014).
6) GIR (2017a)

abatement facilities including scrubbers for F-gases. Some firms use substitutes with lower GWPs for SF6. Automobile and Electronic industries replacing refrigerant by lower GWP substitutes of HFO's (such as R1234yf). Korean government, according to GIR (2017a), will help technology development for substitute refrigerants and promote the use of environment friendly refrigerants

Table 1. Emission Levels and Change Rates of GHGs in Korea (unit: million CO2e)

Year / GHGs		1990	2000	2010	2012	2013	2014	2015	%Δ 90-15	%Δ 14-15
CO2	emission	252.3	441.6	593.8	626.4	635.4	628.7	633	150.9	0.7
	Share (%)	86.1	88.2	90.5	91.3	91.4	91.2	91.7		
CH4	emission	30.4	27.6	27	26.7	26.6	26.1	26	-14.5	-0.4
	Share (%)	10.4	5.5	4.1	3.9	3.8	3.8	3.8		
N2O	emission	9	18.1	13.2	13.5	13.6	13.4	13.5	50.0	0.7
	Share (%)	3.1	3.6	2.0	2.0	2.0	1.9	2.0		
HFCs	emission	1	8.4	8.1	8.7	8.1	8.5	7.9	690.0	-7.1
	Share (%)	0.3	1.7	1.2	1.3	1.2	1.2	1.1		
PFCs	emission	0.01	2.2	2.3	2.3	2.3	2.4	1.5	14,900.0	-37.5
	Share (%)	0.0	0.4	0.4	0.3	0.3	0.3	0.2		
HF6	emission	0.2	2.9	11.9	8.5	9.2	10	8.2	4000.0	-18.0
	Share (%)	0.1	0.6	1.8	1.2	1.3	1.5	1.2		
Total (excluding LULUCF)		292.9	500.9	656.2	685.9	695.2	689.2	690.2	135.6	0.1

Source; GIR (2017b)

Ⅲ. Legal Framework for F-Gas Emission Control in EU

F-gas emission/leakage control policies are of three types: command and control, economic instruments, and voluntary agreement. Command-and-control

includes mandatory recovery and destruction, leakage regulation and leakage standards, certification of F-gas personnel and companies, reporting, labeling, and general prohibitions. Economic instrument (market based mechanism) includes F-gas emission trading systems, deposit systems, and taxations. Most widely used regulatory instrument regarding F-gases is direct regulation, although indirect economic incentives such as deposit system and tax are increasingly used. Considering the informational asymmetry and complexity relating to the management and inventory of F-gases, voluntary approaches are also considered.[7)]

For all three types of policy instruments, the cornerstone is the enforcement. Without enforcement and penalty mechanism, regulations will never work properly. Second concern is the degree of integration and harmonization among laws and regulations in dealing with F-gases. F-gases are emitted at various stages of production, use, and disposal. F-gases are diverse in their physical natures. Because of these natures, laws and regulations tend to be scattered around, not established as a single system of management. If these laws and regulations are left scattered and unorganized, the reduction of F-gas will remain fairly costly. Integrating these laws and regulations into a cohesive system is necessary, for the efficient and less costly reduction of important GHGs. Another concern is the incentives and motivations for the players to behave towards the reduction of emissions in a concerted way. If the laws and regulations do not provide economic or non-economic incentives, the system may not work. The laws and regulations of EU will be reviewed focusing on these concerns of integration, enforcement, and incentives.

The regulation on F-gases in EU is under the authority of the European Commission's Environment Department which sets the comprehensive and general goals and policy frameworks of regulation. However, it is the individual member state that makes country-specific laws and acts, sets specific regulatory objectives,

7) European Commission (2015)

and implements concrete regulatory instruments. Furthermore, EU's F-gas regulation system conforms to various multilateral environmental agreements and adopts different regulatory instruments including direct regulation, market based instruments, voluntary approaches via European Commission's Regulations and Directives and individual member states' legislation procedures.

1. Reduction Target for F-Gas

In EU, a quantitative target was set up simultaneously with the introduction of specific regulatory schemes. In 2006, a quantitative target for F-gases in EU is set which declares 8% reduction during 2008-2012 from the 1990 level.[8] This target is included in European Climate Change Programme (ECCP) which adopted F-gas regulation directions specified in Directive 2006/40/EC (MAC Directive[9]) and Regulation (EC) No 842/2006. It is used as a mid- and long term target for the operation of the EU wide F-gas management processes. In 2007, individual member state's F-gas regulation started based on these targets. In 2007-2008 periods, ten European policy sub-categories and various technical requirements are established and enacted. These step by step guidelines are applied to all member states and individual state's internal legislations sequentially proceeded.[10]

These reduction target and accompanying regulations are reiterated in EU's GHG related decision of 2009, relating to the overall GHG mitigation program for non-ETS sectors in EU.[11] In decision of 2009 (406/2009/EC), it is specified that explicit regulations should be set for the greenhouse gases from non-ETS sectors.[12] In addition, based on the effort sharing principles specified by the decision

8) European Commission (2006a)
9) MAC means mobile air conditioning.
10) Gluckman Consulting (2015).
11) European Commission (2009a)
12) European Commission (2009a)

(406/2009/EC), member states should submit national reduction plans during 2012-2020 period for F-gases which are greenhouse gases not included in the ETS system.[13] PFC for the use of aluminum castings are excluded from this regulatio n.[14] According to this principle, a guideline is provided by which F-gas reduction target and implementation strategy are based on per capita GDP. We can understand that F-gas target has been determined as a broad burden-sharing framework among member states.

2. Regulatory Measures of 2006 Regulation

In 2006, several measures were initiated by EU. The objectives of EU's F-gas regulation (Regulation No 842/2006) of July 2006 are to reduce the emissions, to restrict the use, and to improve the storage and monitoring of specific F-gases. This regulation applies to HFCs (used for refrigerators, blowing agents, and cleaning solvents), PFCs (used for cleaning solvents, blowing agents, and semiconductor manufacturing processes), and SF6 (for magnesium production and heavy electrical equipment's). Major regulations include imposing duty of preventing leakage in use, control of use and ban on sales, reporting on labeling and related information, and certification system for recovery and treatment technicians and penalty system for non-compliances.

The most noteworthy policy tool is the specification of devices for ban and restriction. EU's F-gas regulation (Regulation No 842/2006) bans or restricts the use of F-gases for specific devices. It also requires measures to prevent leakage of F-gases from the devices and mandates the labeling on information regarding F-gases (category and quantity charged) and regulates on the certification scheme for an appropriate recovery of gases.[15] Regarding HFC, PFC, SF6 gases, there are

13) *Ibid.*

14) PFC emissions form aluminum casting is included in EU ETS.

15) EEA, Summary of Legislation, Reduction in fluorinated greenhouse gases, Regulation (EC) No

ban clauses for specific products and devices.[16] Air conditioner for automobile is one of the most important devices where F-gas is used. MAC Directive (Directive 2006/40/EC), regarding air conditioners for less than eight seater passenger cars and commercial automobiles with less than 3.5 ton capacity (category N_1), bans the use of refrigerants with GWP higher than 150 for newly approved automobiles by 2011, and for all automobiles by 2017.

Another important policy measures are imposing duties for users and reporting duties for manufacturers, importers, and exporters. Duty for users is as follows. First, the users of F-gas containers should recover the residual gases when the container is disposed. Second, the duty to recover F-gases contained in other devices by the appropriate certified technicians is also specified. Penalties are charged for the non-compliance of these regulatory obligations. However, although the user has the duty to recover the refrigerant, there are rules that the recovery should be feasible and without severely disproportionate costs.[17]

Reporting duties are imposed for manufacturers, importers and exporters. From March 2008, manufacturers, importers, exporters must report annually to the Commission the relevant information and its related organizations and details of fluorinated greenhouse gases.[18] Details are as follows. First, producers with more than 1 ton per year must report the total production quantity by use and total sales volume by gas type (including recycling, destruction, and reduction). In addition, importer over 1 ton per year should report imports or sales volume by use, including reduction, destruction and recycling volumes. Those who export

842/2006 (https://eur-lex.europa.eu/legal-content/EN/LSU/?uri=CELEX:32006R0842)

16) European Commission (2006b), Directive 2006/40/EC, 2006

17) European Commission (2006a), Regulation (EC) No 842/2006; Article 3 Containment, 1. Operators of the following stationary applications: refrigeration, air conditioning and heat pump equipment, including their circuits, as well as fire protection systems, which contain fluorinated greenhouse gases listed in Annex I, shall, *using all measures which are technically feasible and do not entail disproportionate cost*:

18) EEA, Summary of Legislation, Reduction in fluorinated greenhouse gases, Regulation (EC) No 842/2006 (https://eur-lex.europa.eu/legal-content/EN/LSU/?uri=CELEX:32006R0842)

more than 1 tons F-gases per year must report exports quantity by gas type, including recycling, destruction and reduction volumes. Each member state is required to establish an appropriate reporting system associated with the refrigerant.[19)]

The strategies to reduce F-gas emission in not confined to regulatory instruments. A voluntary approach is also used. For the semiconductor industry, voluntary reduction for F-gases including HFC-23, PFCs, SF6 and NF3 was agreed in 2011.[20)] In aluminum industry, PFC intensity is agreed to be reduced by 50% from the emission level of 2006 until 2020.[21)] F-gas regulations and reactions including voluntary agreements are derived as responses not only to official regulations of governments and intergovernmental institutions but also to the demands of NGOs including consumer groups and environmental activists.[22)] Refrigerators' refrigerants are scheduled to switch from HFC's to eco-friendly substitutes in new products and in the distribution sector, as the Consumer Goods Forum urged.[23)]

3. Performance Evaluation on F-Gas Regulation

Regarding the performance evaluation of EU regulation on F-gas, the Implementation Status is reported in an EU report (Report from the commission, 2011/9/26). This report states that it is basically successful with respect to the restriction of F-gas sales, with some exceptions due to administrative difficulties. Labeling measures has been applied very successfully in most countries. However, duties imposed on users are not fulfilled well. In certain countries, awareness is

19) *Ibid*
20) Schwarz et al. (2011)
21) *Ibid*
22) *Ibid.*
23) Consumer Goods Forum (from website)

low regarding responsibilities for users of small devices. Recovery of F-gases is improving and has large potential for further improvement. However, the report states that it is not easy to provide systematic assessments due to insufficient data. By 2010, member states with facilities for recycling, destruction and reduction of recovered refrigerants is only 50% in EU, only two or three states for SF6 in particular. Reporting obligations are met well in member countries. The penalty has been notified to the Commission in all countries except four Member States.[24)]

European Commission (2018) provided a renewed assessment on the performance of EU's F-gas reduction regulations. It concludes that thanks to the F-gas regulations in EU, around 3 million tons of CO2 equivalent was reduced as compared to BAU baseline. Regarding user's recovery duties, it is roughly estimated to have contributed to the reduction of 29 million tons by 2020, by the leakage prevention and recovery promotion effect of the regulation. MAC Directive is estimated to contribute to the reduction of 13 million tons of CO2 equivalent. F-gas is expected to be reduced by 28% until 2020, which is impressive compared to the reduction of below 3% in 2010.

It is remarkable that EU legislations and policy tools are consistently integrated across various mediums and industries, by focusing on F-gas reduction target. Korea's system lacks this concept of integration due to rigid legal system. EU's directives provide the limits on the total quantity of F-gas, with various measures including ban and restriction on discharge. Unlike Korea where the policies and laws are segmented to air quality, GHG, wastes, etc., a single directive regulates the whole F-gases.

4. New Regulation of 2015

A new Regulation, which replaces the first one of 2006 and applies from 1 January 2015, strengthens the existing measures and introduces a number of far-reaching changes.[25)] By 2030 it will cut the EU's F-gas emissions by two-thirds compared with

24) European Commission (2011)

2014 levels. Simultaneously, the total amount of major F-gases that can be sold in the EU will be phased down to one-fifth of 2014 sales in 2030.[26] The expected cumulative emission savings are 1.5 gigatonnes of CO2-equivalent by 2030 and 5 gigatonnes by 2050. By 2050, F-gas emission will be reduced by 50% from BAU baseline.[27]

European Commission (2018) posits that this represents a *fair and cost-efficient* contribution by the F-gas sector to the EU's objective of cutting its overall greenhouse gas emissions by 80-95% of 1990 levels by 2050.[28] These terms "fair' and 'cost effective' may be interpreted that F-gases are cost effective than other GHGs in reducing global warming potential. Based on this line of judgment, the MAC Directive prohibits the use of F-gases with a global warming potential of more than 150 times greater than carbon dioxide (CO_2) in new types of cars and vans introduced from 2011, and in all new cars and vans produced from 2017. This new reduction target is achievable at relatively low cost, as European Commission (2108) states. It is because climate friendly alternatives are readily available for many of the products and equipment in which F-gases are commonly used today.

The most recent policies regarding F-gas are as follows. The use of F-gases are banned in many new types of equipment where less harmful alternatives are widely available, such as fridges in homes or supermarkets, air conditioning and foams and aerosols. To prevent emissions of F-gases from existing equipment, several measures are required: checks, proper servicing and recovery of the gases at the end of the equipment's life.[29] While the new Regulation repeals the

25) European Commission, Regulation (EU) No 517/2014 of the European Parliament and of the Council of 16 April 2014 on fluorinated greenhouse gases and repealing Regulation (EC) No 842/2006 (Text with EEA relevance), Official Journal of the European Union, 2014

26) European Commission (2018)

27) *Ibid.*

28) *Ibid.*

29) These measures will build on and benefit from the successful phase-out of ozone-depleting substances which was achieved in the EU 10 years ahead of the internationally agreed schedule

original Regulation from 2006, the 10 implementing Regulations adopted under the original Regulation remain in force and continue to apply until new acts are adopted.

The proposed reduction is largely dependent on the quota system. Quotas are required for the import and production of bulk HFCs. HFC quotas are allocated based on a company-specific reference value (determined every 3 years) and/or based on an annual declaration of (additional) anticipated needs from a quota reserve. Transferring bulk quota from one company to another is allowed through the HFC Registry, accessed via the F-gas Portal,[30] operated by European Commission. In EU, although F-gases are included in EU-ETS, European Commission is more concerned with reducing F-gas emission with traditional regulatory measures instead of resorting to emission trading system. Rather, EU designed separate "EU market" on HFCs, including the transferring of HFC quotas on import and production of F-gas.[31]

ECODES, EIA, et al.(2018) concluded that the HFC phase-down is operating as intended, with prices increasing to around 20 Euros per CO2e ton, well within the range considered reasonable climate mitigation for these sectors. For more effective HFC control, they proposed the followings. In addition to this evaluation, ECODES, EIA, et al.(2018) proposed the following: mandatory training on natural-refrigerant, stop installing equipment relying on certain HFC chemicals, use of public procurement to promote the uptake of climate friendly alternatives in air-conditioning and catering facilities (refrigeration) in public buildings, financial and other incentives for small and medium sized end users to adopt low-GWP technologies, and an HFC licensing system without delay, as required under the Kigali Amendment to the Montreal Protocol.

30) European Commission (2018)
31) *Ibid.*

5. Summary of Regulatory Instruments for F-Gas in EU

During the last three decades, CFC and HCFC phase out programs under the Montreal Protocol are the main influencing factors for F-gas markets. Another important factor in the F-gas market is the certification system, which requires certifications/attestations for personnel and companies dealing with F-gases. Containment and recovery systems are also important, for which the systematic operation of enforcement and control is essential. Reporting obligations are well-established in most countries.

Labeling is used mostly in the sector of stationary air conditioning and refrigeration including heat pumps. Compliance with labeling is fairly good among large manufacturers. Another mode of regulation is bans. Bans are considered the most effective type of measure since they resulted in significant and measurable reductions in the use and emissions of F-gases. Following tables summarize various regulatory instruments to control F-gases in Europe. Recently introduced transferable quota system is considered economic instruments, though applied to import and production, instead of emissions.

Table 2. Command-and-control in EU countries: Recovery and Destruction, Leakage control and standard

Mandatory recovery and destruction	Regulation No 842/2006 Mandatory recovery, destruction by certified personnel (household electric appliances, VAC (Ventilating, and Air Conditioning)), Comply destruction standards (2006) Regulation No 517/2014 (effective 2015) - End-of-Life regulation - To prevent emissions of F-gases from existing equipment, several measures are required: checks, proper servicing and recovery of the gases at the end of the equipment's life
Leakage control and test	Regulation No 842/2006 - Mandatory leakage test, repair, F-gas GHG more than 3kg of refrigerants (VAC)
Leakage Standard	No specific standards

Source: Schwarz et al (2011), European Commission (2018), European Commission (2014)

Table 3. Command-and-control in EU countries: Qualification, Reporting, Labeling, and Product Ban

Qualification	Regulation No 842/2006 - Recovery of refrigerants only done by personnel and companies with license
Reporting	Regulation No 842/2006 - Producers, importers, exporters of F-gas over one ton should report annually
Labeling	Regulation No 842/2006 - Producers should present refrigerant information on the surface of products or components
Product ban	MAC Directive 2006/40/EC - Ban refrigerant of over-GWP 150 from 2011 for new cars, all vehicles from 2017 Regulation No 517/2014 (effective 2015) - Use of F- gases banned in new types of equipment where alternatives available - e.g., fridges in homes or supermarkets, air conditioning and foams and aerosols

Source: Schwarz at al. (2011), European Commission (2018), European Commission (2014)

Table 4. Economic instruments in EU countries

F-gas emission trading system	Directive 2009/29/EC - aluminum industry from 2013, including PFC - Other F-gases: no specific yet by 2020, but may consider in ETS in the future - HFC-23: can be included as credit of offsets such as CDM etc
Deposit refund	No EU regulation By individual countries - Denmark, 1992; Sweden, as a producer liability, 2007)
Tax	No EU regulation By individual countries - Slovenia, 2009; Denmark, 2001; Norway, 2003 - Sweden, under consideration of tax on HFC production and import - Poland, proportional tax on F-gas use
Quota (transferable)	Regulation No 517/2014 (effective 2015) - Quota is imposed to - for Importers/producers - Trading is not explicitly allowed, but transfer is facilitated by the F-gas Portal.

Source: Schwarz et al .(2011), European Commission (2018)

Ⅳ. Review of Korea's Legal System on F-Gas Control and Comparison with EU

1. Review of Korean Legal System for F-gases

Korea's regulatory measures towards F-gas are classified by three dimensions: legislative hierarchies, gas types, and the type of policy instruments. By legislative hierarchies, Korea's F-gas measures are derived from general higher legislations, air quality related laws, and industry related laws. By type of F-gases, measures are related to PFC, SF6, and HFC. By industry, they are related to electric and electronic, display, and VAC (ventilating and air conditioning) industries. By policy instruments, the measures are classified into command-and-control, economic instrument, and voluntary agreement. F-gas related clauses in Korean legal system are classified and summarized in the following table.

Table 4. F-gas related Clauses in Korean Legal System

Laws	Control Area			Comments
	production	Use	Disposal	
Basic Law for Green Growth	V	V	V	Suppressing the use of hazardous substances or substances which are difficult to remanufacture or reuse. - Basic Plan for Combating Climate Change - Emission Trading Scheme - Target Management System - ETS and TMS include F-gas.
Act on the Allocation and Trading of Greenhouse-Gas Emission Permits	V	V	V	F-gases are included in emission trading. However, emission trading only applied to large emitters, so HFC, mostly leaked by numerous scattered users are excluded in emission trading in fact.
Basic Law for Resource Circulation			V	General statements for all wastes regarding the status of "resource" rather than "wastes" F-gases contained in wastes may be considered as resources by this law.

Clean Air Conservation Act (CACA)		V		Only for refrigerants for refrigeration and air conditioning equipments - Amendment of CACA in 2013 has strengthened the duties relating to the treatment and management of refrigerant gas management related to air conditioner - - CACA amendment of 2017(effective 2018) strengthened the control duties and extended the coverage of the refrigerant users.
Waste Control Act			V	Allies to refrigerants for home appliances
Act on the Resource Circulation of Electrical and Electronic Equipment and Vehicle (ARCEEV)			V	Waste gas treatment operators are charged with the responsibility to recycle or safely dispose of climate-change-causing substances. - Article 25 (2,5) Automobile subcontractors are required to separate and store climate change causing substances - Article 27
Act on the Promotion of Saving and Recycling of Resources(APSRR)			V	Applied when F-gas is generated in sectors other than electricity, electronics, and automobiles which are subject to ARCEEV.
Act on Control etc. of Manufacture of Specific Substances for the Protection of the Ozone Layer	V			Only for ODS (which are NOT F-gases)
High-Pressure Gas Safety Control Act	V	V		Only for high pressure gases (sometimes F-gases included)

Korea's legal and regulatory systems are intended to regulate F-gases (substances which incur climate and ecological system) at various phases of use, destruction, and recycling by using wide ranges of acts and ordinances. The regulatory systems for Korea's F-gas emission, however, are considered to lack in comprehensive and integrated control scheme, mainly because the legal system is not well organized to

allow a centralized control authority. Therefore, there is a possibility of loopholes and overlaps in regulatory practices. This lack of integration is partially related to the lack of incentive for users and other related agents, because the loopholes and duplications in jurisdictions make the enforcement incomplete.

There has been little regulation at the production stage of F-gas in Korea until 2018. In the amendment of CACA in 2017(effective 2018), new regulations at the production/stage are introduced. Any person who manufactures or imports refrigerants shall notify the Minister of Environment regarding the type, quantity, and sales location of the refrigerant as required by the enforcement (CACA Article 76(14)). In addition a new provision facilitating the efficient management of F-gases by installing and operating a refrigerant information management computer network in accordance with the Environment Ordinance for efficient management of sales, collection and processing of refrigerant (CACA Article 76(15)).

At the consumption stage, mainly Clean Air Conservation Act (CACA) has related clauses. It was 2012 when refrigerants related clauses are included in CACA amendment. However, there are ambiguities in scopes of F-gases between CACA and Waste Control Act (WCA), and linkages between them are unclear, although CACA is basically considered to apply to all F-gases. Therefore, it has been considered necessary to enact a measure, including enacting a new law, to enhance the degree of integration in controlling F-gases. But such a measure has not taken so far. Instead, a new amendment was made on CACA in 2017. To strengthen the management of the refrigerant emission source, the range of the refrigerant-use equipment to be managed is extended from the air conditioner to the equipment that uses refrigerant for industrial use, refrigeration and refrigeration. Before this amendment only equipments for buildings are subject to this standard.[32] The CACA regulate the owner or manager of the air conditioner with charge capacity larger than 50kg shall check on leakage

32) In the new amendment of 2017, which is effective in 2018, articles 9(3) and 9(4) are deleted and new articles are added in chapter 2 of 5, articles 76 (9) to 76(15).

every year and shall recover the refrigerants by using the special equipment when the equipment is disposed or moved, by themselves or by consignment to specialized recovery agents.[33] Management standards are provided by CACA on the refrigerant discharged from equipment using refrigerant for cooling and heating of buildings, refrigeration and freezing of food, and other industrial purposes. In an enactment of subordinate ordinances (MOE enforcement rules) to the 2017 amendment (effective by November 2018), the followings are added or amended. Regarding the compliance and enforcement at the consumption stage, to those responsible for the control of F-gases, fine (less than one million Korean won) can be imposed by Article 94 of CACA if they do not properly manage, recover, or process the refrigerant

Another one is the introduction of the refrigerant recovery agent registration system (Article 9 (6) newly added). Echoing various demands and discussions and referring to foreign country's systems, the Korean government announced to introduce a refrigerant recovery agency system in 2017. The introduction of this system is included in the amendment of the Clean Air Conservation Act. The main contents of the amendment relating to refrigerant management are the registration system of the refrigerant recovery agents and the reporting duty of sales volume (section 11 of article 76 to section 14 of article 76 and section 12-3 to section 125 of article 91). The requirements of refrigerant recovery companies are specified and detailed information on technical personnel training is provided. When a refrigerant is recovered, the refrigerant recovery company must issue a refrigerant recovery result sheet and issue it to the worksite that requested the recovery. The registered technical manpower (refrigerant recovery technicians) must write it manually. The law will come into effect on November 29, 2018, and the Ministry of Environment has announced the enactment of the Enforcement Decree of the Clean Air Conservation Act and the Enforcement Rules, which will strengthen the management of refrigerants. As the amendment is effective, refrigerant management will be further strengthened, minimizing refrigerant leaks, and

33) Enforcement Decree of CACA Article 14(5)

contributing to the reduction of greenhouse gas emissions by improving the recovery rate by professional recovery agents. The refrigerant recovery is required to be made by a professional recovery agent instead user-emitters, and the standards of the agency were strictly specified.

However, in these laws and regulations, it is not certain whether the refrigerant recovery agent receives the compensation proportional to the quantity recovered. The economic incentive to increase the recovery rate of the refrigerant is vague. The recovered refrigerant may be reused with economic value but it is unclear if it is greater than the cost of refrigerant recovery and if the incentive for one additional unit of refrigerant is less than the marginal cost of one unit for the refrigerant, the recovery agents would have very low incentive to recover the refrigerants. Therefore, an effective recovery is not guaranteed. [34)]

Disposal, destruction and treatment stage is the most important stage in controlling F-gas. Wastes Control Act (WCA) and Act on the Promotion of Saving and Recycling of Resources (APSRR) are major relevant laws in this stage. CACA is applied to VAC (ventilating and air conditioning). The waste refrigerants recovered from the waste air conditioner, the waste electrical and electronic products and the waste automobile are subject to the Waste Control Act.[35)] The recovered waste refrigerant material should be handed over to the waste recycling contractor or the waste disposal contractor to be refined and reused or disposed of it at a rate of 99.9% or more.[36)] Act on The Resource Circulation of Electrical and Electronic Equipment and Vehicle (ARCEEV) refers to the electric and electronic products (waste refrigerators,) and automobiles (passenger cars, passenger cars with less than 9 passenger cars, freight cars light & compact). It is obligatory to collect and process the refrigerant at the time of disposal

34) The amount of recycling (2013 ~ 2017) reported by the installation and operation of the air conditioner over charging capacity of 100kg are 861 tons, equivalent to 1.16 million tons of CO2 (Ministry of Environment (2017)).

35) Enforcement Decree of Waste Control Act Schedule 4

36) Enforcement Decree of Waste Control Act Annex 4, Annex 4 and Annex 5

of the product including the refrigerant. The newly amended laws have improved clauses.

Korea has recently passed various legislations relating to refrigerant management at the disposal stage, such as the clauses in the Wastes Control Act, the Act on Control of the Manufacture of Specific Substances for the Protection of the Ozone Layer, the Clean Air Conservation Act, and the Act on Resource Circulation of Electrical and Electronic Equipment and Vehicles. However, as of 2015, reports indicate that these regulations have not been followed effectively due to the lack of a specific system relating to the phased management of production, use, and disposal of refrigerant materials.[37] Korean laws and regulations designate the parties who are responsible for the recovery, transfer, and processing for every product group that uses refrigerants. For instance, the refrigerants recovery agents by CACA amendment of 2017 (effective 2018) are entitled to work on the refrigerants defined by the CACA (for buildings and food refrigerating facilities, etc.). Thus it can be a factor that makes it difficult for the government to manage and supervise the recovery and process of refrigerants at the disposal stage. Business sector complains that there are significant hurdles for the incumbent treatment firms to enter the official F-gas treatment sector due to problems in storage facilities and licenses for transportation, etc.

Recycling rate of F-gas is low in Korea. APSPR enforces the recycling centers to recover F-gases, but the number of certified recycling centers with appropriate facilities is not sufficient. Most wastes containing F-gas go to private recycling centers where facilities are not systematic and efficient. Since some components of F-gas containing wastes (including air conditioner), such as copper cords, are very good in resale prices, private recyclers had just collected valuable components and disposed the wastes without appropriate recovery measures for F-gases. Since the CACA of 2018 has a specialized recovery agent clause, the situation could be improved. However, it is the

37) Myung et al. (2015)

fact that there used to be no incentive to recycle F-gas. It is needed to have a systematic management system for F-gas with economic incentives with legal provisions. Despite of the existence of mandatory appropriate F-gas treatment clauses in the law, compliance and recycling rates are very low due to weak penalty scheme, inefficient regulatory authority and organizations. The rates are very low in air-conditioning refrigerant in vehicles in particular. One of the reasons behind this high non-compliance rate is due to the low level of integration among various sectors and jurisdictions. It is necessary to perform a careful review of current complicated and decentralized F-gas management system. There is no F-gas specific target declared in any government program.

2. Comparison of EU and Korean F Gas Leakage Control System

Amongst the differences between EU and Korea, the most prominent one is the degree of integration among various sources and gases and sectors under the name of F-gas. EU's new regulation, which applies from 1 January 2015, strengthens the existing measures and introduces a number of far-reaching changes. By 2030 it is expected to cut the EU's F-gas emissions by two-thirds compared with 2014 levels. This is considered as "fair and cost-efficient" contribution by the F-gas sector to the EU's objective of cutting its overall greenhouse gas emissions by 80-95% of 1990 levels by 2050. Korea also has a similar target. However, Korea's target is not classified under the title of F-gas. Targets for F-gases are scattered through various sectors. Ministries of the Korean Governments (2014) set the reduction target for the electronics and electrical equipment sector, where F-gases are massively used. It has a reduction target for electronics and electrical equipment sector focused on the reduction of F-gases which states that SF6 is reduced by 49.4% and HFCs are reduced by 10.9% compared to BAU in 2020. For the latter the legal basis is referred to as the Act

on the Resource Circulation of Electrical and Electronic Equipment and Vehicle. Even in the government's roadmap, F-gases do not have separate categorical status. Office of Government Policy Coordination (2016) announced that by 2030, F6 used in the display sector's LCD process will be replaced by NF3, and scrubbers to disintegrate SF6 and CF4 will be installed. Korea will reduce the emission of GHG 10.6 million ton CO2e by using substitutes for refrigerants for refrigerators and air conditioners until 2030. These are also scattered in the 2030 Roadmap and have no integration among them.

Regarding the reporting duty, Korea enforces to report and keep record for disposes of refrigerants for businesses over a certain standards (revised Waste Control Act and CACA, etc.), while EU has a very strict reporting duty regulation. Mandatory destruction and recovery are imposed to the users of F- gas in EU countries. However, in Korea, it is not strict. F-gas management system for importers and producers has lacked until recently. It is only in the amendment of CACA 2017 (effective 2018) that the management duties of importers and producers of F-gas are enacted. By adding a provision for electronic F-gas management system in the 2017 amendment of CACA, there is a possibility to run a quota system just like the EU's transferable quota system. Fines for the non-compliance are set 1,000,000KRW in CACA, but it is not certain how many violations are detected and whether this amount of fine is appropriate to deter the non-compliances. Even in EU and other more developed countries, the non-compliances exist extensively. However, EU's legal system has evolved towards more incentive compatible system, although not perfect. Regarding duty to recover and destroy, Korea has clauses for refrigerants for autos and home appliances (some refrigerators) to be recovered. EU has strict regulations on the duty to recover and destroy F-gases. It is recommended to strengthen the enforcement on the duty to recover and destroy and improve the management system. In some sense, Korea is following the EU's trace in many respects, but degree of integration is still at low level.

Currently, Korea's environmental regulation is not governed by a single integrated

law for the purpose of F-gas (including refrigerants) control. Instead, they are governed separately by the CACA's refrigerant control clauses and the ARCEEV and other laws. As the objective of these laws is described somewhat unclearly as "efficient use and management of resources" or "prevention of air pollution", there are many cases that several major product and industries using or processing F-gases including refrigerants are omitted or neglected in the legal system. In EU, by enacting separate regulations aimed at F-gas as a whole, including refrigerant substances, regulations are designed to avoid the problem of missing certain products, unlike Korea where the product- or industry-based regulations are in operation. Even in the ARCEEV, buses, trucks (large), ships, trains, and refrigerated cars were excluded from the scope of regulation. Therefore, the major facilities and products such as commercial refrigerator and freezer are omitted from the scope of control under the current law.[38)]

Regarding deposit/tax, none of such programs or schemes is in operation in Korea. In EU, several economic incentives are in operation in some member states. EU-wide adoptions of economic instruments do not exist for F-gases emissions. However, EU recently introduced transferable quota for F-gas import and production. This should be considered as an economic instrument, although there is no official report how these quotas are traded and how they contribute to the enhancement of economic efficiency.

The cause of this problem of inconsistency, or lack of integration in F-gas control in Korea, is that fluorinated greenhouse gases are distributed in different products and service sectors that produce and consume fluorinated greenhouse gases, and at different stages in each life cycle. For example, carbon dioxide from fossil fuels is emitted in the combustion process and the calculation is relatively simple. The cause of this problem is thought to be underestimation of the importance of fluorinated greenhouse gas in terms of GWP and excessive administrative supervision cost. However, in the case of the EU, it is demonstrated that such administrative complications can be overcome by introducing an integrated approach at the outset of

38) Myung et al. (2015)

the planning stage, not only in the regulatory stage. In the long term, it is necessary and desirable to have the separate reduction target for F-gas in Korea, apart from the industry-specific targets. It is also desirable to designate the responsible organization that can manage and regularly report on them and make sure that the laws and regulations are constantly supplemented. If necessary, to have a consistency in F-gas control for the lifecycle, we need to have a new law such as "Integrated F-Gas Control Act" to control leakage from the operation and use of F-gases, which should include leakage standard with sufficient economic incentives.

Ⅴ. Summary and Conclusion

It is observed that Korea's micro-level policy tools follow EU with a time lag. However, in terms of integration, it is still scattered and decentralized. Despite the recent amendment of CACA and other related clauses in various laws and regulations, F-gas control system in Korea, lacks integration. Korea's new amendment of CACA seems to have adopted EU's policies to some degree. To overcome the difficulty in the efficient management of F-gas recovery and control, Korea introduced the refrigerant recovery agent system. This amendment is a kind of technical standard for the F-gas recovery agent so illegal and inappropriate disposal can be avoided. The amendment included the industrial users of refrigerants, as well as the VAC equipment owners of buildings to those who should follow the management standard for refrigerants. Despite this amendment, there are still many loopholes. Another aspect derived from the low level of integration is that not all F-gases are controlled by the Korean legal system and some gases in some sectors are virtually free from any regulation. It is questionable whether there is any incentive to diligent recovery activity of the business owners or the recovery agents. Korea's enforcement mechanism is not yet seriously examined, and the effectiveness is questioned. Although there are provisions such as

the penalties for violation of laws and regulations related to F-gases, there is no report or research on whether the violation is actually detected, whether the existence of the fine is really inducing proper treatment of F-gases, and whether they are applied on every stage of lifecycle of F-gases of production, use, and disposal and for every industry producing, using, and disposing F-gases.

EU's legislative structure is unique since it is a transnational entity rather than a single country. Because of this, the directives are effective only by separate legislation process by individual member states, called transposition. This characteristic is possibly the reason behind the higher level of integration in F-gas laws and regulation. At each member state level, the laws and regulations might be scattered and fragmented. In this case, it can be criticized that if Korea mindlessly follows the EU's integration and consistency at EU level, it could be a mistake. However, considering the seriously weak capacity in integration and coordination among ministries and institutions in Korea, pursuing integration in F-gas control is somewhat analogous to EU's effort given individual state's legal environment. Sometimes EU uses regulations which are directly effective rather than using directives which are only indirectly effective. This is analogous to the separate legislation of F-Gas control Act, and amending existing laws and legislations and assigning duties to each ministries and institutions. Our conclusion is that EU's uniqueness as a supranational entity does not hinder the application of EU system to Korea. Rather, the uniqueness may possibly help the applicability of EU laws to Korea.

A comprehensive F-gas control measure at any level deserves a serious consideration. If necessary, to have a consistency in F-gas control for the lifecycle, we need to have a new law such as "Integrated F-Gas Control Act" to control leakage from the operation and use of F-gases, which should include leakage standard with sufficient economic incentives. Of course, this law should direct the establishment of a separate F-gas reduction target and implementation strategies.

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【국문초록】

EU 와 한국의 불소계 온실가스 관리 법체계 비교 연구

한택환 · 임동순

본 논문은 불소계 온실가스 규제에 관한 EU와 한국의 법적 제도적 구조를 검토하고 비교하였다. EU의 불소계 온실가스 배출량을 줄이기 위한 다양한 지침과 규정, 프로그램 및 이니셔티브를 검토하였으며, 한국의 관련 법과 정부 정책을 검토하고 EU의 지침 및 프로그램과 비교하였다. 이에 따라 통합, 집행 및 인센티브의 관점에서 양국의 법과 제도의 성격을 규명하고자 하였다. 우리나라의 불소계 온실가스 규제를 위한 법규는 시차를 두고 EU를 따라가고 있는 것으로 관측되고 있다. 그러나 이는 미시적 수준에 그치고 있다고 판단된다. 최근의 대기환경보전법 및 기타 관련 법률의 개정에도 불구하고 한국의 불소계 온실가스 규제 법체계의 최대 문제점은 통합성의 부족이라고 할 수 있다. 최근의 대기환경보전법 개정법률에는 냉매의 관리 기준 준수의무자의 범위를 확장하고 냉매회수 전문업체제도를 도입하였는데 이는 불소계 온실가스 관리의 유효성과 경제적 효율성을 제고하는 데에 일정 부분 기여할 것이다. 그러나 여전히 한국의 법률 시스템에 의해 명확히 규제되지 않는 일부 가스와 산업분야가 존재한다. 또한 피규제자의 배출감소 노력에 대한 경제적 보상이 미약하고 규제 위반에 대한 제재의 유효성에도 의문이 존재한다. 이러한 여러 문제점들은 불소계 온실가스에 대한 별도의 감축목표 설정을 포함한 감축전략을 종합적으로 관장하는 법률적 장치의 마련으로 해소될 수 있으며 EU 의 법체계는 중요한 참고사항이 될 것이다.

주 제 어 불소계 온실가스, 법체계의 비교, 한국, EU, EU 지침, EU 규정, 법체계 비교, 대기환경보전법, 자원순환법, 폐기물관리법

Key Words F-Gas, Comparison of Legal System, Korea, EU, Directives, Regulations, Clean Air Conservation Act, ARCEEV, Waste Control Act