

Feasibility Studies on Joint Crediting Mechanism Projects towards
Environmentally Sustainable Cities in Asia

Strategic Promotion of Recovery and Destruction of
Fluorocarbons

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I. Summary

In Asian countries, large amount of freezers, refrigerators, and /air-conditioniners have been spreading with the economic development. The fluorocarbons are used as refrigerant in the equipment and are recognized as ozone layer depletion substances and GHG gases. Today, fluorocarbon collection and destruction are carried out in many developed countries including Japan. However, no country has this scheme in developing countries in Asia now, and it is thought that most of the fluorocarbons are discharged into the air. The situation that those countries have no system of fluorocarbon collection and destruction results in continuous negative impact on efforts to prevent the global warming.

On this point, Japan has accumulated knowledge, and if the fluorocarbons management system which is acceptable to the targeted countries is established, destruction of fluorocarbons will bring about big GHG reduction effect. In addition, by promoting collection of End-of-Life (EOL) products and replacing them with the latest energy efficient appliances (technologies which Japanese manufacturers own), the direct effect of energy consumption reduction and GHG reduction effect can be expected. Moreover, by proper collection and disposal of EOL equipment, environmental pollution can be prevented and the energy consumption associated with remediation of environmental pollution will also be reduced. Furthermore, several additional benefits can be expected such as the advantageous sales promotion of Japanese products with high environmental performance and active involvement in metal recycle associated with E-waste recycle.

This project was aimed at Indonesia, Malaysia, and Thailand, whrere highly accumulated population results in advantage on effective establishment and management of fluorocarbons collection system, and establishment of the E-waste recycling system is under consideration.

In Japan, the measures for reduction and destruction of fluorocarbons are managed under the system shown below. Especially, laws for the recovery and destruction of fluorocarbons (CFC, HCFC, HFC) are enacted depending on the type of equipment which contain fluorocarbons, and each recovery and destruction system was established on these bases.

- Fluorocarbon recovery and destruction laws: business-use freezer, refrigeration equipment, and air-conditioning equipment
- Home Appliance Recycling Law: household air-conditioners, refrigerators, etc.
- End-of Life Vehicle Recycling Law: automobile air-conditioners

Japanese home appliance and automobile recycling are performed as a comprehensive system at the highest level in the world, and this is also the same with the destruction of fluorocarbons. About the facility and infrastructure for destruction, if such facility can be built in the target countries, utilization of Japanese know-how on the operation of the destruction facility is also expected. Moreover, Japanese manufacturers have advantage on the sector of the products containing fluorocarbons, such as refrigerator, air-conditioner, and automobile. So considering the replacement products associated with this project, Japanese technologies will be utilized in the whole framework of the project including social system for proper management of fluorocarbons.

Study on Target Items

Study was conducted on distribution status of equipment containing fluorocarbons, flow of EOL equipment, and associated prices in the target three countries. In any of the three countries, the detailed inventory survey of used fluorocarbons has not been conducted until now, but the amounts of fluorocarbons contained in used devices are estimated in this survey. In addition, the investigation on the situations of air-conditioning and refrigeration equipment at the commercial building in the major cities in Malaysia is also conducted.

Study on Manufacturers of Equipment Containing Fluorocarbons

Some manufacturers who produce air-conditioners in Thailand recognize the needs of facilities for proper destruction of fluorocarbons there. Although the legal system of E-waste recycling is being considered in three target countries, and the importance is recognized by the manufacturers, it is difficult for an individual company to deal with, and the government is expected to take the initiative for proper management of E-waste and fluorocarbons. As for fluorocarbon destruction and E-waste recycling, cost sharing is the big issue, which requires discussion among stakeholders. The investigation of manufacturers' service center was conducted to understand the flow of broken or EOL products.

Study on Destruction Facilities

In Indonesia, only one cement company is actively working on the destruction of fluorocarbons, and the destruction amount is small because of high processing costs and lack of systems to promote destruction of fluorocarbons. It is necessary to work on a strategy combined with the collection system in the future.

Thailand has one company which destroy fluorocarbons generated from the own facility, but there is no facility that accepts and destruct fluorocarbons as a business. Since there are some incineration facilities operating in Thailand, in order to establish collection and destruction system of fluorocarbons, it is effective to validate the effects, technologies and management methods by conducting pilot destruction with utilizing Japanese knowledge.

In Malaysia, fluorocarbons are destructed in the hazardous waste disposal facility, but the amount is limited. There are also cement plants in Malaysia, and it is necessary to considere their utilization for the potential destruction facility.

Study on the Local Governments and Local Authorities

In the three target countries, the main focus is on the implementation of their national phase-out plan for fluorocarbons. They are interested in destroying fluorocarbons but they don't have much motivation to actively promote it in the present circumstances. Therefore, for the promotion of the collection and destruction, awareness raising activities can also be an effective approach. In the three target countries, the government agencies in charge of waste management are interested in establishment of legal system for the recycling of E-waste. As the destruction of fluorocarbons contributes to proper disposal of air-conditioning equipment containing fluorocarbons, it is important to obtain understanding on the comprehensive effect of proper management of fluorocarbons.

Consideration on Future Project

In Thailand, the industrial estates authority (IEAT) hold jurisdiction over the Industrial Estates within the country, and Japanese manufacturers of home appliances, automobiles, etc. are also located within these Estates. Promotion of the project targeting these Estates will allow us to take comprehensive and intensive actions on multiple companies within an Estate, so we can also expect that we can actually collect the substances effectively. In addition, by combining with the spread of energy-saving equipment in the future, we can make the Estates more

environmentally friendly and low-carbon. That may result in creating needs in Thailand, which aim to make the Estates environmentally friendly.

By collaborating with large shopping malls and small retailers which have networks through their chain stores, we can expect that the project may lead to energy-saving efforts at a commercial-facility level as well as effective collection of fluorocarbons.

For home appliances, currently no system for collecting home appliances such as air-conditioners has been established, so effective collection of such items is expected to be difficult. In order to construct a footing for future development, the immediate approach seems to be implementation of seminars for government organizations such as PCD and local authorities to disseminate ideas and raise awareness.

For the destruction of fluorocarbons it will be useful to conduct pilot destruction by utilizing Japanese knowledge at the incineration facilities in Thailand to deepen the understanding of the local government officials and to validate their use in the future.

In Malaysia, for fluorocarbon in industrial equipment, in collaboration with fluorocarbon reconditioner who collects fluorocarbon for reclamation purpose from business sector, it may be considered to collect fluorocarbon which was accepted by the reconditioner due to its inappropriate quality for reclamation.

By cooperating with the industry association that consist of air-conditioning / refrigeration apparatus manufacturers, the approach to the government from the industry side can be expected and it may be possible to lead to large development.

For household appliances, currently there is no mechanism of EOL equipment flowing into the recycler with proper license (SW110), and future system design as a country will be an important requirement. Although not much amounts are treated by the proper recyclers at present, in order to promote proper management of EOL equipment and fluorocarbons, the cooperation with those proper recyclers is required. Since air conditioners require specific technology, they are managed by expert company. As the expert company collects air conditioners (broken products) intensively, fluorocarbons may be collected from those which cannot be fixed. The expert company can be considered as future fluorocarbons collection point.

For fluorocarbon destruction, it is necessary to validate the costs, methods etc. concretely for utilization of cement plants in Malaysia, or destruction in Japan as an option.

In Indonesia, it is necessary to understand present flow of fluorocarbon for future fluorocarbon recovery. It is necessary to investigate the point where a large amount of fluorocarbon gathering currently.

For destruction, practical use of the existing facility and local Japanese companies, and export to Japan are considered. For collection, in the detailed feasibility study of next year, cooperative system with industry group related to air-conditioning equipment and universities is established, the method to promote efficient and spontaneous collection is selected, and business framework is established. In addition, collaboration with the project whose target is replacement of energy saving products is sought.

Points of Concern

It is key point that the target equipment is treated as E-waste when it comes to end of life stage. Although it is not carried out now, when such E-waste recycle comes to be carried out in these countries in the future, it is necessary to clarify the meaning of fluorocarbons destruction. In this sense, the effort in G-G base is required. From now on, it is necessary to consider the measures to introduce the incentive fluorocarbons destruction or proper replacement of energy-saving apparatus. In addition, through awareness raising activities, it is important to raise the recognition of effort and significance of the effect of proper management of fluorocarbons in target countries.

II. Results

1. Background and Objective

In Asian countries, large amount of freezers, refrigerators, and /air-conditioniners have been spreading with the economic development. The fluorocarbons are used as refrigerant in the equipment and are recognized as ozone layer depletion substances and GHG gases. Today, fluorocarbon collection and destruction are carried out in many developed countries including Japan. However, no country has this scheme in developing countries in Asia now, and it is thought that most of the fluorocarbons are discharged into the air. The situation that those countries have no system of fluorocarbon collection and destruction results in continuous negative impact on efforts to prevent the global warming.

On this point, Japan has accumulated knowledge, and if the fluorocarbons management system which is acceptable to the targeted countries is established, destruction of fluorocarbons will bring about big GHG reduction effect. In addition, by promoting collection of End-of-Life (EOL) products and replacing them with the latest energy efficient appliances (technologies which Japanese manufacturers own), the direct effect of energy consumption reduction and GHG reduction effect can be expected. Moreover, by proper collection and desposal of EOL equipment, environmental pollution can be prevented and the energy consumption associated with remediation of environmental pollution will also be reduced. Furthermore, several additional benefits can be expected such as the advantageous sales promotion of Japanese products with high environmental performance and active involvement in metal recycle associated with E-waste recycle.

This project was aimed at Indonesia, Malaysia, and Thailand, whrere highly accumulated population results in advantage on effective establishment and management of fluorocarbons collection system, and establishment of the E-waste recycling system is under consideration.

In Japan, the measures for reduction and destruction of fluorocarbons are managed under the system shown below. Especially, laws for the recovery and destruction of fluorocarbons (CFC, HCFC, HFC) are enacted depending on the type of equipment which contain fluorocarbons, and each recovery and destruction system was established on these bases.

- Fluorocarbon recovery and destruction laws: business-use freezer, refrigeration equipment, and air-conditioning equipment
- Home Appliance Recycling Law: household air-conditioners, refrigerators, etc.
- End-of Life Vehicle Recycling Law: automobile air-conditioners

Japanese home appliance and automobile recycling are performed as a comprehensive system at the highest level in the world, and this is also the same with the destruction of fluorocarbons. About the facility and infrastructure for destruction, if such facility can be built in the target countries, utilization of Japanese know-how on the operation of the destruction facility is also expected. Moreover, Japanese manufacturers have advantage on the sector of the products containing fluorocarbons, such as refrigerator, air-conditioner, and automobile. So considering the replacement products associated with this project, Japanese technologies will be utilized in the whole framework of the project including social system for proper management of fluorocarbons.

2. Results of the Project (this fiscal year)

2.1 Outline of the study

Consideration was made on destruction of fluorocarbons (CFC, HCFC, HFC) contained in electric appliances, and EOL equipment/fluorocarbons collection system which is required for destruction of fluorocarbons.

- 1) Social system: establishment of social system for collection of EOL equipment which contain fluorocarbons (refrigerator, air conditioner, vehicle AC etc.), consideration of cost sharing, awareness raising in target countries and cities, and provision of incentives
- 2) Technology & Infrastructure: facility and system for extraction of fluorocarbons from each equipment and proper destruction of extracted fluorocarbons

This year, fact finding research was conducted to develop a grand design for pilot project which is planned to be conducted after next year.

As contents of this year, by utilizing existing research results and statistical data, current status of fluorocarbons and EOL products in the target countries were understood. In addition, interview and site visit to local government and manufacturers were conducted in order to confirm their opinion and needs. In all target countries, new legal system for E-waste management is under consideration. Therefore, among the above, this research put emphasis on collection system of EOL products and fluorocarbons.

2.2 Study on Target Items

Study was conducted on distribution status of equipment containing fluorocarbons, flow of EOL equipment, and associated prices in the target three countries. The result of the study is as follows.

i) Thailand

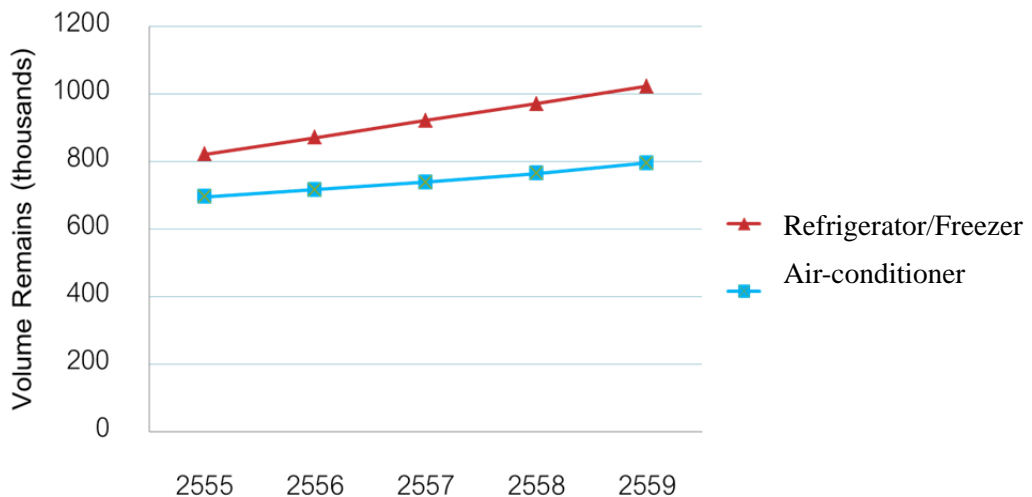
In Thailand, the detailed inventory survey of used fluorocarbons has not been conducted until now, but the amounts of fluorocarbons contained in used devices are estimated in this survey.

The survey found that some used FCs is collected for reuse purpose. However, most of FCs may be released in to the atmosphere due to its impurity. The data collected and estimated in the survey is shown below.

Table2-1 Spread Status of Equipment in Thailand

	Ownership among household (%)	Age of service (year)	Number of equipment owned by household
Air conditioner	40	5	0.5
Refrigerator/Freezer	95	6-7	1.3

(PCD)



(PCD)

Figure2-1 Generation Estimation of Used Air-conditioner and Refrigerator/ Freezer in Thailand

Table2-2 Estimation of HCFC to be Recovered

(unit: ton)

		Amount of Refrigerant Contained in Equipment in Operation		Amount of Refrigerant contained in End of Life Equipment	
		2010	2013	2010	2013
Room-air conditioner	HCFC-22	12,000	15,000	204	255
Commercial Refrigerator/freezing machine	HCFC-22	17,719	18,712	302	319
Chiller	HCFC-22	281	296	5	5
	HCFC-123	366	539	6	9

ii) Malaysia

In Malaysia, the detailed inventory survey of used fluorocarbons has not been conducted until now, but the amounts of fluorocarbons contained in used devices are estimated in this survey. In addition, the investigation on the situations of air-conditioning and refrigeration equipment at the commercial building in the major cities in Malaysia is also conducted.

The survey found that FCs are collected for reuse purpose. Malaysia has a lot of service centers run by manufacturers (e.g. 250 service sites for just one manufacturer) and also there are about 170 recyclers (SW110). Maintenance method of Malaysia is mainly exchange of FCs in each equipment. (Replacement of whole sets is main way in Japan, especially for household). EOL air conditioners are sold to scrap dealers since the scrap price is higher. The figure show current flow of air-conditioner in Malaysia and utilization status of air-conditioning and refrigeration equipment at the commercial building in the major cities.

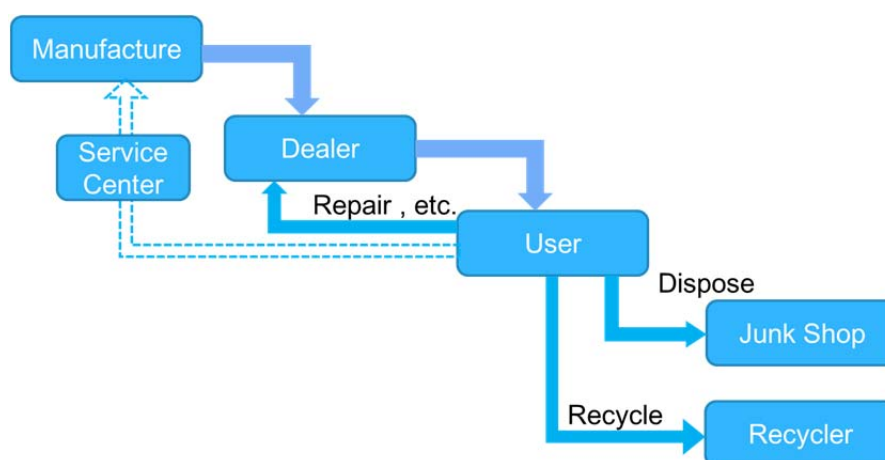
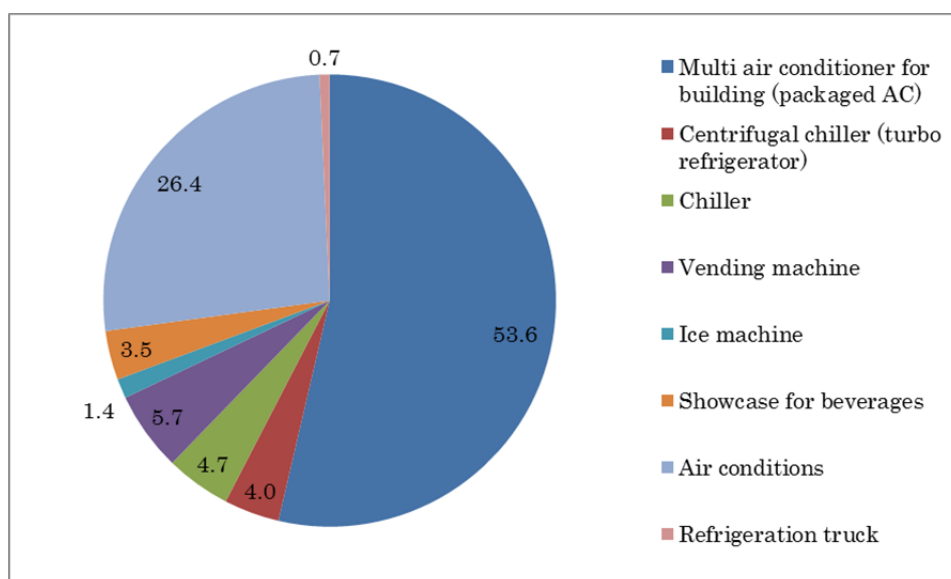


Figure2-2 Current Flow of Air-conditioner in Malaysia



(Data obtained from University of Malaya)

Figure 2-3 Utilization status of air-conditioning and refrigeration equipment at the commercial building in the major cities.

iii) Indonesia

In Indonesia, the detailed inventory survey of used fluorocarbons has not been conducted until now, but the amounts of fluorocarbons contained in used devices are estimated in this survey.

The survey found that some FCs is collected for reuse purpose. However, most of FCs may be released in to the atmosphere due to its impurity. Flow of E-waste in Indonesia is still unclear and need further investigation. The data collected in the survey is shown below.

Table 2-3 Estimation of HCFC to be Recovered

(unit: ton)

	Amount of Refrigerant Contained in Equipment in Operation		Amount of Refrigerant contained in End of Life Equipment	
	2010	2013	2010	2013
AC (stationary type)	15,347	20,427	261	348
Household Refrigerator	437	582	7	10
Commercial Refrigerator	3,090	4,113	53	70
Industrial Refrigerator	423	563	7	10
Transportation Refrigerator	364	485	6	8

2.3 Study on Manufacturers of Equipment Containing Fluorocarbons

Some manufacturers who produce air-conditioners in Thailand recognize the needs of facilities for proper destruction of fluorocarbons there. Although the legal system of E-waste recycling is being considered in three target countries, and the importance is recognized by the manufacturers, it is difficult for an individual company to deal with, and the government is expected to take the initiative for proper management of E-waste and fluorocarbons. As for fluorocarbon destruction and E-waste recycling, cost sharing is the big issue, which requires discussion among stakeholders. The investigation of manufacturers' service center was conducted to understand the flow of broken or EOL products.

2.4 Study on Destruction Facilities

In Indonesia, only one cement company is actively working on the destruction of fluorocarbons, and the destruction amount is small because of high processing costs and lack of systems to promote destruction of fluorocarbons. It is necessary to work on a strategy combined with the collection system in the future. In terms of transportation, potential exists to transport temperature exchange equipment and FCs by utilizing existing logistics for waste transportation.

Thailand has one company which destroy fluorocarbons generated from the own facility, but there is no facility that accepts and destruct fluorocarbons as a business. Since there are some incineration facilities operating in Thailand, in order to establish collection and destruction system of fluorocarbons, it is effective to validate the effects, technologies and management methods by conducting pilot destruction with utilizing Japanese knowledge. In terms of transportation, potential exists to transport temperature exchange equipment and FCs by utilizing existing logistics for waste transportation.

In Malaysia, fluorocarbons are destructed in the hazardous waste disposal facility (only one in Malaysia), but the amount is limited. There is a company which reuses refrigerant in Malaysia. Identification of FCs types and measurement of purity are also available. However, mixed FCs cannot be accepted for reuse. So the amount of reuse is very few. Also, there are cement plants in Malaysia, which have a possibility as a future FCs destruction facility with additional equipment. There is an example that FCs were exported and destroyed in other country by BtoB basis, but, there is no similar case about Japan.

2.5 Study on the Local Governments and Local Authorities

In the three target countries, the main focus is on the implementation of their national phase-out plan for fluorocarbons. They are interested in destroying fluorocarbons but they don't have much motivation to actively promote it in the present circumstances. Therefore, for the promotion of the collection and destruction, awareness raising activities can also be an effective approach. In the three target countries, the government agencies in charge of waste management are interested in establishment of legal system for the recycling of E-waste. For example, PCD in Thailand has been engaged in E-waste recycling in Thailand, and this is the same with DOE in Malaysia, and KLH in Indonesia. As the destruction of fluorocarbons contributes to proper disposal of air-conditioning equipment containing fluorocarbons, it is important to obtain understanding on the comprehensive effect of proper management of fluorocarbons.

3. CO₂ Reduction Effect

3.1 Estimation of CO₂ reduction amount

At the moment, detailed contents, target, and scheme of the future project plan cannot be defined. Therefore, estimation of Carbon Dioxide (CO₂) reduction amount is conducted based with some assumptions. In the future project, 5 collection points in each target country (200 unit/year, collection point) are assumed to be established. With this assumption, CO₂ reduction amount is estimated to be 1,488 tCO₂/year. If the assumption is also made on remaining amount of fluorocarbons in each EOL equipment as 50% of initial amount, CO₂ reduction amount is estimated to be 724 tCO₂/year. The remaining amount and type of fluorocarbons need to be confirmed in the detailed feasibility study. Though fluorocarbons which can be collected from commercial/industrial equipment and facility can be the target of this project, the estimation value shown below does not include this amount. Therefore, in addition to the estimation value below, CO₂ reduction effect from commercial/industrial equipment and facility can also be expected.

■ CO₂reduction amount (1,448 tCO₂/year)

= Amount of fluorocarbons (R-22) per air conditioning unit (0.8kg/unit) × Collection amount (1,000 unit/year) × GWP (1,810)

When assuming that 1,000 units (each country) are replaced with energy efficient products, CO₂ reduction amount is estimated as shown below. The effect of energy consumption reduction by introducing energy efficient products is estimated as 480 tCO₂/year.

■ CO₂reduction amount (480 tCO₂/year)

=(Rated power consumption before replacement (3.4kW)–Rated power consumption after replacement (1.8kW))× Utilization rate of equipment (60%)× Number of unit (1,000 units)× Running hours per day (8 hours)× Running days per year (160 days)× CO₂ conversion factor (0.000387tCO₂/kWh)

3.2 Co-benefit effect

By implementation of this project, CO₂ reduction effect derived from replacement of energy efficient products and GHG reduction effect derived from destruction of fluorocarbons in EOL products are expected. In addition, this project can promote environment sound management of E-waste and hazardous waste in developing countries, where inappropriate recycling and associated environment and health impact by hazardous substances are recognized. All target countries recognize necessity of proper E-waste management, and its legal system is under consideration. Given the situation, starting from the proper management of fluorocarbons and EOL products, promotion of 3R in those countries are also expected. Moreover, fluorocarbons can be destructed by utilizing heat of waste incineration facilities, so additional energy consumption by fluorocarbon destruction can be minimized.

4. Conclusion

4.1 Consideration on Future Project

Based on the results of this year's research on potential of collection and destruction of fluorocarbons, consideration is made on contents of detailed feasibility study, pilot project, and business plan (target equipment, area, collection & destruction method) planned after the next year. In the pilot project, demonstration of collection and destruction of fluorocarbons (detailed method depends on each country) is to be implemented. In addition, formation of future social system is sought through the pilot project.

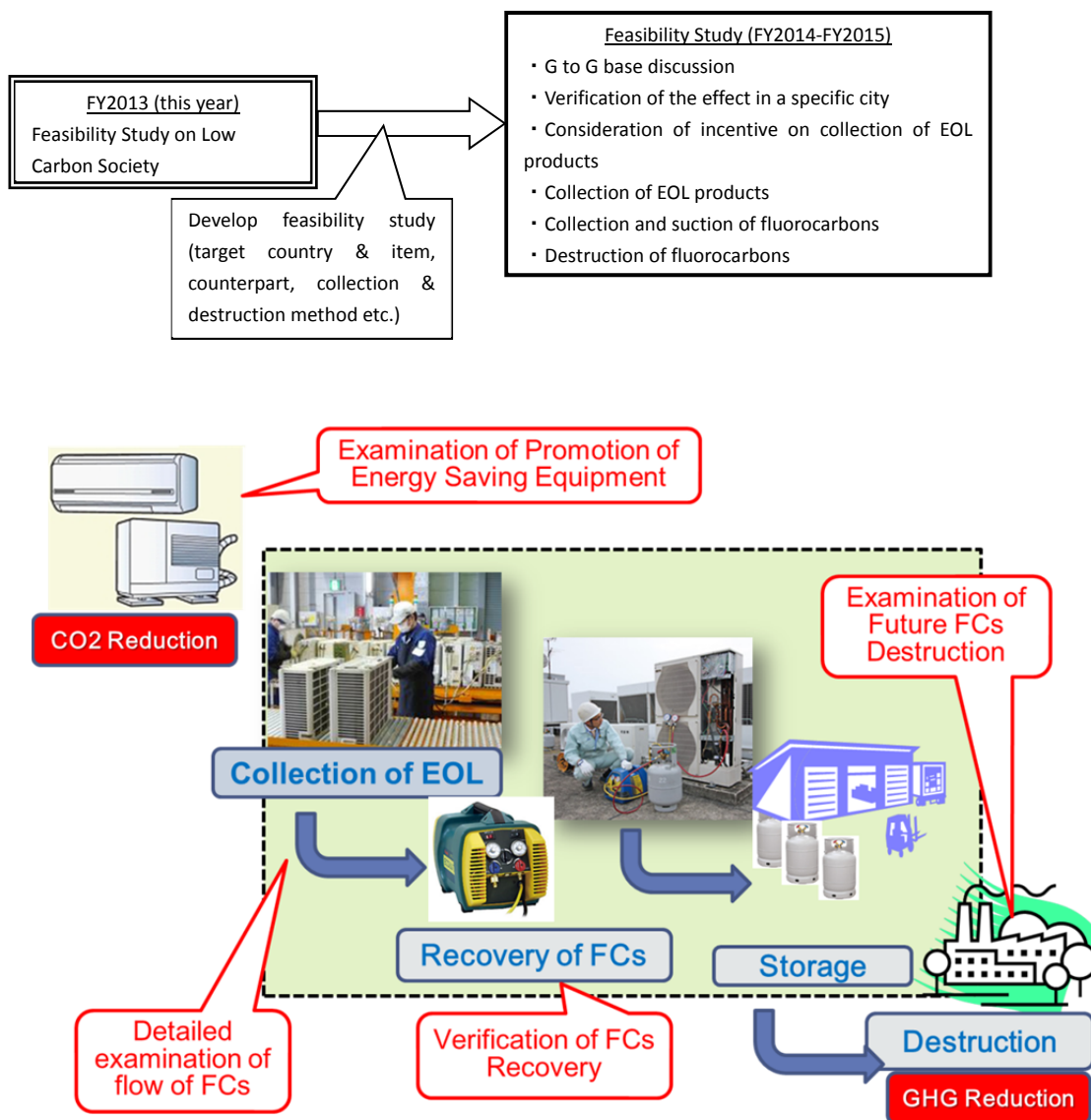


Figure4-1 Image of Pilot Project

i) Thailand

In Thailand, the industrial estates authority (IEAT) hold jurisdiction over the Industrial Estates within the country, and Japanese manufacturers of home appliances, automobiles, etc. are also located within these Estates. Promotion of the project targeting these Estates will allow us to take comprehensive and intensive actions on multiple companies within an Estate, so we can also expect that we can actually collect the substances effectively. In addition, by combining with the spread of energy-saving equipment in the future, we can make the Estates more environmentally friendly and low-carbon. That may result in creating needs in Thailand, which aim to make the Estates environmentally friendly.

By collaborating with large shopping malls and small retailers which have networks through their chain stores, we can expect that the project may lead to energy-saving efforts at a commercial-facility level as well as effective collection of fluorocarbons.

For home appliances, currently no system for collecting home appliances such as air-conditioners has been established, so effective collection of such items is expected to be difficult. In order to construct a footing for future development, the immediate approach seems to be implementation of seminars for government organizations such as PCD and local authorities to disseminate ideas and raise awareness.

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In Malaysia, for fluorocarbon in industrial equipment, in collaboration with fluorocarbon reconditioner who collects fluorocarbon for reclamation purpose from business sector, it may be considered to collect fluorocarbon which was accepted by the reconditioner due to its inappropriate quality for reclamation.

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present, in order to promote proper management of EOL equipment and fluorocarbons, the cooperation with those proper recyclers is required. Since air conditioners require specific technology, they are managed by expert company. As the expert company collects air conditioners (broken products) intensively, fluorocarbons may be collected from those which cannot be fixed. The expert company can be considered as future fluorocarbons collection point.

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In Indonesia, it is necessary to understand present flow of fluorocarbon for future fluorocarbon recovery. It is necessary to investigate the point where a large amount of fluorocarbon gathering currently.

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4.2 Points of Concern

It is key point that the target equipment is treated as E-waste when it comes to end of life stage. Although it is not carried out now, when such E-waste recycle comes to be carried out in these countries in the future, it is necessary to clarify the meaning of fluorocarbons destruction. In this sense, the effort in G-G base is required. From now on, it is necessary to consider the measures to introduce the incentive fluorocarbons destruction or proper replacement of energy-saving apparatus. In addition, through awareness raising activities, it is important to raise the recognition of effort and significance of the effect of proper management of fluorocarbons in target countries.