Final Report

Analysis of Thailand's Commercial Refrigeration and Air-Conditioning (AC) Service Sector

Green Cooling Initiative (GCI) for Thailand and Asia

Submitted to

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

GIZ Office Bangkok

193/63 Lake Ratchada Office Complex (16th Floor)

New Ratchadaphisek-Rama 4 Road, Khlong Toey,

Bangkok 10110

Thailand

Tel: +66 65 017 4664

E-mail: denise.andres@giz.de

Submitted by

Bright Management Consulting Co., Ltd.

EEC Academy Building,

40 Ramintra 97, Ramintra Rd., Kannayao, Bangkok 10230

Date May 31, 2022

List of Content

List of Table

List of Figure

Abbreviation

AC	Air-Conditioning
ACAT	Air Conditioning Engineering Association of Thailand
B2B	Business-to-Business
B2C	Business-to-Consumers
B2G	Business-to-Government
BMC	Bright Management Consulting Co., Ltd.
BMUV	German Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection
BTU	British Thermal Unit
CB	Certification Body
CBTL	Certification Body Testing Laboratory
Com. Ref.	Commercial Refrigeration
CVM	Center of Vocational Manpower Networking Management
DBD	Department of Business Development
DIW	Department of Industrial Works
DPT	Department of Public Works and Town & Country Planning
DSD	Department of Skill Development
EEC	Eminent Exploring Center
EEI	Electrical and Electronics Institute
EGAT	Electricity Generating Authority of Thailand
GCI	Green Cooling Initiative
GHG	Greenhouse Gas
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH
GSP	Good Servicing Practices
GWP	Global Warming Potential
HCFC	Hydrochlorofluorocarbon
HFC	Hydrofluorocarbon
HP	horsepower
HVAC	Heating Ventilation and Air Conditioning
IECEE	International Electrotechnical Commission system for conformity testing and certification of Electrical Equipment
IPCC	Intergovernmental Panel on Climate Change
IPPU	Industrial Processes and Product Use
ISO	International Organization for Standardization
JLL	Jones Lang LaSalle, IP, Inc.
KMUTNB	King Mongkut's University of Technology North Bangkok
kW	Kilowatt
MHESI	Ministry of Higher Education, Science, Research and Innovation
NAMA	Nationally Appropriate Mitigation Action
NCB	National Certification Body
NDC	Nationally Determined Contribution
NISS	National Industrial Skill Standard
NOSS	National Occupational Skills Standard

Abbreviation

NSO	National Statistical Office
OEM	Original Equipment Manufacturer
OIE	Office of Industrial Economics
OVEC	Office Vocational Education Commission
PFM	Project Fund Manager
PTEC	Electrical and Electronic Products Testing Center
RAC	Refrigeration and Air-Conditioning
RAC NAMA	Refrigeration and Air Conditioning Nationally Appropriate Mitigation Action
RMUTI	Rajamangala University of Technology Isan
SMEs	Small and Medium Enterprises
SSO	Social Security Office
TATA	Thai Air Conditioning Traders Association
TC	Testing Center
TIS	Thai Industrial Standard
TISI	Thai Industrial Standards Institute
TPQI	Thailand Professional Qualification Institute (Public Organization)
TSIC	Thailand Standard Industrial Classification
UL	Underwriters Laboratories
UNFCCC	United Nations Framework Convention on Climate Change
VRF	Variable Refrigerant Flow
VRV	Variable Refrigerant Volume
VSD	Variable Speed Drives

1. Introduction

The Green Cooling Initiative (GCI) is funded by BMUV and is a global project aiming to promote sustainable and climate-friendly cooling technology by engaging public and private stakeholders, and strengthening their awareness and competence for the approach.

Thailand has a high potential to be a source of inspiration and experience/expertise for the neighboring countries. As a regional hub for Asia, Thailand will be in the lead for organizing and setting the content for regional green cooling events and activities, which aim to enhance awareness and strengthen regional networks for green cooling technology.

The sustainability of existing and potential training on green cooling approaches (e.g., The Safe Use and Handling of Flammable Refrigerants) in compliance with international standards is one topic on which GCI aims to support Thailand. Specifically, the project ensures to promote and support the long-term capacity development of Thailand's technicians and technical officers working in the service sector of Refrigeration and Air-Conditioning (RAC) products, especially split-type air-conditioners, in the domestic market.

- Objectives
  1) To assess and review Thailand's RAC service sector (including installation, maintenance, cleaning, repair, and decommission), as well as the current situation of the cooling appliance market towards the use of national refrigerants;
  2) To provide in-depth analysis and identify gaps of Commercial Refrigeration and AC service sector in terms of the operation, capacity development system or activities, skill and know-how level of Thai technicians both from formal and informal workforces;
  3) To develop recommendations to enhance the sustainability of knowledge transfer on green cooling technologies and the use of natural refrigerants throughout the country.

- Scope of Work
  Task 1: Carry out an Assessment and Review of the Overall Structure of RAC Service Sector
  Task 2: Carry out an In-depth Analysis of Thailand's Commercial Refrigeration and AC Service Sector
  Task 3: Develop and Elaborate Recommendations and Potential Linkage

2. Project Schedule

Table 1 Timeline for activities and deliverables

Activities and Deliverables (in red)	Tentative Date	2021					2022																					
		December					January				February				March					April				May				
		W1	W2	W3	W4	W5	W1	W2	W3	W4	W1	W2	W3	W4	W1	W2	W3	W4	W5	W1	W2	W3	W4	W1	W2	W3	W4	W5
		1-3	6-10	13-17	20-24	27-31	3-7	10-14	17-21	24-28	1-4	7-11	14-18	21-25	1-4	7-11	14-18	21-25	28-31	4-8	11-15	18-22	25-29	2-6	9-13	16-20	23-27	30-31
Kick-off Meeting/Call with GIZ	6-Dec-21		x																									
Study/Research Methodology, Expected Outputs, Timeline, and the Use of Man-days + Task 1 (1/3): Assessment of the overall structure of Thailand's RAC service sector and the overview of its practical process of servicing in the following subsectoes: Commercial Refrigeration and AC (to be approved by GIZ)	8-Dec-21		x																									
Task 1 (2/3, cont.): Review of the training, certification, and licensing scheme, current market penetration and trends of green cooling market)	21-Jan-22																											
Progress Update Call	31-Jan-22										x																	
Task 2: In-depth Analysis of Thailand's Commercial Refrigeration and AC Service Sector	21-Feb-22																											
Interim Report of Task (cont.): Review of the training, certification, and licensing scheme, current market penetration and trends of green cooling market + Task 2: Commercial Refrigeration and AC Service Sector Analysis (to be approved by GIZ)	23-Feb-22													x														
Feedback Call (1)	25-Feb-22													x														
Additional Revision of Task 1 and Task 2 + Direction of Task 3	18-Mar-22																											
Feedback Call (2)	25-Mar-22																	x										
Task 3: Develop Recommendations and Potential Linkages	18-Apr-22																											
Draft Report Task: Recommendations and Potential Linkage + Draft Final Report and Required Materials	22-Apr-22																					x						
Feedback Call (3)	26-Apr-22																						x					
(1) Final report in Thai and in soft file (Word document and PDF) in USB with executive summary in both Thai and English (2) Presentation in GIZ-corporate PowerPoint formate and in both Thai and English (to be approved by GIZ) containing essential key results of the study for further dissemination (3) At least Three 1-page factsheets with infographics containing essential key results of the study for further dissemination in both Thai and English	Before the contract ends																											x

To gain more information, the Consultants had contacted directly to stakeholders for requesting an online interview and distributed questionnaires to receive their responses. For the data collection, the Consultant had conducted as planned as shown in **Table 2.**

Table 2 Schedule of Stakeholders Interviews

No.	Organization	Date	Time	Type	Task	Remark
1	Grand Richmond Hotel	24/01/2022	02:00 – 03:00 pm	Private Sector	Characteristic of Technicians	End-User (Hotel)
2	Mitsubishi Electric Kang Yong Watana Co., Ltd.	27/01/2022	02:00 – 03:00 pm	Private Sector	Training/Characteristic of Technicians	Producer Air Conditioning
3	Rajamangala University of Technology Isan (RMUTI)	28/01/2022	09:00 – 10:00 am	Educational Institute	Training	
4	Department of Skill Development (DSD)		10:00 – 11:00 am	Government	Training	
5	King Mongkut's University of Technology North Bangkok (KMUTNB)		01:30 – 02:30 pm	Educational Institute	Training	
6	Pro Service Network Co., Ltd.		03:30 – 04: 30 pm	Private Sector	Characteristic of Technicians	Service Provider
7	EEC Engineering Network Co., Ltd.	31/01/2022	04:00 – 05: 00 pm	Private Sector	Characteristic of Technicians	End-User (Building Office)
8	Siam Daikin Sales Co., Ltd.	01/02/2022	09:00 – 10:00 am	Private Sector	Training/Characteristic of Technicians	Producer Air Conditioning
9	Pattana Intercool Co., Ltd.		10:00 – 11:00 am	Private Sector	Training/Characteristic of Technicians	Producer Commercial Refrigeration
10	Sanden Intercool Thailand Public Co., Ltd.	02/02/2022	01:30 – 02: 30 pm	Private Sector	Market penetration/ Characteristic of Technicians	Produce Commercial Refrigeration
11	Jones Lang LaSalle, IP, Inc. (JLL)	03/02/2022	09:30 – 12: 00 am	Private Sector	Characteristic of Technicians	End-User (Building Office and Residential)
12	Ek-Chai Distribution System Co., Ltd.		05:00 – 06: 00 pm	Private Sector	Characteristic of Technicians	End-User (Department Store)
13	The Office of Physical Systems Management, Chulalongkorn University	04/02/2022	09:00 – 10:00 am	Government	Characteristic of Technicians	End-User (Building Office and University)
14	Office of the Vocational Education Commission (OVEC)		10:00 – 12:00 am	Educational Institute	Training	
15	CP Retailink Co., Ltd.	11/02/2022	02:00 – 03: 00 pm	Private Sector	Characteristic of Technicians	End-User (Supermarket)
16	Systemform Co., Ltd.	18/04/2022	10:00 – 11:00 am	Private Sector	Characteristic of Technicians	Producer Commercial Refrigeration

3. Assessment and Analysis

In this final report, there are 3 tasks which are **Task 1** on assessment and review of the overall sector of the RAC Service Sector, **Task 2** on in-depth analysis of Thailand's Commercial Refrigeration and AC Service Sector. The key substances will be arranged respectively, as well as **Task 3** on Developing and Elaborate Recommendation and Potential Linkage.

Task 1: An assessment and review of the overall structure of RAC Service Sector

There are 3 sub-tasks in Task 1 which are;
Sub-Task 1: Carry out an assessment of the overall structure of Thailand's RAC service sector and provide the overview of its practical process of servicing in the following subsectors: Commercial Refrigeration and AC;
Sub-Task 2: Review of the training, certification, and licensing scheme for RAC technicians of the Department of Skill Development (DSD), technical colleges under the Office Vocational Education Commission (OVEC), and universities with relevant curriculum on RAC;
Sub-Task 3: Review the current market penetration and trend of cooling appliances (specifically Commercial Refrigeration and AC) with the use of natural refrigerants in Thailand – based on technical and statistical data/survey.

In this task, the overall structure of the RAC service sector regardless of refrigerant use shall be reviewed to gain more information and the assessment shall be carried out. For the service sector, the general life cycle flow of refrigerants contained in the cooling appliances in the market.

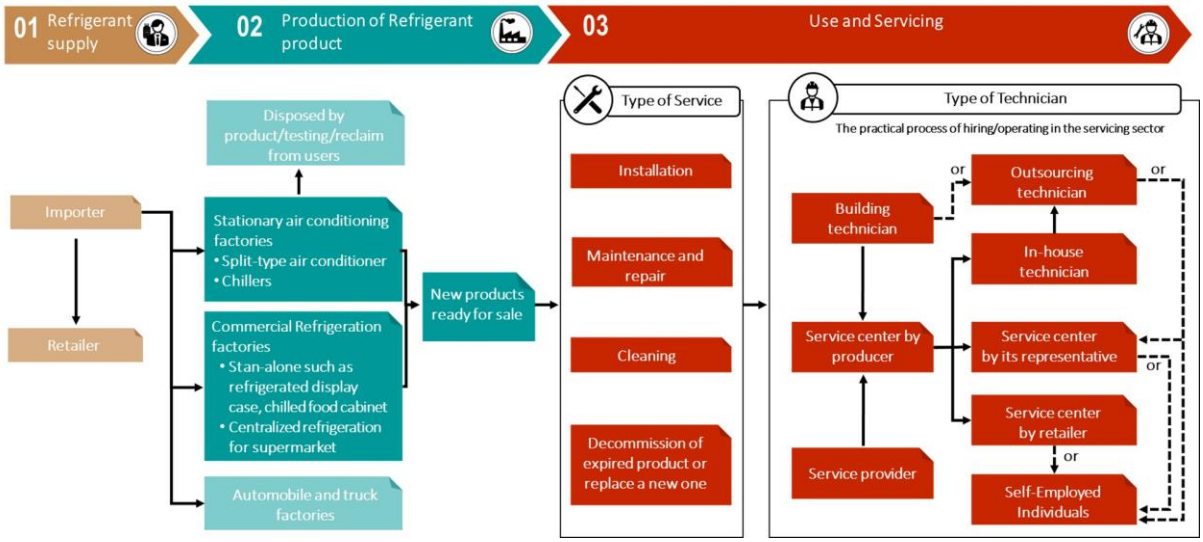

Figure 1 The general life cycle flow of refrigerants contained in the cooling appliances in the market

According to **Figure 1,** the consultant has described the servicing sector additionally from the desk reviews and bilateral discussions with the stakeholders. It can be categorized into 4 key activities for services; (1) Installation, (2) Maintenance and Repair, (3) Cleaning, and (4) Decommissioning of the expired product or relace a new product.

The service providers can be divided into 4 characteristics such as:

1) **Service center by the producer:** Most of the companies have their own service centers and in–house technicians. The in–house technicians are trained within companies and certified by the National Occupational Skill Standard (NOSS).
2) **Service center by the retailer:** The retailer shops including dealers and service providers. The service center has employed in–house technicians or outsourcing from an individual service center, and most of them have been trained by the producers.
3) **Individual service center:** Individual service center has serviced for all brands by in–house technicians who have both trained and untrained.
4) **Self-Employed Individuals:** The technicians who work independently from any service center, and may be trained or untrained.

In addition, there are various types of technicians for these 4 key activities can be described as follow;

1. **Building Technicians** who are employed permanently by the employer or building's owner. For some serious problems which have difficulties and are complicated, the employer or building's owner may hire outsourcing technicians temporarily or the technicians authorized by the producers.

2. **Technicians in the Service Centers organized by the producers** are categorized into 3 sub-categories which are;
   (1) Permanently technicians who are directly employed by the companies;
   (2) Technicians who are employed by the companies' representatives or service providers organized by the producers;
   (3) Technicians who are employed by the dealers or service providers organized by the producers.

   Regarding the sub-category (2) and (3), some of them are employed and are not employed permanently by the producers depending on the condition of each company. Although the technicians in these 3 sub-categories are employed, the companies are also able to hire outsourcing technicians to provide some services as mentioned before.

3. **Technicians authorized by the service companies (service providers)** who are directly employed by the service companies directly to provide servicing to the clients who directly contact the companies including the service center organized by the producers.

For the service contract, it is depended on the warranty from the producer semi-annually, annually, or when the product is in malfunction.

The servicing areas mainly occur during the system installations, operation, and maintenance. When focusing on the service sector, in general, there are various types of services from servicing companies or service providers ranging from large companies to small shops. Those servicing companies normally hire in-house service technicians to provide such needed services to their customers while the customers who own the systems are able to hire outsourcing technicians or the other service companies, especially for installing larger systems. Because of the variety of service levels where the quality of service and good practices may be highly different, to those service providers whose technicians can be well-educated and well-trained while **on the contrary, they are also poor-educated and poor-trained technicians available in the market.**

Task 1 (sub-task 1/3): Assessment of the overall structure of Thailand's RAC service sector and provide the overview of its practical process of servicing in the following subsectors: Commercial Refrigeration and AC

1) **Standards and regulations:** to check whether there are any progress and update on the standards and regulations that are applied to the service sector at company level as well as individual level.

   In present, there are standardized products which certified by the Thai Industrial Standard Institute (TISI) in regards to RAC products (Air-Conditioning and Commercial Refrigeration) as shown in **Table 3.**

Table 3 Products Standards for the RAC sector

Sub-sector	Standards and Regulations
Air-Conditioning	**TIS 1155 – 2557:** Air-cooled split type room air conditioners This standard covers only split-type room air conditioners, air-cooled and air-cooled added with water. The net total room cooling effect of a unit not exceeding 12000 W.
	TIS 1529 – 2561: Air-Conditioner: Safety Requirement This standard covers the safety of air-conditioners including motor compressors, having maximum rated voltages being not more than 250 V for single-phase appliances and 600 V for all other appliances. This standard also covers air-conditioner with having total cooling capacity of up to 18000 Watts.
	TIS 2134 – 2553: Room Air Conditioners: Energy Efficiency This standard covers the energy efficiency of room air conditioners for both split-type and not split-type that uses alternating current with a frequency of 50 Hz, and the net total of cooing capacity not exceed 12000 W.
	TIS 385 – 2524: Room air conditioners This standard specifies type and size, making and neatness, general requirements, marking, sampling and criteria for conformity, and testing for room air conditioners with the condenser.
	TIS 2712 – 2558: Multiple Split-System Air-Conditioners and Air-to-air heat pumps This standard specifies performance testing methodology for home, commercial, and industrial air-conditioners which must be finished from the factory.
Commercial Refrigeration	**TIS 2700 – 2558:** Commercial refrigerator: Energy efficiency requirement This standard covers only refrigerated display cabinet of type 'vertical glass door chilled' net volume: 250 L to 1500 L and 'horizontal glass door chilled' net volume: 150 L to 350 L.
	TIS 2808 – 2560: Refrigerated Display Cabinet: Vocabulary Vocabularies and its definition, as well as the designation of refrigerated display cabinet families.
	TIS 2675 – 2558: Commercial refrigerator: Safety requirement This standard specifies safety requirements for commercial refrigerating appliances type that have a built-in compressor, or a split type. *Examples* of commercial refrigerators that are within the scope of this standard are refrigerated display and storage cabinets; refrigerated trolley cabinets; service counters and self-service counters; blast chillers and blast freezers.

Sub-sector	Standards and Regulations
	TIS 2738 – 2559: Cabinet blast chiller and freezer This standard covers cabinet blast chiller and/or freezer is suitable for use in the production process or food processing and food preservation by shock freezer in order to inhibit the growth of microorganisms. On a chilled and frozen level of food catering services such as restaurants, hotels, hospitals, etc., and food industries with having the self-contained unit.
	TIS 1235 – 2556: Refrigerated display cabinets: classification requirement and test condition This standard specifies requirements for the construction, characteristics, and performance of refrigerated display cabinets used in the sale and display of foodstuffs. It specifies test conditions and methods for checking that the requirements have been satisfied, as well as classification of the cabinets, their marking, and the list of their characteristics to be declared by the manufacturer. It does not apply to refrigerated vending machines or cabinets intended for use in catering or similar non-retail applications; nor does it cover the choice of the types of foodstuffs chosen to be displayed in the cabinets.
Other	**TIS 812 – 2548:** Motor-compressors: safety requirements This standard specifies safety for motor compressors such as hermetic and semi-hermetic for refrigerators, freezers, ice makers, air-conditioners, heat pumps, dehumidifiers, commercial dispenser appliances, vending machines, and heat transfers, etc.

The service type is depended on requirements from users or customers, which can be divided into 4 types i.e., 1) Installation, 2) Operation and Maintenance (refill refrigerant and/or cleaning), 3) Repair equipment when there is a malfunction, and 4) Decommissioning (replace new equipment, if needed).

In addition, there are updated regulations, and standards for technicians in the service sector that need to comply for air-conditioning (AC) as shown in **Table 4.**

Table 4 Standards and Regulations for technicians in the service sector

Standards and Regulations	Description
ACAT Standard	Regulation for installation: Air conditioner 5 RT (Ton of Refrigeration) or smaller
	Regulation for installation: Air conditioner 5 – 20 RT (Ton of Refrigeration)
	Standard for installation: Split Type Air Conditioner
Ministerial Announcement No. 4412 (B.E. 2555) **TIS 2564 – 2555**	Room Air Conditioner: Installation relevant with operation during installation
THAI SMEs STANDARD **(TIS-S) 24 – 2561**	Air Conditioning Maintenance and Cleaning Services

Remark: ACAT Standards are relevant to the service sector such as a standard for installation which the installers or engineers must have a License for Professional Practice. For the warranty and maintenance, the service provider must guarantee at least 1 year after installation (for maintenance including cleaning and repair).

However, there are the standards for technicians in the service sector that have to apply for the personal certificates and licenses that need to be complied with, such as the National Occupational Skill Standard (NOSS) or National Industrial Skill Standard (NISS) which are approved as a Labor Skill Standards of Professionals by Department of Skill Development (DSD) under the Ministry of Labour. The relevant occupations which have to be trained and certificated in the field of Electrical, Electronics, and Computer have shown in **Table 5.**

Table 5 The relevant occupations which have to be trained and certificated in the field of Electrical, Electronics, and Computer

No.	Types of technicians by occupations
1	Air conditioning Technician for cleanrooms
2	Home and Commercial Refrigeration Technician
3	Air-conditioning Technician (Home and Small Commercial Use)
4	Chilled Water Air-conditioning System Installation and Maintenance (less than 20 tons) Technician
5	Industrial Split Inverter Air-conditioning System (less than 60,000 BTU) Installation and Maintenance Technician
6	R-32 Refrigerant Air Conditioning (less than 50,000 BTU) Installation and Maintenance Technician
7	Large Air-conditioning Technician
8	Air-conditioning Assembler
9	Home and Light Commercial Air-conditioning Technician

Remark: All these occupations must have been trained and certificated.

Although, there are standards for both products and technicians, but for the usage of the eco-friendly refrigerants in high-rise buildings still be a strong barrier.

- According to Ministerial Regulations No. 33, B.E. 2535 (1992) Issued pursuant to the Building Control Act, B.E. 2522 (1979), The high-rise building means a building that can be accessed or used for living which has a height of 23 meters and higher.
- Item 10: Ventilation for high-rise or extra-large buildings with air-conditioners must follow its sub-item. The sub-item (2) has referred to refrigerant use which prohibited the hazardous or highly flammable refrigerants that are directly used in air-conditioners.
- For a new type of refrigerant, it must have relevant research to prove the safety (flammable status: fire spread) of that refrigerant as well as it must be proved and approved by the relevant ministries before proposing to the Department of Public Works and Town & Country Planning (DPT) to amend the regulations.

2) **Technology and products:** to check and assess on the currently available products and compliance standards.

Recently, there are the expanded and improved standards for the products using eco-friendly refrigerants such as AC, and Commercial Refrigeration as shown in **Table 6.**

Table 6 The expanded and improved standards for the products using eco-friendly refrigerants

Sub-sector	Description
Air Conditioning	**TIS 1529 – 2561:** Air-Conditioner Safety Requirement Uses *ISO 817 and ASHRAE 34* which included R-290, R-600a, and R-744 or Carbon Dioxide (CO_2). **TIS 2712 – 2558:** Air-cooled air conditioners and air-to-air heat pumps

Sub-sector	Description
	Uses *ISO 15042:2011* which is referring to *ISO 817* that included R-290, R-600a, and R-744 or Carbon Dioxide (CO_2).
Commercial Refrigeration	**TIS 2738 – 2559:** Cabinet blast chiller and freezer Uses *ISO 817 and ASHRAE 34* which is including R-290, R-600a, and R-744 or Carbon Dioxide (CO_2). **TIS 1235 – 2556:** Refrigerated display cabinets: classification requirement and test condition Uses *EN 378-2* which is referring to *ISO 817* that included R-290, R-600a, and R-744 or Carbon Dioxide (CO_2).

Although, there are expanded and improved standards for green cooling technology products, but the available products that have been launched in the current market are the commercial refrigeration systems only. Due to the COVID-19 pandemic, even the air-conditioner's producers have changed the production line for green cooling technology products but the order is still lacking. Therefore, the green cooling technology products (air-conditioners) are only in the training centers which provided by the RAC NAMA project.

3) **Training Curriculum and Institutes:** to check and update on the current available training and institutes available in the markets.

Currently, there are training curricula and training centers which are provided by the government sector and private sector that are available and authorized by the DSD. The training curricula and training centers function to support the personal certificates and licenses as shown in **Table 7.**

Table 7 Training Curriculum and Training Centers for RAC technicians

No.	Training Center	Training Curriculum
1	Department of Skill Development (DSD)	1) Air-conditioning Technician (Home and Small Commercial Use) 2) Air Condition Installation of Advanced VRF System *(Jointed with Eminent Air)* 3) Air-condition installation (Residential) 4) Installation and Maintenance Technology of Air Conditioner with Inverter System 5) Small Air-conditioner Maintenance 6) Maintenance of Air Conditioning in Homes and Small Commercial 7) The Clean Air in Homes and Small Commercial 8) Installation of Home and Commercial Inverter Air Conditioner 9) Small Air-Conditioning Mechanic 10) Domestic and Light Commercial Refrigerator 11) Domestic and Light Commercial Refrigerator and Air-Conditioning Mechanic *Green Job (Green Skill)* 12) Maintenance of Air Conditioning in Homes and Small Commercial (*see no. 6*) 13) The Clean Air in Homes and Small Commercial (*see no.7*) Installation Split Type Air Conditioners that use the refrigerant R32

No.	Training Center	Training Curriculum
2	Mitsubishi Electric Kang Yong Watana Co., Ltd. Brand: MITSUBISHI ELECTRIC	In-house training center for technicians and sales representatives.
3	Haier Electric (Thailand) Public Co., Ltd. Brand: Haier	In-house technical training center for technicians; refrigerator, air-conditioner, freezer, etc.
4	LG Electronics (Thailand) Co., Ltd. Brand: LG	Skill Standards Testing Center in Bangkok by LG for Air-conditioning which has been **certified by the Department of Skill Development (DSD).** The testing center aims to provide training and skill testing services for air conditioning technicians in home and small commercial.
5	Thai Samsung Electronics Co., Ltd. Brand: Samsung	Thai Samsung Electronics Co., Ltd., has collaborated with *The Office of Vocational Education Commission (OVEC)* under Samsung Dual Vocational Education project. This project aims to train professional skills for students in the refrigeration system technician sector.
		Thai Samsung Electronics Co., Ltd., has collaborated with the *Department of Skill Development (DSD)*, the Ministry of Labor to trained skill development of air conditioning technicians consists of installation, repair and maintenance.
6	Daikin Industries (Thailand) Ltd. Brand: Daikin	Daikin Industries (Thailand) has collaborated with the *Department of Skill Development (DSD)*, Ministry of Labor for training and skill development of air conditioning technicians.
7	Eminent Air (Thailand) Co., Ltd. Brand: EMINENT	Eminent Air (Thailand) has collaborated with the *Department of Skill Development (DSD)*, Ministry of Labor – to establish the Eminent Exploring Center (EEC). EEC Center is a training and testing center for air conditioner technicians.

4) **Service Providers:** to check and assess the characteristic of service providers in the service sector, the service providers shall include the product testing centers to certify green cooling technologies products and training centers that provide technical and practical knowledge to technicians in the service sector.

In Thailand, there are so many testing centers for the RAC products which is including the education institutes, government agencies, and private companies based on the product standards as shown in **Table 8** regarding to the testing centers for non-green cooling initiative and green cooling initiative products.

Table 8 Testing Centers for non-green cooling initiative and green cooling initiative products

Agency	Sub-sector	Standards
Non-Green Cooling Initiative Products		
Chulalongkorn University (Mechanical Engineering, Faculty of Engineering)	Air-Conditioning (AC)	**TIS 385 – 2524** Room Air Conditioners
Electrical and Electronics	Domestic Refrigeration	**TIS 2186 – 2547**

Agency	Sub-sector	Standards
Institute (EEI)		Household Refrigerators: Environment Requirements; Energy Efficiency TIS 455 – 2537 Household Refrigerating Appliances TIS 2214 – 2561 Household Refrigerator and Refrigerator-Freezer: Safety
	Commercial Refrigeration, Industrial Refrigeration	TIS 812 – 2548 Motor Compressors: Safety
	Air Conditioning	TIS 1155 – 2557 Air-cooled split type room air conditioners TIS 2134 – 2545 Room Air Conditioners: Environment Requirements; Energy Efficiency
Electrical and Electronic Products Testing Center (PTEC)	Domestic Refrigeration	TIS 2214 – 2548 Household Refrigerators: Safety
Ministry of Higher Education, Science, Research and Innovation (MHESI)	Domestic Refrigeration	TIS 2214 – 2548 Household Refrigerators: Safety
Japan Electrical Testing Laboratory (Thailand) Co., Ltd.	Domestic Refrigeration	TIS 2186 – 2561 Household Refrigerator and Refrigerator-Freezer: Environmental Requirements; Energy Efficiency TIS 2214 – 2561 Household Refrigerator and Refrigerator-Freezer: Safety
Green Cooling Initiative Products		
Electrical and Electronics Institute (EEI)	Air Conditioning	TIS 1529 – 2561 Safety of Household and similar electrical appliances
	Commercial Refrigeration	TIS 1235 – 2556 Refrigerated Display Cabinets: Classification Requirement and Test Condition
Japan Electrical Testing Laboratory (Thailand) Co., Ltd.	Air Conditioning, Commercial Refrigeration, Industrial Refrigeration	TIS 2712 – 2558 Multi split-system air-conditioners and air-to-air heat pumps
Underwriters Laboratories (Thailand) Co., Ltd.	1) 10&5 Ton Test Chambers for HVAC products (Ability to	The equipment and instrumentation are applicable to residential and commercial air conditioners, washing

Agency	Sub-sector	Standards
	do VRF testing and multiple testing) 2) Flammable Refrigerant Leakage Testing Apparatus 3) Test Room for Ingress Protection Testing, Lock Rotor Testing, Material Testing, Electrical Testing and Mechanical Testing	machines, tumble dryers, refrigerators, freezer and motor compressors. **Note:** UL Thailand received the official laboratory accreditation certificate (TIS17025-2548) from Thai Industrial Standards Institute (TISI). UL also received the CBTL certificate, which accepts the UL Thailand lab to operate as a CB Testing Laboratory under the responsibility of National Certification Body (NCB) UL-DEMKO under the IECEE CB Scheme.

5) **End users:** to learn about the behavior of service needs.

For learning the behavior of the customers or users in need of services. The consultant has studied through the in-house consultant staff via a questionnaire regarding air-conditioning and commercial refrigeration (if any). Regarding the studies, the results has shown in **Table 9.**

Table 9 In-house consultant staff's practice in calling service

Topic	Service type		
	Installation	Maintenance (Refilling and Cleaning)	Repairing
Service provider	• Service center by retailer or modern trade • Self-employed individuals	• Technicians provided by residential juristic person • Self-employed individuals • Service center by retailer	• Service center by producer • Self-employed individuals • Service center by retailer
Service frequent	• Once	• Every 6 months • Annually • When not cool	• More than 1 year after installation • 3 years after installation
Contact service providers	• N/A	• Contact through the residential juristic person • Direct contact • Contact through service center by retailer	• Contact through service center by producer • Contact through service center by retailer
Contracting by service providers	• N/A	• N/A	• Product warranty
Qualifications of services providers	• N/A	• N/A	• N/A
Expected quality of the services	• The appliance can be used normally.	• The appliance can be used normally.	• The appliance can be used normally.

The consultant is aware of the lack of sufficient data, studies, and publications that are publicly available related to the service sector in Thailand. The alternative option that was proposed to gain more information by conducting bilateral meetings with the stakeholders as well as sending questionnaires.

Regarding the issues of the service sector, there are 3 groups of stakeholders which are training centers, relevant agencies in market penetration, and associations and the private sector which are relevant to service technicians.

For the training centers, the consultant has planned to gain information by direct contact and conduct bilateral meetings (via online meeting) with both the public sector and private sector such as DSD, OVEC, KMUTNB, RMUTI, etc. There are examples of the scope of guiding questions for the relevant agencies in this group as follows:

- Guiding Questions
  1) How many technicians have been trained using the training curriculum provided in the RAC NAMA project? Or newly developed training curriculum if applicable?
  2) Are the existing training centers (TC) providing sufficient knowledge to the technicians to serve the technologies? And need to be improved?
  3) Are the existing TC facilities adequate to serve the demand in the market?
  4) How has the training curriculum been integrated into the institute certification system?
  5) How is the certifying system formulated? And what is the progress of the certificate process?
  6) How is the licensing system formulated?
  7) How are the database and network for the trained technician to the service market?

For the market penetration, the consultant has planned to gain information by direct contact and distribute questionnaires from both the public sector and private sector such as EGAT, OEI, Sanden Intercool (Thailand) Public Co., Ltd., Saijo Denki International Co., Ltd., etc. As well as the distributors and retailers such as Lotus's, CP Retailink, etc. to see the behavior of the agencies and customers (end-users). There are examples of the scope of guiding questions for the relevant agencies in this group as follows:

- Guiding Questions
  - EGAT: Annual productions, annual label no. 5, type refrigerant
  - OIE: Annual productions, domestic sales and trade market of Commercial Refrigeration and AC
  - Private Sector (Producer)
    1) Annual productions, domestic sales, export and trade market of Commercial Refrigeration and AC with the use of natural refrigerant
    2) Type of natural refrigerants?
    3) Have a service center for the technicians?
    4) What are the service types such as installations, maintenance, etc.? And types of contracts?
    5) What are the sizes of service providers - companies, contractors, sub-contractors, shops, self-employed individuals?
    6) What are general practices? And qualifications of the staff?

For the characteristic of service technicians, the consultant has planned to gain information by direct contact and conduct bilateral meetings (via online meeting) with both the public sector and private sector such as Mitsubishi Electric Kang Yong Watana Co., Ltd., Siam Daikin Sales Co., Ltd., Sanden Intercool (Thailand) Public Co., Ltd., Pattana Intercool Co., Ltd., etc. As well as Modern Trades like Siamchai Service Co., Ltd. There are examples of the scope of guiding questions for the relevant agencies in this group as follow:

- Guiding Questions
  1) What is the estimated number of technicians for these appliances?
  2) How to categorize these technicians (i.e., formal vs informal, freelance vs corporate, etc.)?
  3) How are technicians from different categories educated and/or trained?
  4) What are the general service operations of these technicians? (e.g., How are technicians from different categories hired by which customers? How are servicing contracts structured and agreed upon?)
  5) What are the service types such as installations, maintenance, etc.? And types of contracts?
  6) What are the sizes of service providers - companies, contractors, sub-contractors, shops, self-employed individuals?
  7) What are general practices? And qualifications of the staff?
  8) What are the servicing types that are needed such as cleaning, refilling, and changing? And how frequent are services needed?
  9) How do you get contact those service providers?
  10) What are general practices for contracting the service providers?
  11) What are the qualifications of staff expected to perform services?
  12) What is the expected quality of the services?

Once all the information is collected, the assessment will be concluded on developing the practical process for servicing sector including the market penetration and characteristic of service technicians.

Task 1 (sub-task 2/3): Review of the training, certification, and licensing scheme for RAC technicians of the Department of Skill Development (DSD), technical colleges under the Office of Vocational Education Commission (OVEC), and universities with relevant curriculum on RAC

This sub-task has provided an overview of the educational systems in Thailand as well as the training, certification, and licensing mechanism including for RAC technicians, the Consultant has conducted desk reviews of the available information from relevant sources.

1. Educational System in Thailand

According to the Section 15 of the National Education Act. B.E. 1999, Additional Version (No.2) B.E. 2002, and (No.3) B.E. 2010, there are 3 types of education which are formal education, non-formal education, and informal education as shown in **Figure 2.** These types of education are in accordance with the Act. which are not separated by the educational system, but counted as a different type of pathway. Therefore, people are able to choose their pathway which is up to the learners to study and practice before entering into the labor market.

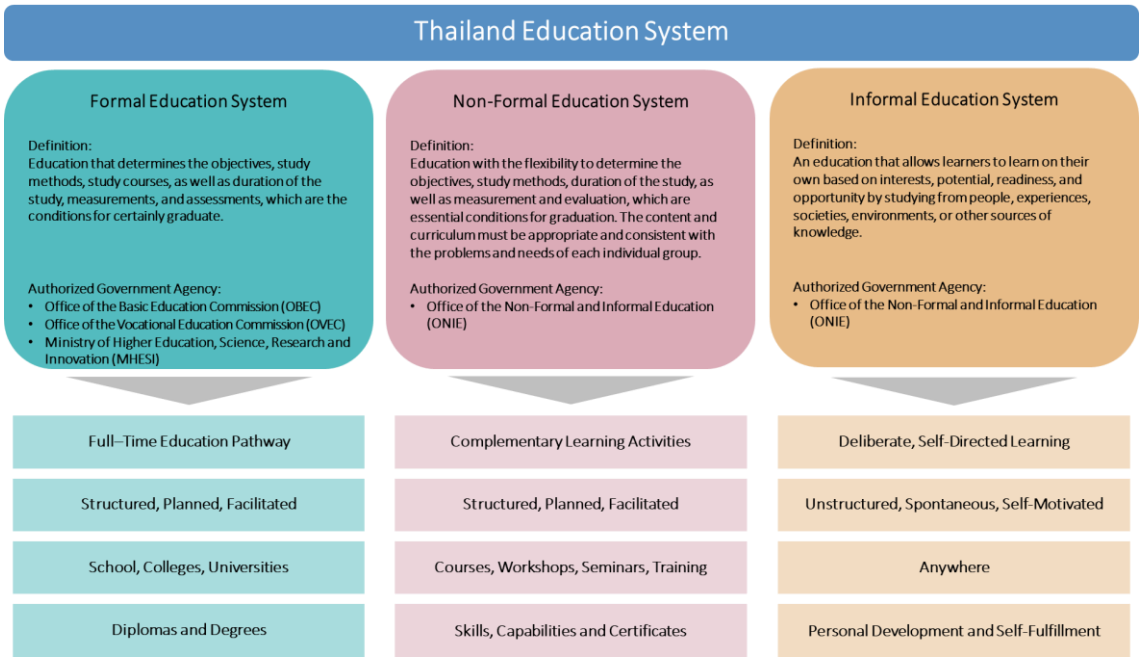

Figure 2 Thailand Education System

In addition, some institutes may have only 1 type of education system while some of them may have all 3 types in which the learners are able to transfer the study results between types of education regardless of the institutes. Including, non-formal education, informal education, occupational training, or work experience which must be in accordance with the National Education Act., and other relevant laws. Thus, those who have graduated from the non-formal or informal education system are able to take the equivalence certificate for continuing in vocational education and higher education as shown in **Figure 3.**

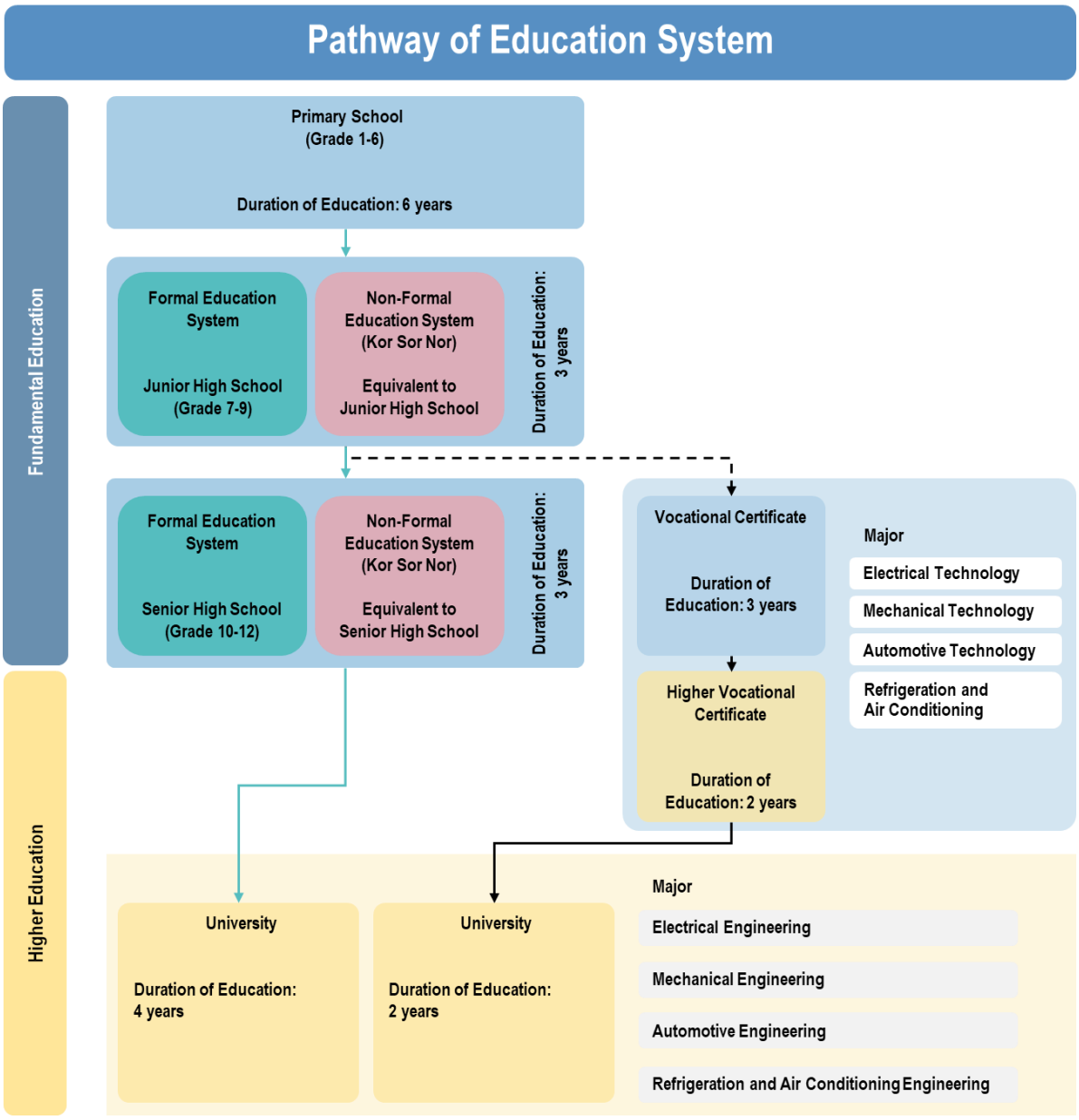

Figure 3 Pathway of Education System

- Vocational Education
  Vocational education is one of the educational systems which aims to produce and develop workforces at levels of professional skills, technical, and technological. The Office of Vocational Education Commission (OVEC) has developed various study programmes as follow;
  - Vocational Education Courses: produce and develop workforces at levels of occupational skills, technical, and technological.
    (1) Vocational Certificate
    (2) Higher Vocational Certificate

  - Vocational Training Courses: short-term and long-term courses for professional knowledge and skills both inside and outside the vocational institutes.

  According to the interview, the Office of Vocational Education Commission (OVEC), there is a field of Commercial Refrigeration and Air-Conditioning as shown in **Table 10.**

Table 10 Vocational Training Courses regards Commercial Refrigeration and Air Conditioning

Topic	Training Courses		
	Vocational Education Courses		Vocational Training Courses
	Vocational Certificate (B.E.2562)	Higher Vocational Certificate (B.E.2563)	
Target Group	Graduated from Junior High School	Graduated from High School or Vocational Certificate	General Public/Handicapped Person/Student (Junior High School, Senior High School/Vocational Certificate)
Major	Refrigeration and Air Conditioning for Technician	Techniques of Refrigeration and Air Conditioning	Refrigeration and Air Conditioning for Technician
Relevant Subject	• Home and Commercial Refrigeration - Disassembly and Assembly of Electrical Components - Piping Installation and Refrigerant Circuit Installation - Repair and maintenance of refrigeration systems (refrigerant filling) • Air Conditioning - Disassembly and assembly of electrical and mechanical parts of inverter air conditioners - Piping and installation of various types of air conditioners - Repair and maintenance of air conditioning systems such as leak testing, refrigerant filling, refrigerant retention, etc. - Cleaning	• Industrial Air Conditioning - Working principle of split-type air conditioner - Selecting type and size of air conditioners - Installation - Control and maintenance of industrial air conditioners	- Cleaning of air conditioner - Repair and installation of inverter air conditioners - Repairing the electrical circuit of small air conditioners - Installation of wall-mounted air conditioners - Installation of inverter air conditioner - Refrigerant Replacement for Energy Saving - Cleaning of Small Air Conditioners - Cleaning and maintenance of small air conditioners - Technician for air conditioner maintenance - Technician for air conditioner cleaning - Cleaning and servicing single-phase air conditioners - Refrigeration and air conditioning - Maintenance of air conditioners - Repair and maintenance of air conditioners - Installation of air conditioners - Installation and maintenance of air conditioners - Installation, repair, and cleaning of air conditioners - Repair of 3-phase electrical circuits - Repair of electrical circuits and small refrigeration and air conditioners - Maintenance of air conditioners in office buildings - Replacing refrigerant in Air Conditioners by the standard of the UN - Technician for refrigeration - Technician for single-phase air conditioners
Duration	3 years	2 years	12 – 150 hours

Apart from the fields relevant to Commercial Refrigeration and Air-Conditioning as described, there are other fields such as electrical, mechanical, and automotive which are able to work in the field of Commercial Refrigeration and Air-Conditioning as well.

For the Vocational Education Courses development, the **Office of Vocational Education Commission (OVEC)** has developed the courses with representatives from government agencies, associations, and the private sector. For short-term and long-term vocational training courses, they are the default courses developed by the OVEC which the other vocational colleges are able to apply or develop a new curriculum with the approval of the school administrator. Currently, there are no courses in regard to natural refrigerants such as R600a and R290.

- Higher Education

According to the National Education Act, higher education is an education system higher than fundamental education which aims to create and publish knowledge and innovation as well as produce and develop workforces in terms of academic and professional. Those who aim to enroll have to graduate from Senior High School or Higher Vocational Certificate or equivalent.

There is a study programme directly to the Refrigeration and Air-Conditioners which is the Refrigeration and Air Conditioning Engineering Technology. This programme is applied in only 2 universities which are King Mongkut's University of Technology North Bangkok (KMUTNB) and Rajamangala University of Technology Isan (RMUTI). However, most of the RAC technicians in the labor market are not graduated directly from the Refrigeration and Air Conditioning Engineering Technology, but graduated from other relevant fields such as electrical, mechanical, automotive, etc. which are able to work in this field as well. As a study result, there are the study programmes in the universities which provided some subjects relevant to the Refrigeration and Air-Conditioning as shown in **Table 11.**

Table 11 Study programmes in the universities which provided subjects relevant to the RAC

No.	Program (s)	Subject (s)
1	Aeronautical and Aerospace Engineering	- Aircraft Air Conditioning and Pressurization Systems
2	Automotive and Motorsport Engineering	- Refrigeration and Air Condition in Building and Automotive - Energy Conservations in Building and Manufacturing Industry - Heat Transfer and Air Conditioning
3	Electrical Engineering	- Energy Conservation and Management - Energy Control System in Building - Electrical Energy Management - Electrical Energy Conservation and Management - Industrial Factory and Building Energy Management - Domestic and Light Commercial Air-Conditioning Engineering Laboratory - Refrigeration and Air Conditioning for Electrical-Mechanical Manufacturing Engineering*
4	**Energy and Air Conditioning Engineering**	**Direct program;** **There are 9 subjects with 12 optional subjects.**
5	Heavy Equipment Engineering	- Air Conditioning

No.	Program (s)	Subject (s)
6	Mechanical Engineering	- Mechanical Engineering Laboratory for Non-ME - Ventilation and Air Conditioning - Energy Management in Building - Refrigeration and Air Conditioning - Practice in Refrigeration and Air Conditioning - Principles of Energy Conservation - Refrigeration and Air Conditioning Laboratory - Air-Conditioning and Ventilation Engineering - Refrigeration - Manufacturing Logistics and Energy Cost Saving for SMEs - Energy Conservation and Management - Air Conditioning - Energy Conservations in Building and Manufacturing Industry - Air Conditioning Systems Design - Dehumidification for Buildings* - Applications in Refrigeration System* - Control Elements and Application in Air Conditioning System* - Clean Room and Applications in Air Conditioning System* - Aircraft Air Conditioning and Pressurization System* - Applied Thermodynamics for Engineering Applications - Railway Air Conditioning System* - Building System Design for Mechanical Engineering* - Refrigeration and Air Conditioning in Mechanical/ Electrical System - Industrial Refrigeration
7	Naval Architecture and Marine Engineering	- Marine Refrigerator and Air Conditioner - Refrigeration and Air Conditioning

Remark *optional subject

2. Skill Development Training

Skill Development Training has been developed by the **Department of Skill Development (DSD)** and provided to any level of worker regardless of educational background and work experience. The DSD is responsible for promoting and developing systems of skill development, potential workforce and entrepreneurs, National Occupational Skills Standard (NOSS), National Industrial Skill Standard (NISS), as well as providing certification for NOSS and NISS.

The Department of Skill Development (DSD) has categorized the training programmes for the RAC technicians into the field of Electrical, Electronics, and Computer. In addition, the RAC technicians can be categorized into 3 types of technicians which are (1) Refrigeration and Air-Conditioning Technician, (2) Home Air-Conditioning Technician, and (3) Refrigeration Technician. There are training courses for these 3 types of RAC technicians that differ in the difficulties, qualification of the trainee, and training duration which are following as shown in **Table 12;**

1) Upgrade Training
2) Pre-employment
3) Re-Training

Table 12 Type of training course and the trainee's qualification

Topic	Type of training course		
	Upgrade Training	Pre-employment Training	Re-Training
Objectives	To increase knowledge, competence, and skills in careers in terms of management or other additional knowledge that will support the working process to a higher potential.	Skill training for the workers to perform their duties and meet the standards of each occupation.	To increase knowledge and competence in other occupations apart from the current occupation or beyond the existing knowledge.
Target Group	Those who are employed or unemployed people who used to work must have knowledge, competence, and skills related to the training courses.	Those who are new workers or workers who are entering the labor market without work experience or with experience but are not yet working.	Those who are already employed or unemployed who wish to pursue a new or a part-time job.
Qualification	1. 18 years old or above 2. Those who have graduated from primary school (grade 6), junior high school (grade 9), or vocational education.	1. 15 years old or above 2. Those who have graduated from junior high school (grade 9), or vocational education.	1. 18 years old or above 2. Unlimited educational qualifications
	3. Those who have a physical and mental condition that does not hinder training, and are able to attend throughout the training course.		
	4. Those who have work experience as an air conditioning technician or other related jobs, or have at least 1 year of experience in any fields related to the training course.	4. Those who do not have or have work experience in the relevant field of available training courses.	4. No work experience is required
Duration	Up to 6 hours, but not exceed 240 hours	Theory Training 280 – 840 hours, Practical Training (internship) with the entrepreneur for 1 – 2 months (depending on the professional field)	Up to 6 hours, but not exceed 480 hours
Certification	A certificate will be provided to the trainee who passed the assessment and trained more than 80% of the total training period.		
		1. A certificate will be provided to those who have completed the course and passed the assessment, trained more than 80% of the total	

Topic	Type of training course		
	Upgrade Training	Pre-employment Training	Re-Training
		training period, but were not able to intern for any reason. 2. A diploma and certificate of the internship will be provided to those who have completed the course and passed the assessment, trained more than 80% of the total training period as well as passed the assessment from the internship.	

In addition, the consultant has reviewed the training programmes related to the Commercial Refrigeration and Air-Conditioning from the DSD's Mobile Application which can be summarized as shown in **Table 13** and **Figure 4.**

Table 13 Summary of training courses regards to the RAC servicing sector from the DSD's Mobile Application

No.	Type of Service	Amount of Training Courses			
		Upgrade Training	Pre-employment Training	Re-Training	Total
1	Installation	36	2	10	48
2	Maintenance	26	1	11	37
3	Repair	23	4	9	36
4	Cleaning	8	0	7	15
5	Decommissioning	0	0	0	0
6	Installation and Maintenance	14	0	4	17
7	Installation and Repair	7	4	1	8
8	Installation and Cleaning	1	0	0	1
9	Installation and Decommissioning	2	0	1	3
10	Maintenance and Repair	23	2	12	36
11	Maintenance and Cleaning	6	0	2	7
12	Repair and Cleaning	0	0	1	1
13	Installation, Repair, Maintenance	1	4	0	5

No.	Type of Service	Amount of Training Courses			
		Upgrade Training	Pre-employment Training	Re-Training	Total
Total		144	13	57	214

Remark: For the detail, see Annex C
Source: DSD's Mobile Application, 1 February 2022.

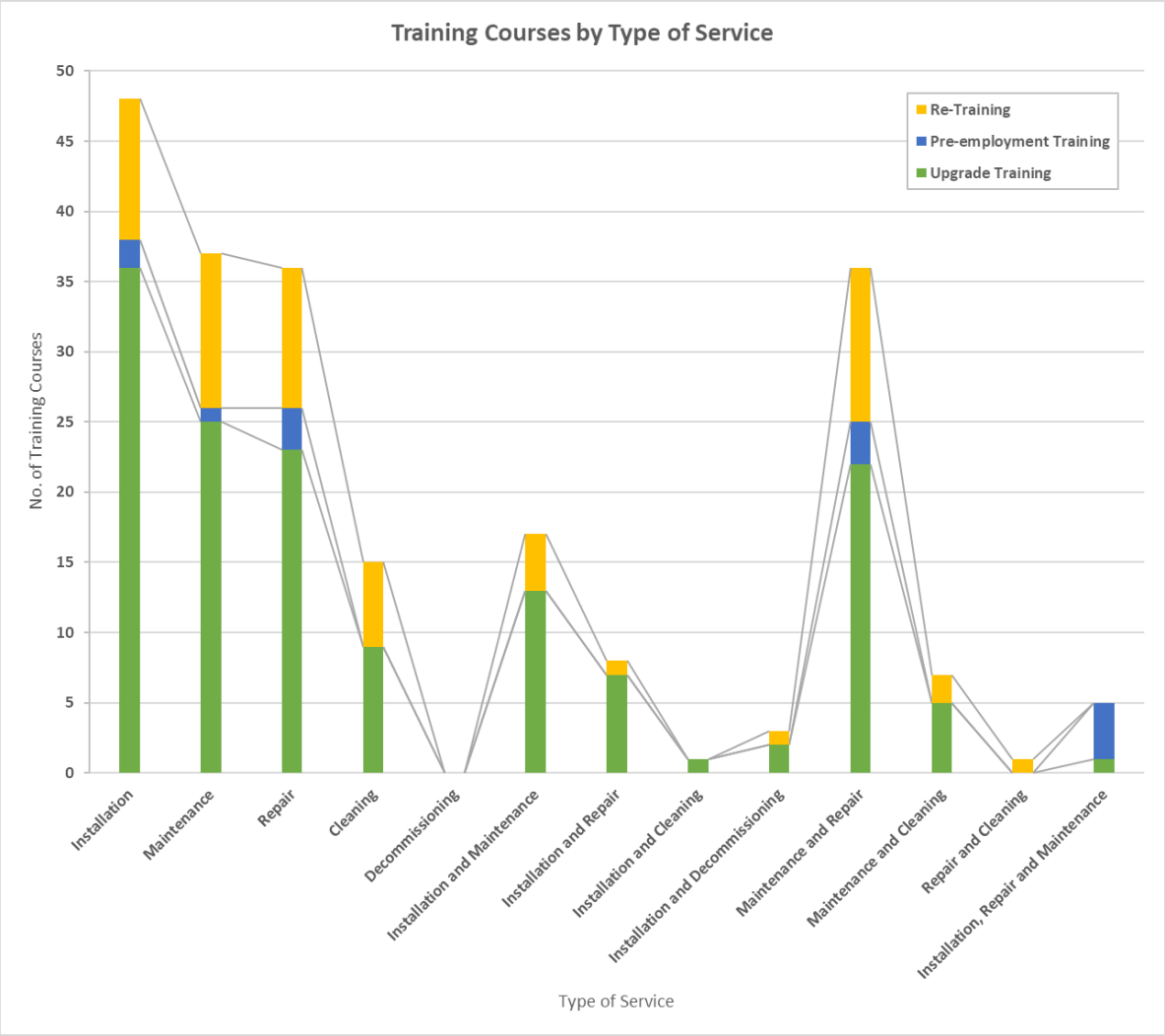

Figure 4 Training Courses by Type of Service
Source: Department of Skill Development (DSD)

In addition, there are also other related training courses such as the Standard Test Preparation Course in **Home and Small Commercial Air Conditioning Technician Level 1** and **Level 2,** Air Conditioning Technology, Refrigeration and Air Conditioning Operations, and Safe use of flammable natural refrigerants (Using R290 refrigerant), as well as the training courses invented in collaboration with the private sector, manufacturers of air conditioners such as;

- Haier Electrical Appliance (Thailand) Co., Ltd.
- Thai Samsung Electronics Co., Ltd.
- Eminent Air (Thailand) Co., Ltd.
- Siam Daikin Sales Co., Ltd.
- Mavell Corporation Co., Ltd.
- Thai Tasaki Engineering Co., Ltd.
- Saijo Denki International Co., Ltd.

In Thailand, there is a national skill standard implemented under the Skill Development Promotion Act B.E. 2545 for being a technician in commercial refrigeration and air conditioning which has described that the RAC technician is included in the fields of electrical, electronics, and computer occupations that can be categorized into relevant fields for 3 sub-fields as follows:

(1) Air-conditioning Technician (Home and Small Commercial Use)
(2) Home and Commercial Refrigeration Technician
(3) Large Air-conditioning Technician

The Department of Skill Development (DSD) is the authorized government agency for the national skill standard test, certificate, and license which is called the National Occupational Skills Standard (NOSS) or National Industrial Skill Standard (NISS), it is an academic requirement used for measuring skill levels, knowledge, abilities, and working attitudes of those who are working in various fields. This test is intended to assess the potential, skills, and performance of skilled workers as well as increase efficiency, productivity, and create value for the country's competitiveness.

Each sub-field has a national skill standard level classification according to the knowledge and ability for working that is separated by the difficulties of the job and test in knowledge, abilities, skills, and working attitude of the occupations according to the criteria of NOSS/NISS. Those who passed the test will receive a certificate certifying that they are skilled at the national skill standard, which can be summarized in detail as shown in Table 14 – 16.

Table 14 National skill standard level for Air-conditioning Technician (Home and Small Commercial Use)

Detail	Level 1	Level 2	Level 3
Definition	Those who have knowledge and ability to operate with split-type air conditioners, single-phase electrical systems, not exceeding 11 kilowatts (36,000 BTU/hour).	Those who have knowledge and ability to operate with split-type air conditioners, 1-phase or 3-phase electrical systems, with a size of not more than 21 kW (72,000 BTU/hour).	Those who have knowledge and ability to operate all types of air conditioners, 1-phase or 3-phase electrical systems, with a size of not more than 70 kW (240,000 BTU/hour).
Knowledge and Skill	- Installation of Condensing Unit or Fan Coil Unit - Piping and its connection to the refrigerant system - Sewer piping - Charging refrigerant - Electrical system - Functional Test - Basic Maintenance - Cleaning	- Installation, decommissioning, move, or change Condensing Unit or Fan Coil Unit - Modification (adjustment) of piping for the refrigerant system - Sewer piping - Charging and draining the refrigerant - Electrical System - Functional Test - Maintenance - Cleaning - Repairing - Able to advise on the operation of AC	- Installation, decommission, move, or change Condensing Unit or Fan Coil Unit - Modification (adjustment) of piping for the refrigerant system - Charging and draining the refrigerant - Electrical System - Functional Test - Maintenance or cleaning of the whole 1-phase or 3-phase electrical system - Cleaning - Repairing - Able to advise on the operation and control of the AC
Qualification	- 18 years old or above, and; - Those who have work experience in the field of air-conditioning technician in homes and small commercial use for not less than 1 year, or; - Those who trained by DSD in this field not less than 60 hours, as well as having internship experience or work experience in relevant field not less than 300 hours.	- 18 years old or above, and; - Those who have work experience in the field of air-conditioning technician in homes and small commercial use for not less than 1 year after receiving the certificate of National Skill Standard Level 1, or; - Those who passed the National Skill Standard Level 1 with 85% or above.	- 18 years old or above, and; - Those who have work experience in the field of air-conditioning technician in homes and small commercial use for not less than 1 year after receiving the certificate of National Skill Standard Level 2, or; - Those who passed the National Skill Standard Level 2 with 85% or above.

Detail	Level 1	Level 2	Level 3
	- Those who have graduated with at least a vocational certificate or above in a relevant field to this occupation.		
Certification Scheme	Those who passed the knowledge and proficiency test with a score of not less than 70% of the total score.		

Table 15 National skill standard level for Home and Commercial Refrigeration Technician

Detail	Level 1	Level 2	Level 3
Definition	Those who have knowledge and competence in the level of assistant for the technician.	Those who have knowledge and competence at the technician level.	Those who have knowledge and competence at the level of a chief technician.
Knowledge and Skill	- Refrigerant pipe cutting, expansion, and flair tubing - Size selection and electrical wiring - Assembly and disassembly	- Assembly and disassembly - Installation of cooling components and equipment - Detect cause of failure and repair - Adjust the refrigeration with a size of up to 5 horsepower (HP) to work normally	- Reading and drawing electrical circuits - Control and installation - Analyze problems and fix various failures caused by electrical and electronic systems - Adjust the refrigeration with a size of up to 5 horsepower (HP) to work normally - Calculate the electrical model and refrigeration size, and estimate the cost of work.
Qualification	- 18 years old or above, and; - Those who have work experience in the field of Home and Commercial Refrigeration Technician for not less than 1 year, or; - Those who trained by DSD in this field not less than 60 hours, as well as having internship experience or work	- 18 years old or above, and; - Those who have work experience in the field of Home and Commercial Refrigeration Technician for not less than 1 year after receiving the certificate of National Skill Standard Level 1, or;	- 18 years old or above, and; - Those who have work experience in the field of Home and Commercial Refrigeration Technician for not less than 1 year after receiving the certificate of National Skill Standard Level 2, or;

Detail	Level 1	Level 2	Level 3
	experience in relevant field not less than 300 hours. - Those who have graduated with at least a vocational certificate or above in a relevant field to this occupation.	- Those who passed the National Skill Standard Level 1 with 85% or above.	- Those who passed the National Skill Standard Level 2 with 85% or above.
Certification Scheme	Those who passed the knowledge and proficiency test with a score of not less than 70% of the total score.		

Table 16 National skill standard level for Large Air-conditioning Technician

Detail	Level 1	Level 2	Level 3	Level 4
Definition	Those who have knowledge, skills, and the ability to work.	Those who have knowledge, skills, and the ability to repair and install.	Those who have knowledge, skills, and ability to diagnose defects and plan for work.	Those who have knowledge, skills, and the ability to control work.
Knowledge and Skill	- Preparation of equipment and tools before installing the air conditioner - The sub-cleaning and the big cleaning of the air conditioner	- Repair and installation of air conditioners according to the service manual - Inspection and testing of sub and big cleanings	- Diagnosis of defects - Air Conditioner Repairing - Planning on installation and positioning - Operation testing, and principles of installation and repair	- Supervise and knowledge sharing - Fault diagnosis, sophisticated breakdowns, re-repairs, and advanced technical faults - Prepare reports on problems, repairs, and installation reports to deliver to customers
Qualification	- 18 years old or above, and; - Those who have work experience in the field of Large Air-conditioning Technician for not less than 1 year with a certificate of work or occupation from a	- 18 years old or above, and; - Those who have work experience in the field of Large Air-conditioning Technician for not less than 1 year after receiving the	- 18 years old or above, and; - Those who have work experience in the field of Large Air-conditioning Technician for not less than 3 years after receiving the	- 18 years old or above, and; - Those who have work experience in the field of Large Air-conditioning Technician for not less than 3 years after receiving the

Detail	Level 1	Level 2	Level 3	Level 4
	relevant professional association or an entrepreneur, or; - Those who trained by DSD in this field not less than 560 hours and certificated from DSD, educational institutes, or else, or; - Those who have graduated with at least a vocational certificate or above in a relevant field to this occupation.	certificate of National Skill Standard Level 1, or; - Those who have work experience in the field of Large Air-conditioning Technician for not less than 3 years with a certificate of work or occupation from a relevant professional association or an entrepreneur, or; - Those who have graduated with at least a higher vocational certificate or above in a relevant field to this occupation, and have work experience in this field not less than 1 year with a certificate of work or occupation from a relevant professional association or an entrepreneur.	certificate of National Skill Standard Level 2, or; - Those who have work experience in the field of Large Air-conditioning Technician for not less than 7 years with a certificate of work or occupation from a relevant professional association or an entrepreneur, or; - Those who have graduated with at least a higher vocational certificate or above in a relevant field to this occupation, and have work experience in this field not less than 3 years with a certificate of work or occupation from a relevant professional association or an entrepreneur.	certificate of National Skill Standard Level 3, or; - Those who have work experience in the field of Large Air-conditioning Technicians for not less than 10 years with a certificate of work or occupation from a relevant professional association or an entrepreneur.
Certification Scheme	Those who passed the knowledge and proficiency test with a score of not less than 75% of the total score.	Those who passed the knowledge and proficiency test with a score of not less than 85% of the total score.		

For the certification scheme, Air-conditioning Technician (Home and Small Commercial Use) is defined in the Ministry of Labour announcement (B.E.2558) as a potentially dangerous occupation to the public and must be operated by those who have possessed a certificate of competence. There is a law requiring occupations in this field to obtain a certificate of competence since 26 October 2016. Therefore, there is not only a test but there is also an assessment to ensure the knowledge and skills of technicians. As the authorized government agency, DSD has set the procedure and the criteria for assessing the results of the National Skills Standards Test. Those who passed the test (NOSS/NISS) are able to make a request for the skill assessment to get the license as shown in **Figure 6.**

There are criteria for those who take the skill assessment as follows;

(1) Those who have knowledge, abilities, skills, working attitude, and results from the National Skills Standards Test. The score is accounted for 50% of the total score;
(2) Those who have professional experience such as education, work, training, seminars, etc. The score is accounted for 25% of the total score;
(3) Those who have personal attributes that represent professional or work potential. The score is accounted for 25% of the total score.

Figure 5 Skill Assessment Score Criteria

In addition, the criteria for the skill assessment are including the following factors:

- Fundamentals of operations
- Work safety
- Appropriate working procedure
- Correct use and maintenance of equipment
- Economical selection and use of materials
- Appropriate working time for performance
- Successful work

As for the training center and testing center, the Department of Skill Development (DSD) has the authority to provide certificates and licenses by law and regulation for those who are willing to learn and develop themselves. However, there are also educational institutes that have provided education with education certificates such as vocational education (college of technology) as well as universities, for those who are in the educational system.

In addition, there are colleges, universities, as well as private companies which have been appointed by the Department of Skill Development (DSD), (see **Annex D**) to be skill standard testing and proficiency certification centers for **Air Conditioning technicians in Home and Small Commercial Level 1** and **Level 2** as shown in **Figure 7.**

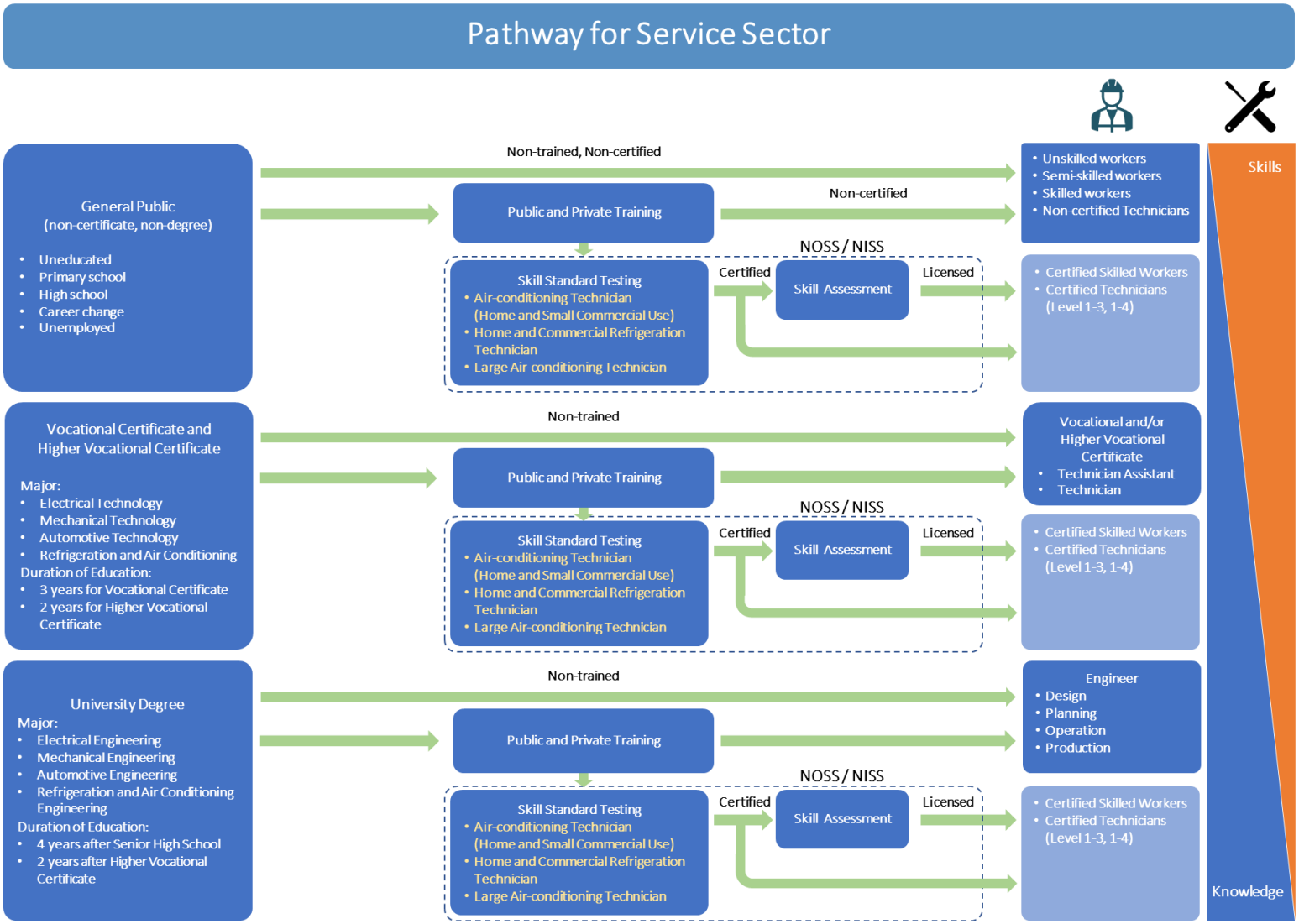

Figure 6 Pathway for Service Sector

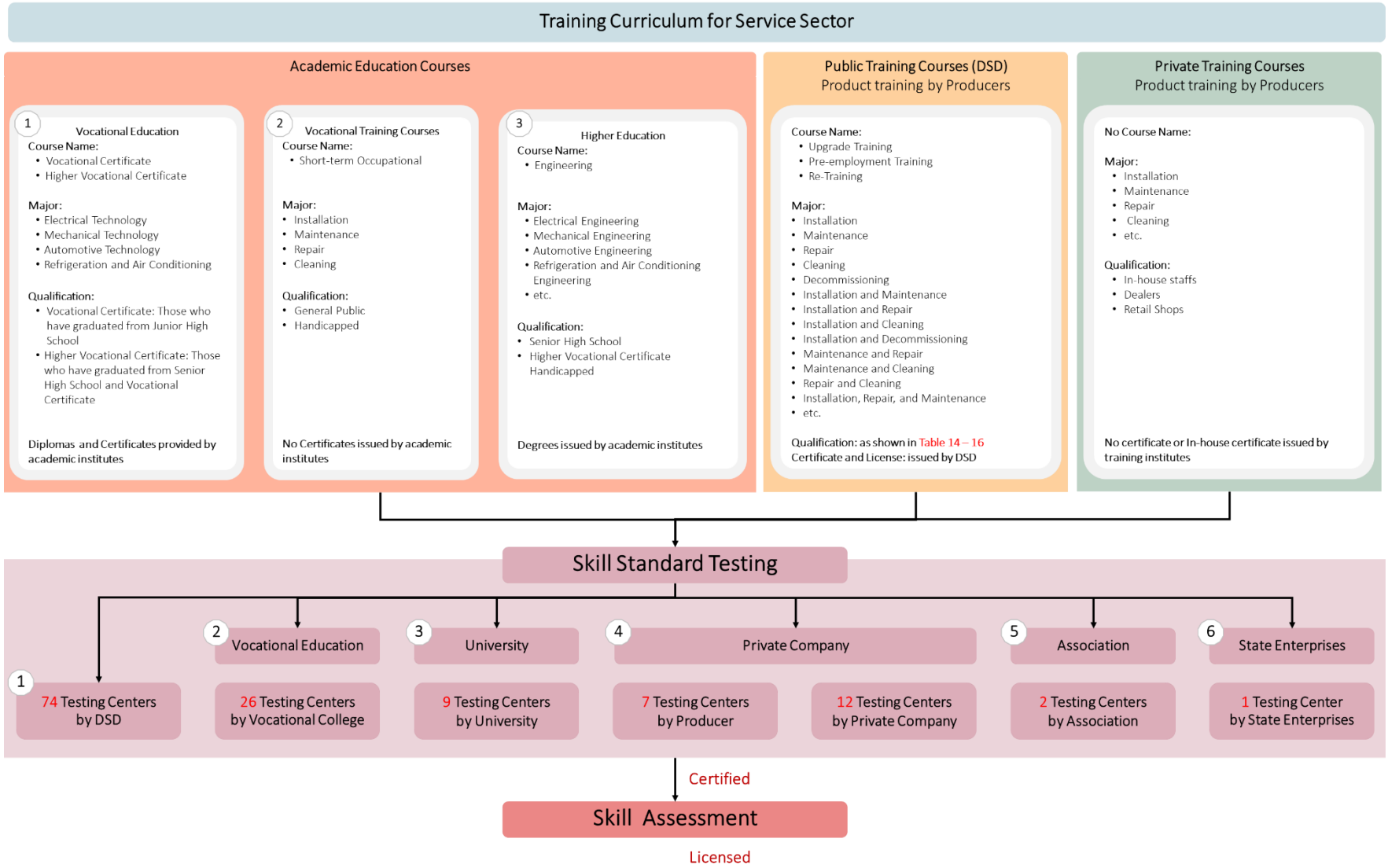

Figure 7 Training Curriculum for Service Sector

Task 1 (sub-task 3/3): Review the current market penetration and trend of cooling appliances (specifically Commercial Refrigeration and AC) with the use of natural refrigerants in Thailand – based on technical/statistical data/survey

The market overview, economy, and trends are important roles in the cooling industry in Thailand. This review obtains some relevant market statistics such as production rate, annual growth, and trend of **using natural refrigerants in Thailand.**

The consultant has reviewed by using 2 approaches i.e., (1) reviewed public data from the **Office of Industrial Economics (OIE)** which has 70 – 80% historical data of the country, and (2) sent questionnaires to the **Electricity Generating Authority of Thailand (EGAT)** who is the Project Fund Manager (PFM) of RAC NAMA project in Thailand that has supported the producer and the consumer on using natural refrigerant.

(1) Data from the Office of Industrial Economics (OIE)

There are data on aggregate level from their website which cannot be separated by types of products or refrigerants, as well as there is only data on AC as shown in **Table 17** and **Figure 8** which means there is no data on Commercial Refrigeration that may be aggregated with other data but has not shown.

Table 17 Historical data on Split-Type Air Conditioners (ACs) products by OIE (aggregate level)

Year	Production (Unit)		Domestics Sale (Unit)	
	Condensing Unit	Fan Coil Unit	Condensing Unit	Fan Coil Unit
2015	8,187,525	9,686,129	1,706,137	1,728,317
2016	10,123,469	11,867,448	1,946,631	2,007,956
2017	8,745,641	10,639,987	1,696,416	1,780,163
2018	9,174,109	11,200,075	1,575,986	1,671,124
2019	10,493,536	12,590,218	2,001,327	2,099,314
2020	9,696,004	11,329,752	2,008,511	2,094,516
2021	9,163,998	10,689,044	1,706,795	1,756,684

Remark: There is no data on one set as a unit for Air Conditioner (AC).

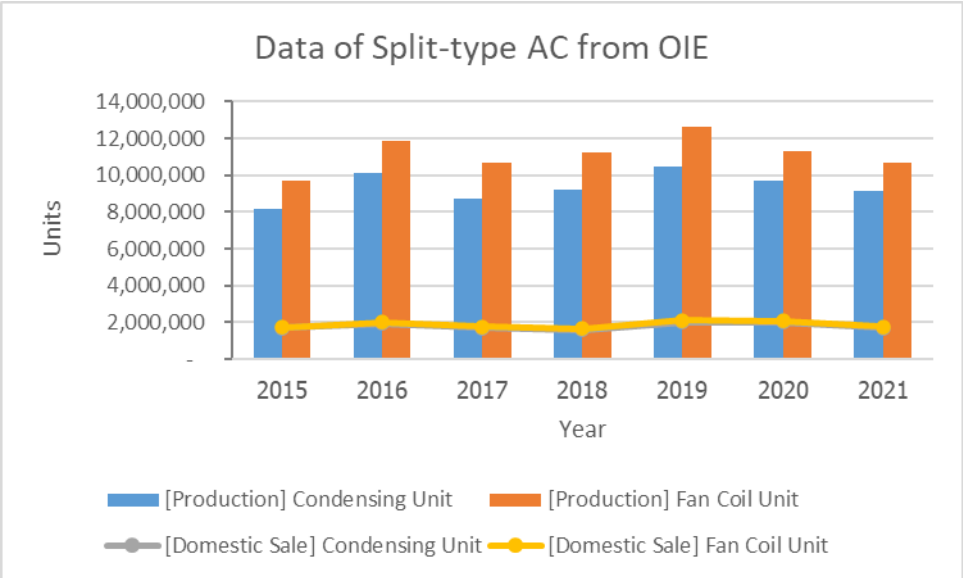

Figure 8 Data of Split-type AC from OIE (2015 – 2021)

According to the data of split-type AC from OIE, it has shown that the amount of proportion or AC production is still stable and almost equal in each year. Although it can be seen like that, there is hidden data such as refrigerant used that cannot be seen its trends. Regarding to bilateral discussions with relevant organizations, there is a trend of HCFC phase-down to almost out, the uptrend of HFC (R125, R134, R134a, R143a, R152a, R23, R32, R404A, R407C, R407F, R410A, R507A, and R508B), and uptrend of natural refrigerant (R600a, and R290).

(2) According to the data from EGAT

There are both data on **requesting label No.5** (likewise production data) of AC and Commercial Refrigeration (vertical refrigerated display cabinet) as shown in **Table 18,** as well as **Figure 9** and **Figure 10.** There are 2 types of data which are non-natural refrigerant and natural refrigerant, then the questionnaire has been developed for data in 2019 – 2021 regards to the production of products that use natural refrigerant.

However, there is no production data on AC that uses natural refrigeration due to many occurrences such as the COVID-19 pandemic situation has caused a delay in machine import, lacking of international trade, and high price of raw materials. Although there was a production only for being training facility, there was not ordered into the market due to the reliability and confidence of the consumers in using natural refrigerants that are highly flammable refrigerants.

On the other hand, there is data of the growth rate since 2019 of commercial refrigeration (vertical refrigerated display cabinet; plug-in type) using natural refrigerants.

Table 18 Historical data on RAC products by EGAT (RAC NAMA)

Year	AC (Unit)		Commercial Refrigeration (Unit)	
	Non-Natural Refrigerant*	Natural Refrigerant**	Non-Natural Refrigerant*	Natural Refrigerant**
2015	2,754,258	N/A	33,100	N/A
2016	3,771,294	N/A	66,850	N/A
2017	3,769,307	N/A	57,740	N/A
2018	3,288,928	N/A	82,700	N/A
2019	5,570,733	**N/A**	90,220	**2,500**
2020	5,724,255	**N/A**		**4,950**
2021		**N/A**		**84,150**

Remark: * data from another project
** data from the questionnaire for this project

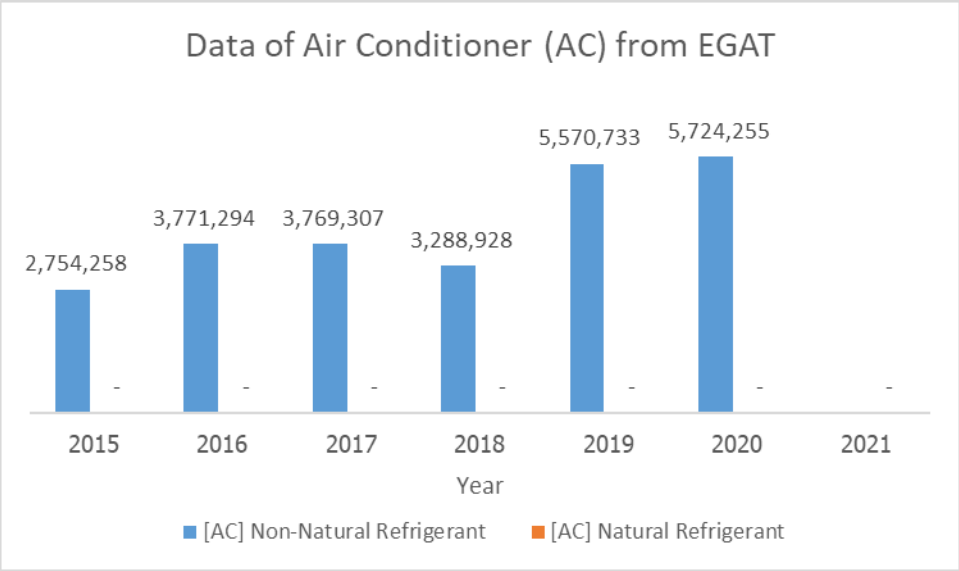

Figure 9 Data of Air Conditioner (AC) from EGAT (2015 – 2021)

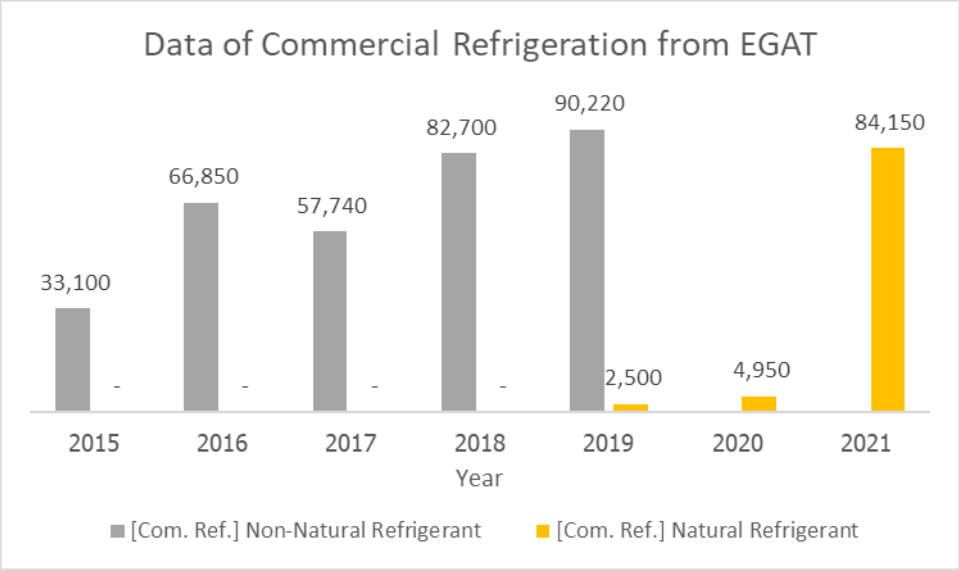

Figure 10 Data of Commercial Refrigeration from EGAT (2015 – 2021)

Task 2: An in-depth analysis of Thailand's Commercial Refrigeration and AC Service Sector

There are 3 sub-tasks in Task 2 which are;
Sub-Task 1: Provide a comprehensive study on the characteristic of service technicians for Commercial Refrigeration and AC;
Sub-Task 2: Analyse the Commercial Refrigeration and AC servicing operation in terms of the correspondence among the existing and potential required skills/certifications (e.g., capacity development, national training curriculum, training centers/institutes) of Thai technicians, the sufficient number of trained technicians from both formal and informal system, and/or additional requirements needed for the services;
Sub-Task 3: Identify technical, institutional and regulatory gaps/barriers to the Commercial Refrigeration and AC servicing and the use of cooling appliances with natural refrigerants in Thailand.

Task 2 (sub-task 1/3): Provide a comprehensive study on the characteristic of service technicians for Commercial Refrigeration and AC

This assignment aims to address characteristics of service technicians such as estimated number of technicians, category of technician, education and training, type of servicing operation, and service agreement.

Regarding to the desk reviews, there are results from the National Statistical Office (NSO) that there are relevant data such as the category of technicians both its definition and number which called formal and informal technicians that separated by the Social Security as shown in **Table 19** and **Figure 11.**

Table 19 Categories of Technician

Topic	Category	
	Formal Technician	Informal Technician
Definition	Employed persons who are protected or have social security from work such as; 1. Government Officer, Government Permanent Employees of Central Office, Provincial Office, and Local Office; 2. State Enterprises Employees; 3. Headmasters or teachers in Private schools, according to schools' laws; 4. Employees of Foreign Government or International Organizations; 5. Employees who are protected by labor laws; 6. Insured person according to the Social Security Act, Article 33, 39, and 40.	Employed persons who are not protected or have no social security from work like formal employment.
Corporate	Those who follow the Social Security Act of Social Security Office (SSO); 1) **Section 33.** The employee who has been over fifteen (15) years of age and not more than sixty (60) years of age, shall be insured person. [managed by company and owner] 2) **Section 39.** Any person who is an insured person under *Section 33,* has paid contribution for a period of not less than twelve months. [managed personally]	N/A
Freelance	Those who follow the Social Security Act of Social Security Office (SSO); 1) **Section 39.** Any person who is an insured person under section 33, has paid contribution for a period of not less than twelve months. [managed personally] 2) **Section 40.** Any other person who is not an employee under *Section 33* may apply to be an insured person under this Act by notifying his or her intention to the Office. [managed personally]	Those who do not follow the Social Security Act of Social Security Office (SSO); are not paid for being an insured person.

Source: 1) Informal Employment Survey, National Statistical Office (NSO)
2) Labour Statistics Yearbook, Ministry of Labour

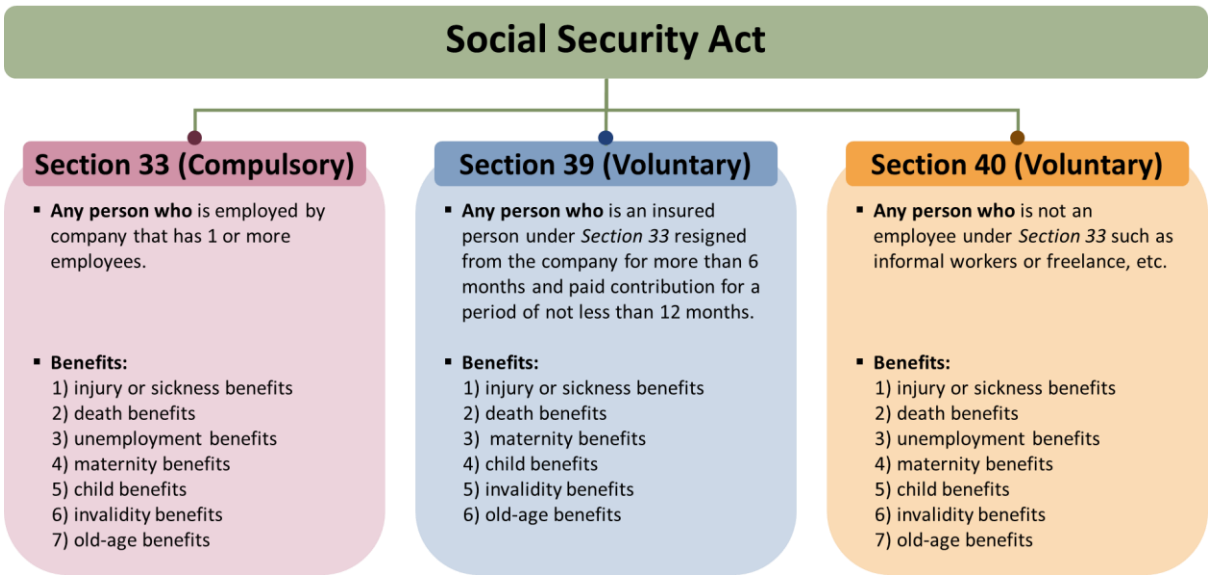

Figure 11 Social Security Act of Thailand
Source: Social Security Office

Regards to the category of technicians, they are able to attend any type of training if their qualification meets the requirement such as age, educational background, etc. which has been shown and described in the Review of the training, certification, and licensing scheme for RAC technicians of *Task 1 (sub-task 2/3)* [page 21].

According to the information from the National Statistical Office (NSO), there is the number of formal and informal employment in Thailand, as well as the overall number of technicians in all fields both formal and informal technicians as shown in **Table 20** and **Figure 12.**

Table 20 Number and Proportion of Formal and Informal Employment in Thailand

Information		Year				
		2016	2017	2018	2019	2020
Total Employment	**Persons**	**38,300,000**	**37,700,000**	**38,300,000**	**37,500,000**	**37,900,000**
	Percentage (%)	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
- Formal Employment	Persons	17,000,000	16,900,000	17,100,000	17,100,000	17,500,000
	Percentage (%)	44.39	44.83	44.65	45.60	46.17
- Informal Employment	Persons	21,300,000	20,800,000	21,200,000	20,400,000	20,400,000
	Percentage (%)	55.61	55.17	55.35	54.40	53.83
Total Technicians	**Persons**	**4,400,000**	**4,120,000**	**4,220,000**	**3,970,000**	**4,090,000**
	Percentage (%)	**11.49**	**10.93**	**11.02**	**10.59**	**10.79**
- Formal Technicians	Persons	2,400,000	2,300,000	2,350,000	2,270,000	2,320,000
	Percentage (%)	6.27	6.10	6.14	6.05	6.12
- Informal Technicians	Persons	2,000,000	1,820,000	1,870,000	1,700,000	1,770,000
	Percentage (%)	5.22	4.83	4.88	4.53	4.67

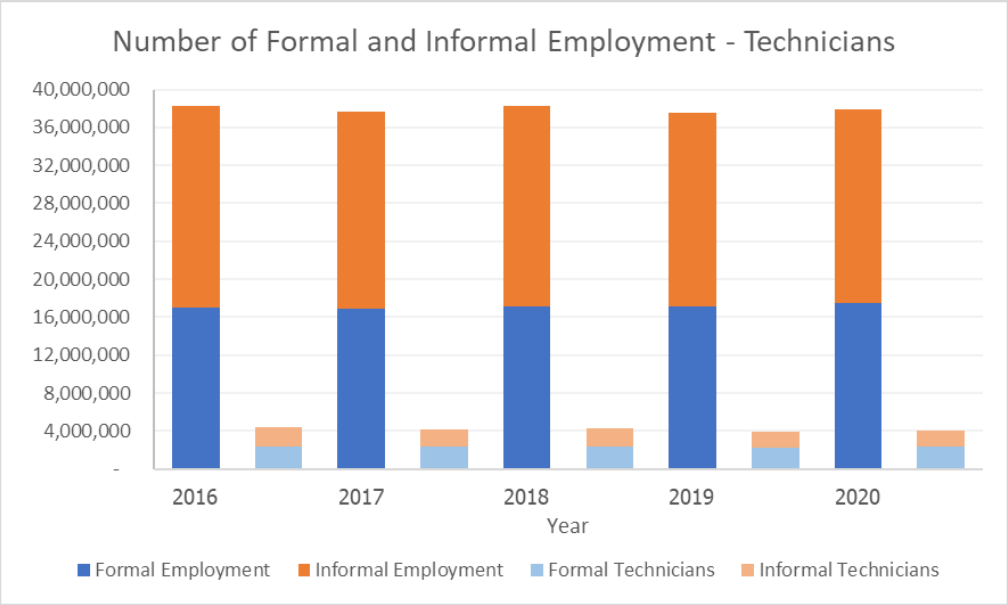

Figure 12 Number of Formal and Informal Employment – Technicians in Thailand
Source: The National Statistical Office (NSO)

According to Table 20, the number of technicians is including technicians in all fields such as Construction Technician, Electrical Technician, Plumber, Automotive Technician, Mold Technician, etc. which is approximately 1,641 fields including Refrigeration and Air Conditioning (RAC) Technician that is accounted for 0.67% of all fields. Therefore, it can be estimated the number of RAC technicians as shown in Table 21 and Figure 13.

Table 21 Estimated number and proportion of formal and informal RAC Technicians in Thailand

Information		Year				
		2016	2017	2018	2019	2020
Total RAC Technicians	Persons	29,480	27,604	28,274	26,599	27,403
	Percentage (%)	100.00	100.00	100.00	100.00	100.00
- Formal RAC Technicians	Persons	16,080	15,410	15,745	15,209	15,544
	Percentage (%)	54.55	55.83	55.69	57.18	56.72
- Informal RAC Technicians	Persons	13,400	12,194	12,529	11,390	11,859
	Percentage (%)	45.45	44.17	44.31	42.82	43.28

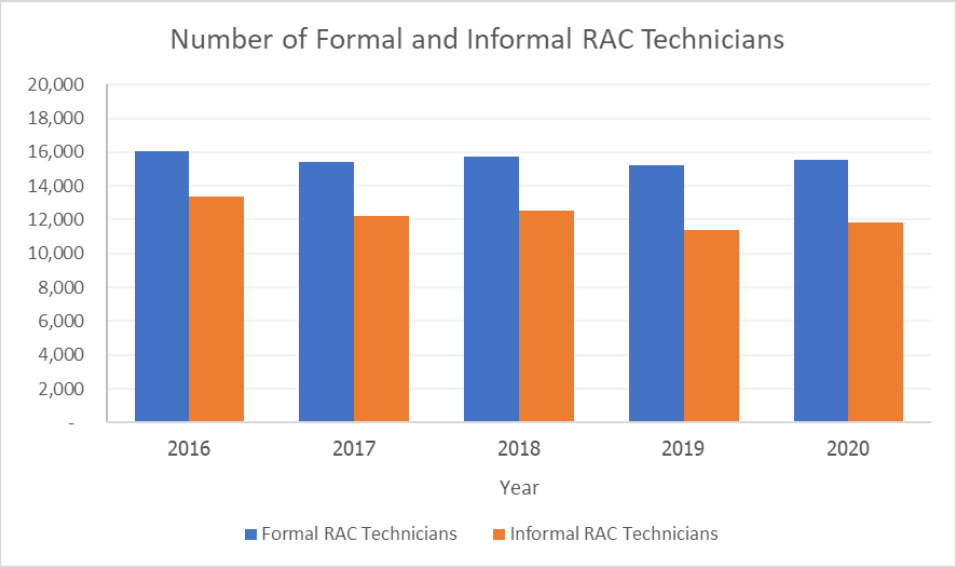

Figure 13 Number of Formal and Informal RAC Technicians

In addition, the consultant has studied and reviewed the most relevant information from different sources in order to see the exact characteristics of the RAC Technicians in Thailand. There were 2 key approaches for data collection; (1) Bilateral Discussions by self-developed guiding questions with stakeholders, and (2) Short Interviews via Phone with Service Providers.

(1) **Bilateral Discussions with stakeholders,** there were interviews with relevant agencies in many aspects such as end-user (hotel, office building, department store, and residence), service providers, producers, etc. to gain the exact information regards to the characteristics of service technicians in Thailand. There is a schedule as shown in **Table 22** and a summary as shown in **Table 23 - 26.**

Table 22 Bilateral Discussions on Characteristics of Service Technicians for RAC products

No.	Date	Time	Type	Organization
1	24 January 2022	2 – 3 PM	End-User: Hotel	Grand Richmond Hotel
2	27 January 2022	2 – 3 PM	Producer: AC	Mitsubishi Electric Kang Yong Watana Co., Ltd.
3	28 January 2022	1.30 – 4.30 PM	Service Provider	Pro Service Network Co., Ltd.
4	31 January 2022	4 – 5 PM	End-User: Office Building	EEC Engineering Network Co., Ltd.
5	1 February 2022	9 – 10 AM	Producer: AC	Siam Daikin Sales Co., Ltd.
6	1 February 2022	10 – 11 AM	Producer: Com. Ref.	Pattana Intercool Co., Ltd.
7	2 February 2022	1.30 – 2.30 PM	Producer: Com. Ref.	Sanden Intercool Thailand Public Co., Ltd.
8	3 February 2022	9.30 AM – 12.00 PM	End-User: Office Building, Residential	Jones Lang LaSalle, IP, Inc. (JLL)
9	3 February 2022	5 – 6 PM	End-User: Department Store	Ek-Chai Distribution System Co., Ltd.
10	4 February 2022	9 – 10 AM	End-User: Office Building, University	The Office of Physical Systems Management, Chulalongkorn University
11	11 February 2022	2 – 3 PM	End-User: Supermarket	CP Retailink Co., Ltd.
12	18 April 2022	10 – 11 AM	Producer: Com. Ref.	Systemform Co., Ltd.

Table 23 Summary of Key Findings from Bilateral Discussions – End-Users (1/2)

Topics	End-User					
	Hotel	Condominium	University	Office Building - Government	Office Building – Private	Office Building for Rental Shop
Type of Equipment	- 10 Split-type Air Conditioners (18,000 – 24,000 BTU); - 5 Chillers (420 Ton Refrigeration); Magnetic, Variable Speed Drives (VSD), and Centrifugal; ▪ 3 Chillers of age under 5 years; ▪ 2 Chillers of age more than 10 years; - 5 Food Storages (Refrigerators and Freezers).	- Split-type Air Conditioners (ACs)	- Split-type Air Conditioners (ACs)	- Split-type Air Conditioners (ACs) - VRF-type Air Conditioners (ACs) - 250 – 800 Ton Refrigeration Chillers	- 3 Chillers	- 7 Split-type Air Conditioners (ACs) in Office Zone; - 5 Chillers (800 Ton Refrigeration) in Office Zone, and Rental Shop Zone.
Type of Refrigerant	- R410a for Split-type ACs - R123 and R134a for Chillers - Unknown for Refrigerators and Freezers	- R32 for Split-type ACs		- R22, R134a, R410a, and R32 for Split-type ACs - R22, R134a, and R410a for Chillers	- R410a for Chillers	
Type of Technician	- In-house technicians - Outsourcing technicians from producers	- In-house technicians are selected by the buildings' owner for ACs in central space; - Outsourcing technicians are from the contractors of cleaning and maintenance for ACs in central space; - Outsourcing technicians are selected by Residential Juristic Person for residence.	- In-house technicians - Outsourcing technicians from contractors of Split-type Air Conditioners (ACs)	- In-house technicians - Outsourcing technicians for Chillers from producers - Outsourcing technicians from contractors for Split-type ACs	- In-house technicians - Outsourcing technicians for Chillers from producers	- In-house technicians are hired by the buildings' owner; - Some outsourcing technicians are hired by the contractors of system installation; - Some outsourcing technicians are from chiller producers; - Some outsourcing technicians are from the contractors of cleaning AC.
Qualification	- In-house technicians have graduated from high school, vocational certificate, and higher vocational certificate in the field of Electrical, Automotive, etc. - There is no qualification set for outsourcing technicians.			- In-house technicians graduated from high school/higher vocational certificate which is not directly from the field of RAC; - There is a qualification of outsourcing technician depends on level; ▪ Engineer must have graduated from Faculty of Engineering in field of Mechanical Engineering and possessed a License for Professional Practice in Associate Engineer Level	- In-house technicians must have graduated from the undergraduate level; - Outsourcing technicians must have graduated from the vocational and higher vocational certificate.	- There is a set qualification for the chief of in-house technicians that has to graduate from the higher vocational certificate (Electrical, Mechanical, and Automotive), or university. - There is no qualification which has been set for outsourcing technicians, except for their company or employer.

Topics	End-User					
	Hotel	Condominium	University	Office Building - Government	Office Building – Private	Office Building for Rental Shop
				▪ Technician must have graduated from Higher Vocational Certificate or above in the field of Electrical, Mechanical, or equal. ▪ Technician Assistant must have trained in course of Repairing Air Conditioners by DSD.		
Scope of Work	- In-house technicians have to deal with basic issues, cooperate with outsourcing technicians as well as make a maintenance plan and summary report. - Outsourcing technicians are from producers who have duty on repairing, maintenance, and cleaning by contract only for Chillers and Freezers.	- In-house technicians have to manage work for outsourcing technicians as well as make a maintenance plan for central space; - Outsourcing technicians are from the contractor of cleaning and maintenance AC in central space by schedule; - Outsourcing technicians are selected by Residential Juristic Person, and service by the requirement of the client.		- In-house technicians have to do a basic inspection, as well as manage work for outsourcing technicians and approve the maintenance plans from outsourcing technicians; - Outsourcing technicians have duty on maintenance and cleaning as planned.	- In-house technicians have to basic inspection, as well as manage work for outsourcing technicians and making a maintenance plan with outsourcing technicians; - Outsourcing technicians are from the producers and have duty on repair, maintenance and cleaning as planned.	- In-house technicians have to cooperate with outsourcing technicians, and make a maintenance plan; - Outsourcing technicians are from the contractors of system installation have maintained by product warranty; - Outsourcing technicians are from the chillers' producers after the contract with the contractor has expired. The in-house technicians are responsible for contacting; - Outsourcing technicians for cleaning from the contractor of cleaning.
Type of Servicing	- Split-type ACs are operated by in-house technicians on installation, repairing, cleaning, refrigerant refilling, decommissioning, and analyzing the causes of malfunction. - Chillers and Freezers are operated by outsourcing technicians on maintenance, cleaning, and inspection as well as report to in-house technicians if there are any issues to consider and estimate the cost of repairing.	- ACs in central space are maintained by outsourcing technicians for cleaning and maintenance under control by in-house technicians; - ACs in resident rooms will be maintained by the client's requirements such as repairing, cleaning, etc.		- Split-type ACs have been taken care of by outsourcing technicians such as cleaning, inspection, as analyze the causes of malfunction; - Chillers have been taken care of by its producers on maintenance and cleaning as planned.	- For chillers, in-house technicians have to do a basic inspection and clean filter, and; - outsourcing technicians have duties on maintenance, repair, internal cleaning, and inspection. - Outsourcing technicians have to report to in-house technicians if there are any issues to estimate and consider on repairing.	- Split-type ACs have been operated by in-house technicians for maintenance, repair, and inspection. There are outsourcing technicians for cleaning. - Chillers have been operated by outsourcing technicians for maintenance and cleaning by schedule.
Number of Technicians	- There are 4 – 5 in-house technicians for split-type	- There are 15 in-house technicians per condominium.		- There are 7 in-house technicians;	- There are 4 in-house technicians;	- There are 16 in-house technicians per building.

Topics	End-User					
	Hotel	Condominium	University	Office Building - Government	Office Building – Private	Office Building for Rental Shop
	ACs and Chillers (basic issues, and inspection). - There are 2 – 3 for each group of outsourcing technicians for Chillers and Freezers (maintenance by plans), depending on the amount of work.			- There are 2 outsourcing technicians.	- There are 3 – 10 outsourcing technicians.	
Servicing Contract	- Chillers; ▪ A 1-year contract; ▪ 4 contracts on servicing every 3 months. (3 contracts for chillers, 1 contract for freezers) - Servicing contracts are excluding the cost of repairing and spare parts.	- There is a 3-years contract with the buildings' owner; - There is a 3-year contract for cleaning and maintenance of Split-type Air Conditioners (ACs) in central space.	- It is an annual contract only. There is no hiring by case.	- There are 2 contracts of a 1-year contract for chillers; - There is 1 contract of a 1-year contract for split-type ACs; - Servicing contracts are excluding the cost of repairing and spare parts.	- There is a 1-year contract for chillers; - Servicing contracts are excluding the cost of repairing and spare parts.	- There is a 3-years contract with the buildings' owner; - There is a 2-years contract with the contractor of system installation; - There is a 1-year contract for cleaning split-type ACs; - There is a 3-years contract for Chillers from producers; - There are contracts with outsourcing technicians, excluding repairing costs and spare parts.
Satisfactory of Customer	- In-house technicians have to report on outsourcing technicians and assess satisfaction to Purchase Division such as characteristics of work, troubleshooting, and personality.				- There is a satisfactory assessment after every servicing.	
Training	- In-house technicians have always been trained on Large Air Conditioning, Personnel Responsible for Energy (PRE) by the Ministry of Energy, and Electrical Courses by DSD. - There is no direct course on Refrigeration and Air-Conditioning Systems by DSD.	- In-house technicians have been trained internally on the refrigeration system, general issues, and technical issues differently by level; - In-house technicians have been trained externally on electrical safety, and specific skills for different jobs. - There is no direct course on Refrigeration and Air Conditioning Systems by DSD.		- There is 1 in-house technician who had been trained on Large Air Conditioning by EGAT, and there are in-house technicians who have been trained by DSD.	- In-house technicians have been trained internally on basic electrical issues. - There is no direct course on Refrigeration and Air Conditioning Systems by DSD.	- In-house technicians have been trained internally on the refrigeration system, general issues, and technical issues differently by level; - In-house technicians have been trained externally on electrical safety, and specific skills for different jobs. - There is no direct course on Refrigeration and Air Conditioning Systems by DSD.
Perspective on current technicians	- Currently, the technicians have worked by their experiences. Therefore, training is the best thing for technicians to work					- Technician Assistants from outsourcing are lacking of knowledge, skills, and work experiences which may cause trouble.

Topics	End-User					
	Hotel	Condominium	University	Office Building - Government	Office Building – Private	Office Building for Rental Shop
	properly, reduce cost, reduce duration, and reduce trouble from lacking of knowledge. - There is no direct field of study on Refrigeration and Air-Conditioning Systems.					- Outsourcing technicians from other service providers are full of experiences and skills.
Perspective on using natural refrigerant	- Regards to transition to the natural refrigerant, the potential trouble on existing equipment should have been considered.					

Table 24 Summary of Key Findings from Bilateral Discussions – End-Users (2/2)

Topics	End-User	
	Department Store	Convenient Store
Type of Equipment	- Split-type Air Conditioners (ACs) - Chillers - Plug-in refrigerators and freezers - Remote condensing refrigerator	- Split-type Air Conditioners (ACs) - Plug-in Refrigerators - Remote Condensing Refrigerators
Type of Refrigerant	- R134a (95%) and R22 (5%) for Split-type ACs; - R134a for Chillers; - R290 (20 – 30%) and R134a (70 – 80%) for Plug-in refrigerators and freezers; - R404A (10 – 20%) and R448 (80 – 90%) for Remote condensing refrigerators.	- R32, R22, and R410A for Split-type ACs - R410A and R290 for Plug-in Refrigerators and Freezers as well as Remote Condensing Refrigerators in 200 places in Thailand.
Type of Technician	- In-house technicians in all regions; - There are 2 types of outsourcing technicians; service providers (70%), and producers (30%).	- In-house technicians - Outsourcing technicians are from the contractors which are those who use to be in-house technicians (in-house contractors).
Qualification	- Regional technicians must have graduated from vocational/higher vocational certificate in fields of electrical (70%), and mechanical (30%), as well as have work experiences.	- In-house technicians must have graduated from the vocational and higher vocational certificate (70%) and undergraduate level (30%) in the fields of Electrical, Mechanical, and Mechatronics.
Scope of Work	- Regional technicians have duty on basic stuff which not complicated such as maintenance, cleaning, etc. - Outsourcing technicians always handle the work that have to service more than 2 hours or above.	- In-house and Outsourcing technicians have been worked under the Company (Convenient Store); they have to work for the company only.
Type of Servicing	- There are basic and not complicated works of split-type ACs and Freezers such as maintenance, cleaning, etc. which have been taken care of by regional technicians. However, outsourcing technicians will be called if there is a complicating work that has to be taken care of more than 2 hours such as changing compressor, installing new equipment, etc.	- Maintenance, cleaning, repair, etc. for split-type ACs and refrigerators.

Topics	End-User	
	Department Store	Convenient Store
Number of Technicians	- There are regional technicians for 40 teams which are approximately 360 – 480 technicians in Thailand.	- There are 1,400 in-house technicians; - There are 600 in-house contractors.
Servicing Contract	- There is a contract for freezers which the customer can call whenever necessary.	
Communication Channel	- The customer has to contact the central service center which will coordinate with technician teams.	- The customer has to contact the central service center which will coordinate with technician teams.
Satisfactory of Customer		- There are satisfactory assessments every servicing; - There is monitoring on assessments every 3 months.
Training	- There is an internal course for regional technicians regards to the safety of work, refrigeration and air conditioning, electrical system, etc. - There are 1,300 technicians who passed the National Industrial Skill Standard (NISS) Testing in the field of Home Air Conditioner and Small Commercial Use.	- There is an in-house training for in-house technicians on Refrigeration and Air Conditioning; - In-house technicians are selected to train with producers of AC; - In-house technicians are selected to train with producers of refrigerators regards to R290; - In-house technicians have trained with DSD in the field of Electrical and Air Conditioning. - There are 200 – 300 in-house technicians who passed the National Skill Standard Testing.
Perspective on current technicians		- Students in Refrigeration and Air Conditioning or other related fields who are nearing graduation should undergo the National Skill Standard test before entering the labor market; - Technicians should have both knowledge and skills.

Table 25 Summary of Key Findings from Bilateral Discussions – Service Providers

Topics	Service Provider
Type of Equipment	- Fixed Speed and Wall-Type Air Conditioners (ACs)
Type of Refrigerant	- R32, R22, and R410A
Type of Technician	- In-house technicians
Qualification	- Graduated from under high school, 10%; - Graduated from high school, vocational certificate (Electrical), 90%. - There are 2 ranges for work experiences; (1) those who have 1 – 3 years of work experience are 70%, (2) those who have 3 – 5 years of work experience are 30%.
Scope of Work	- In-house technicians are able to do an installation, maintenance, cleaning, and decommissioning for all AC brands.
Target Group	- Residential, Condominium, Clinic, Hospital, and School
Type of Servicing	- Installation, maintenance, cleaning, decommissioning; most of them are cleaning services, approximately 80 – 100 units a day. - There is a goal for technicians to clean ACs not less than 4 units a day.
Number of Technicians	- There are 35 technicians – 26 teams; Installation and decommissioning 4 teams (2 or more technicians/team), cleaning 22 teams (1 technician/team).
Communication Channel	- The customers are able to contact directly through the website, and other channels provided on the website.
Satisfactory of Customer	- There is a satisfactory assessment after every service.
Training	- Applicants have to be trained on AC cleaning course in 1 week before the assessment. If they do not pass, they cannot become an in-house technician or even an assistant. - The trainers are those who passed the National Skill Standard Testing by DSD.
Perspective on technician	- There are few service providers in official companies.

Table 26 Summary of Key Findings from Bilateral Discussions – Producers

Topics	Description
Type of products and customer service	- Chillers, Room Air, Sky Air Conditioning, Package Air Conditioning, VRV/VRF, and other types of ACs; - Plug-in Refrigerators, plug-in freezers.
Type of Refrigerant	- R32, R410A, R134a, R123a, R1234zd for some models of chillers, R22 for old types of AC, R600a, R404A, and R290. - The company uses R290 as 90%, and R404A and R134a as 10% of total refrigerant use.
Target Group	- Residence, Industrial Factory, Office Building, Hospital, Hotel, School, Restaurant, Convenient Store, Super Market, and OEM.
Service Center	- There are appointed service centers in nationwide; regional hubs. - There are representative service centers; service only, service, and sales. - There are both in-house and outsourcing technicians
Type of Servicing	- Installation, cleaning, repairing, refrigerant refilling, and maintenance
Communication Channel	- The customers are able to contact directly through the appointed dealers, appointed service centers, or representative service centers in the nearest regional hub.
Assignment	- Companies have assigned to the technician teams; average 4 – 5 jobs/day for some service centers, and 10 jobs/day for some service centers.
Qualification of Technician	- Contractors in each region are responsible for selecting proper technicians; some contractors have not set the qualification of technician, while there is a set qualification in some contractors by considering; ▪ Educational Background: graduated from primary school, junior high school, senior high school, vocational certificate, higher vocational certificate (it is a must in some companies), university (it is a must in some companies); ▪ Work Experiences; ▪ Knowledge and Skills; ▪ Readiness for work and using tools; ▪ Readiness of team; *** Those who meet all requirements are sent for internal training and testing before they are sent out for work.
Social Security	- There are 2 types of companies that have the Social Security as an allowance (30%), and without this allowance (70%).
Servicing Contract	- There is servicing by the products warranty; - There are 1-year servicing contracts in several terms for many target groups such as Industrial Factory, Office Building, Hospital, Hotel, School, etc.; - There is a servicing on a case-by-case basis.
Self-Developed Training Course	- There are internal training courses which the difficulties are depended on the trainers; ▪ AC repairing (there is no limit to educational qualifications for trainees, but must have work experience);

Topics	Description
	▪ VRF systems (trainees must have graduated from higher vocational certificate level or above); ▪ Preparation for the NOSS/NISS (2 days); - There are co-op training courses with DSD in upgrade training course such as; ▪ Course: Installation of AC that uses R32 and Repairing Inverter AC; ▪ Course: Installation of Small AC and Small Commercial Use that use R32; *** Those who passed this course are able to participate in NOSS/NISS (Technicians of Home Air Conditioning and Small Commercial Use – Level 1); - There are co-op training courses with OVEC in 2020 to train the trainers (200 trainers) in nationwide; ▪ Inverter AC; ▪ Air Conditioners (ACs) that use R32; - There is a network collaboration with other private companies known as the "Center of Vocational Manpower Networking Management (CVM)" in 2021 – 2022. This collaboration aims to train students in the field of Refrigeration and Air Conditioning Techniques at Rajasitharam Technical College.
Training	- There are training courses for 2 - 3 in-house technicians and contractors' technicians annually (all courses); - Some companies have provided certificates for trainees to build up the confidence for customers; - There are 20 technicians who have completed the course of Preparation for the NOSS/NISS, including 6,000 technicians who have completed in-house training courses across the country for some companies. - Some companies only offer in-house training courses for knowledge sharing. - Some companies had the opportunity to participate in the course of natural refrigerants provided by KMUTNB.
National Skill Standard Testing	- Some companies are designated by DSD as testing centers for NOSS/NISS in the field of Technician for Home Air Conditioning and Small Commercial Use (Level 1); - 90 – 100% of Technicians at some companies must pass the test of NOSS/NISS at least level 1 (1 technician in a service center of some company is allowed); - Some companies have 6 – 11 technicians who have passed Level 1 and Level 2 of NOSS/NISS testing.
Perspective on Technician	- Most technicians across the country have graduated in vocational and higher vocational certificate levels. - There are up to 60% of technicians who lack knowledge and skills across the country. - There are few technicians who directly graduated in the field of Refrigeration and Air Conditioning, and few technicians have working experience. The number of technicians with knowledge and experience in the labor market is insufficient, which the employers have to pay their training fees.

Topics	Description
	- Many companies agree on having a law to compel technicians in the refrigeration and air conditioning field to pass the NOSS/NISS tests and skill assessments. - Technicians should have passed the NOSS/NISS tests and skill assessments to ensure proper operations and minimize damage from improper operations. - There are 3 classes for experienced technicians; ▪ Class A: There are 30% of technicians who have work experience for 10 years or above; ▪ Class B: There are 50% of technicians who have work experience between 3 to 5 years (most refrigeration and air conditioning technicians are in this class); ▪ Class C: There are 20% of technicians who have work experience less than 3 years (most technician's assistants who have been able to do only cleaning are in this class).

Regarding to the bilateral discussions, it can be concluded that Thailand has few skilled and experienced technicians which is insufficient for the labor market. Although most technicians have graduated from higher vocational certificates, there is still a lack of knowledge and skill due to their graduated field was not directly to refrigeration and air conditioning systems. Therefore, these technicians should have been passed the NOSS/NISS testing and skill assessments by DSD before entering the labor market.

In addition, possessing a license in the direct or other relevant fields will increase the trust and confidence of clients as well as their employers. Therefore, most employers agree on having certain laws or regulations for refrigeration and air conditioning technicians to possess the license or at least passed the NOSS/NISS testing and skill assessments in Level 1 or Level 2 which means they are skilled and ready to work immediately.

Regarding to the bilateral discussions, technicians are able to be categorized into 2 types by Social Security as described in *Task 2 (sub-task 1/3)* [page 42]; formal and informal technicians, which these technicians in both types are able to work in many terms as shown in **Figure 14.**

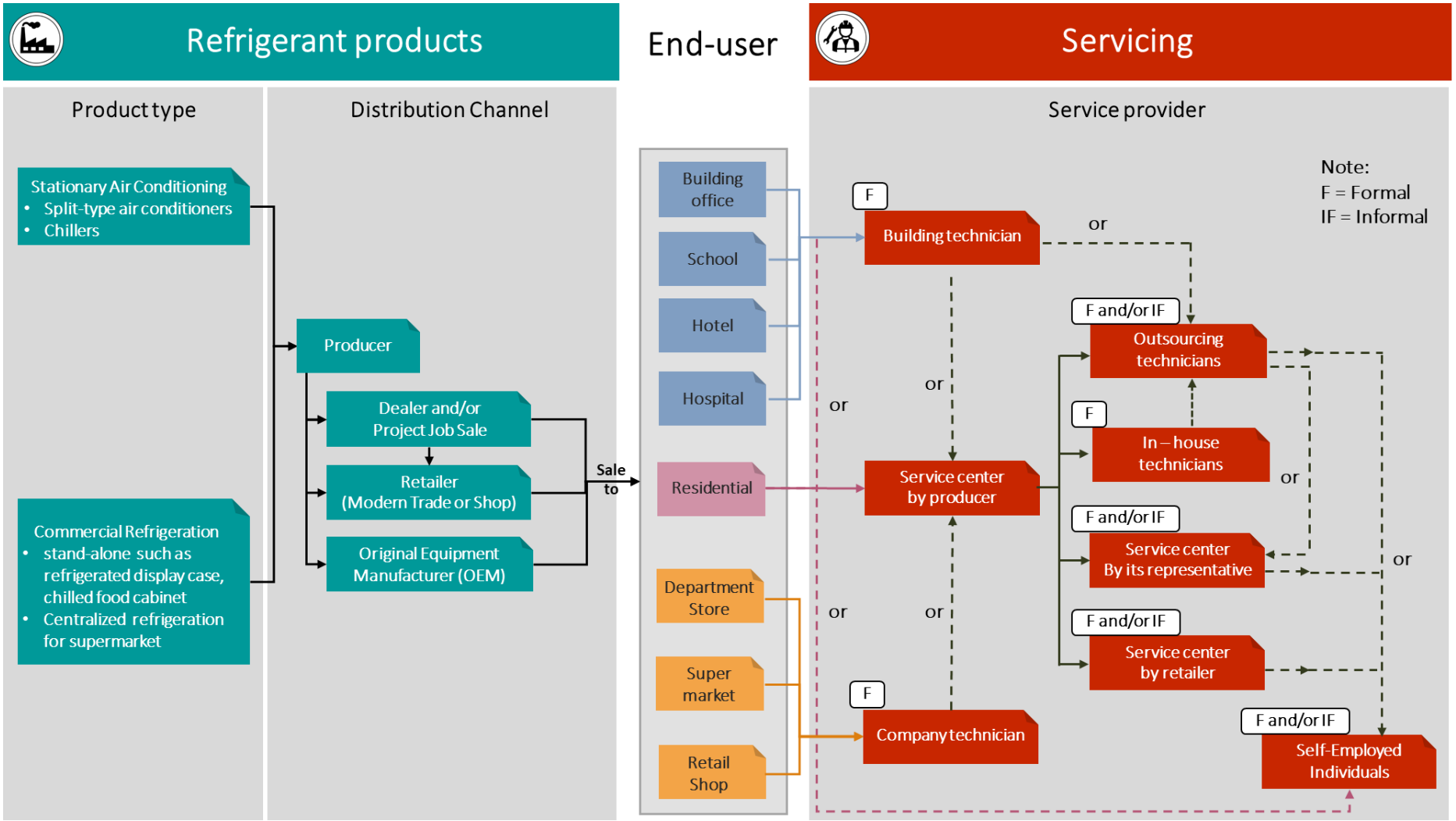

Figure 14 Characteristics of Servicing in RAC Sector (Air Conditioning and Commercial Refrigeration)

(2) Short Interviews via Phone with Service Providers, there are 2 sources of information which are (1) the service providers who registered in the Department of Business Development (DBD), (2) local service providers in Bangkok and nearby provinces. It was an informal interview (short interview) via phone call which asking by short guiding questions developed by the consultant via Google Form; type of equipment on service, type of servicing, number of technicians, social security, educational background, and training.

According to the name list from the DBD, there are 2 relevant TSIC numbers i.e., 43223 (installation) and 95220 (repairing), which has shown that there are more than 2,500 registered service providers, as well as there are local service providers searched in Bangkok and nearby provinces.

Regards to this approach and time, there were 90 out of 498 (18.07%) contacted service providers which from 75 out of 425 (17.65%) registered service providers and 15 out of 73 (20.55%) local service providers had provided that information. It can be assumed by scaling-up to 2,500 entrepreneurs as shown in Table 27 and Figure 15 - 20.

Table 27 Information from short interviews and making an assumption (scale-up)

Information	Short Interview with Service Providers		Scale-up (unit)
	Amount (unit)	Percentage (%)	
1) Type of equipment on service			
- Air Conditioners (entrepreneur)	74 out of 90	82.22%	2,056 out of 2,500
- Commercial Refrigerators (entrepreneur)	7 out of 90	7.78%	194 out of 2,500
- Air Conditioners and Commercial Refrigerators (entrepreneurs)	9 out of 90	10.00%	250 out of 2,500
2) Type of servicing			
- Installation (entrepreneur)	7 out of 90	7.78%	194 out of 2,500
- Maintenance and Repairing (entrepreneur)	6 out of 90	6.67%	167 out of 2,500
- Cleaning (entrepreneur)	0 out of 90	0.00%	0 out of 2,500
- Decommissioning (entrepreneur)	0 out of 90	0.00%	0 out of 2,500
- Installation, Maintenance, and Repairing (entrepreneur)	9 out of 90	10.00%	250 out of 2,500
- Installation and Cleaning (entrepreneur)	1 out of 90	1.11%	28 out of 2,500
- Maintenance, Repairing and Cleaning (entrepreneur)	5 out of 90	5.55%	139 out of 2,500
- Maintenance, Repairing and Decommissioning (entrepreneur)	1 out of 90	1.11%	28 out of 2,500
- Installation, Maintenance, Repairing and Cleaning (entrepreneur)	8 out of 90	8.89%	222 out of 2,500
- Installation, Maintenance, Repairing and Decommissioning (entrepreneur)	1 out of 90	1.11%	28 out of 2,500
- Installation, Maintenance, Repairing, Cleaning and Decommissioning (entrepreneur)	41 out of 90	45.56%	1,139 out of 2,500
- Other (entrepreneur)	8 out of 90	8.89%	222 out of 2,500

Information	Short Interview with Service Providers		Scale-up (unit)
	Amount (unit)	Percentage (%)	
- N/A (entrepreneur)	3 out of 90	3.33%	83 out of 2,500
3) Number of technicians			
- In-house Technicians (persons)	511 persons	6 persons/ entrepreneur (avg.)	15,000 persons
- Outsourcing Technicians (persons)	58 persons	2 person/ entrepreneur (avg.)	5,000 persons
4) Social Security for in-house technicians			
- Section 33	59 out of 90 (entrepreneur)	65.56%	9,834 persons
- Section 39	1 out of 90 (entrepreneur)	1.11%	166 persons
- Section 40	1 out of 90 (entrepreneur)	1.11%	167 persons
- Unknown, N/A	29 out of 90 (entrepreneur)	32.22%	4,833 persons
- **Total**	**90 out of 90 (entrepreneur)**	**100.00%**	**15,000 persons**
5) Educational Background of in-house technicians			
- Primary School (Grade 6, Por 6)	7 out of 90 (entrepreneur), 7.78%	2.83%	425 persons
- Junior High School (Grade 9, Mor 3)	38 out of 90 (entrepreneur), 42.22%	15.39%	2,309 persons
- Senior High School (Grade 12, Mor 6)	42 out of 90 (entrepreneur), 46.67%	17.00%	2,550 persons
- Vocational Certificate	51 out of 90 (entrepreneur), 56.67%	20.65%	3,098 persons
- Higher Vocational Certificate	53 out of 90 (entrepreneur), 58.89%	21.45%	3,219 persons
- Undergraduate	42 out of 90 (entrepreneur), 46.67%	17.00%	2,550 persons
- Unknown, N/A	14 out of 90 (entrepreneur), 15.56%	5.67%	851 persons
Total		**100.00%**	**15,000 persons**
6) Training status of in-house technicians			
- Trained	53 out of 90 (entrepreneur)	58.89%	8,834 persons

Information	Short Interview with Service Providers		Scale-up (unit)
	Amount (unit)	Percentage (%)	
- Never trained	33 out of 90 (entrepreneur)	36.67%	5,500 persons
- Unknow, N/A	4 out of 90 (entrepreneur)	4.44%	666 persons
Total	90 out of 90 (entrepreneur)	100.00%	15,000 persons

Remark: Self-analysis by the consultant, 2022.

According to **Table 27,** all the data has been scaled up to the current maximum of entrepreneurs and it has shown that there are approximately 2,056 entrepreneurs (82.22% of 2,500) are servicing only for air conditioners products, 194 entrepreneurs (7.78% of 2,500) are servicing only for commercial refrigerators products, and 250 entrepreneurs (10% of 2,500) are servicing for both air conditioners and commercial refrigerators products which can summarize that the most entrepreneurs are servicing for air conditioners products as shown in **Figure 15.**

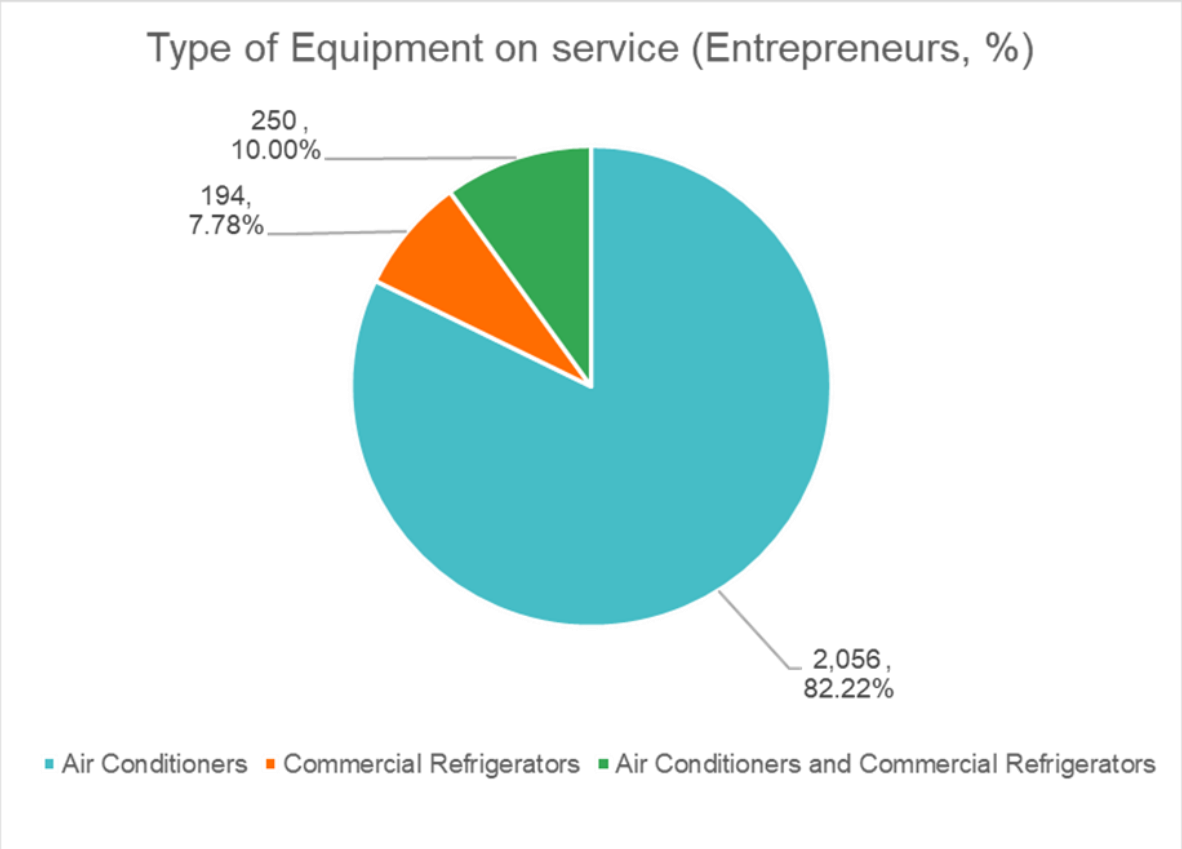

Figure 15 Type of Equipment on service

In addition, it can be divided in type of servicing such as Installation, Maintenance and Repair, Cleaning, and Decommissioning. Most of entrepreneurs are servicing in many types which not only a 1-type servicing. The most operation of entrepreneurs is "Installation, Maintenance, Cleaning, and Decommissioning" which accounted for 45.56% (1,139 out of 2,500 entrepreneurs) as shown in **Figure 16.**

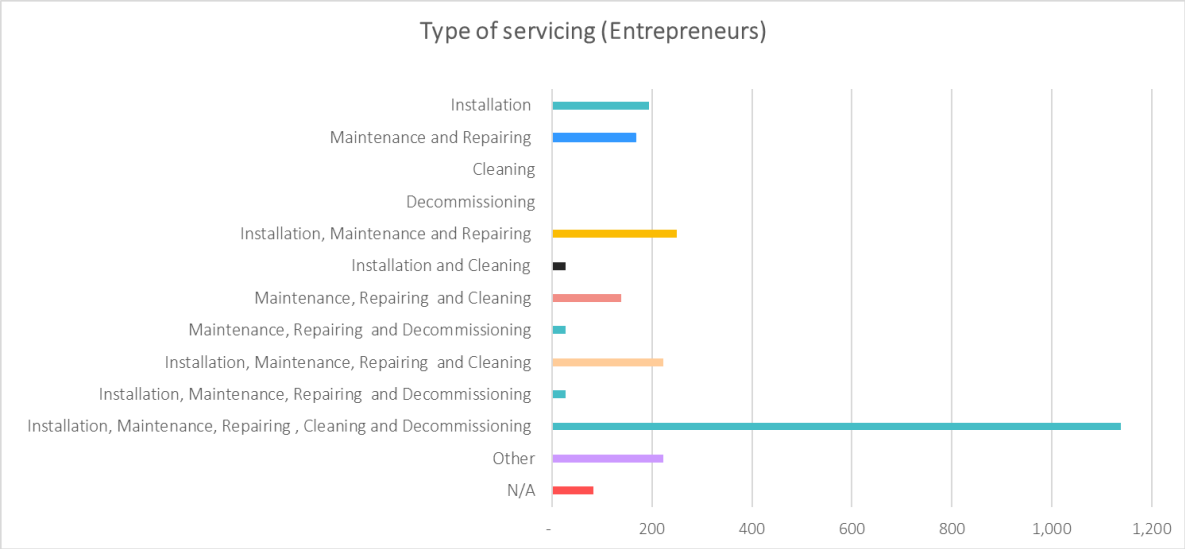

Figure 16 Type of Servicing

According to **Table 27,** it has shown that there are approximately 6 in-house technicians per entrepreneur and 2 outsourcing technician per entrepreneur which is able to scale up for 2,500 entrepreneurs as shown in the table that there are approximately 20,000 technicians in the labor market. In this case, it is focusing on in-house technicians which are approximately 15,000 technicians as shown in **Figure 17.**

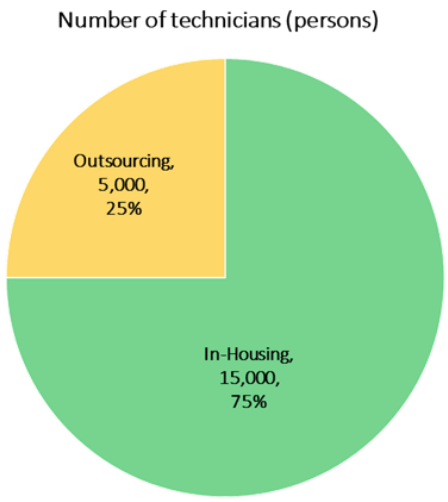

Figure 17 Number of technicians

In addition, it can be categorized that there are **formal technicians approximately 10,167 persons** which up to 67.78% that can be separated by the social security's sections, and there are **informal technicians approximately 4,833 persons** which up to 32.22% as shown in **Figure 18.**

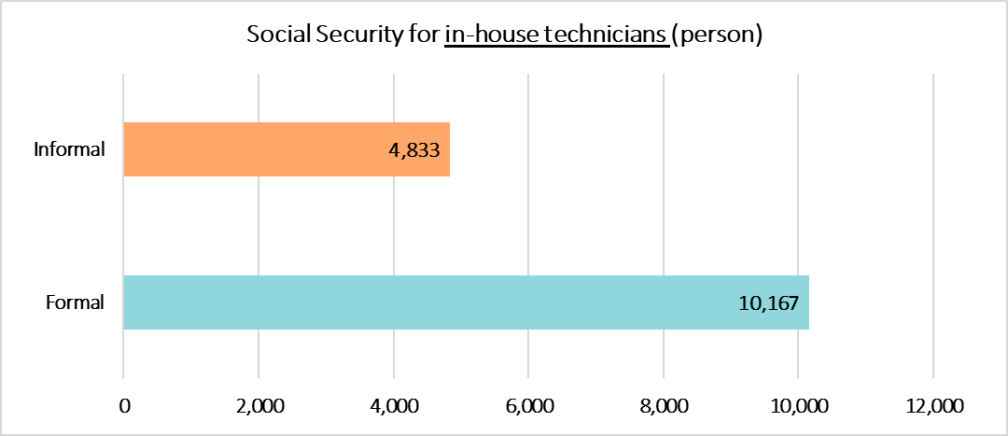

Figure 18 (a) Social Security for in-house technicians

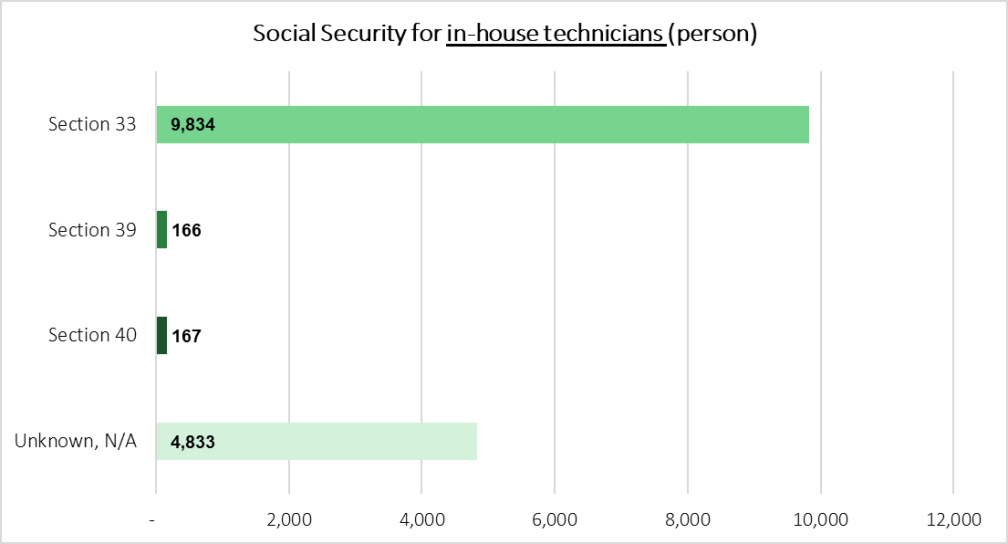

Figure 18 (b) Social Security for in-house technicians

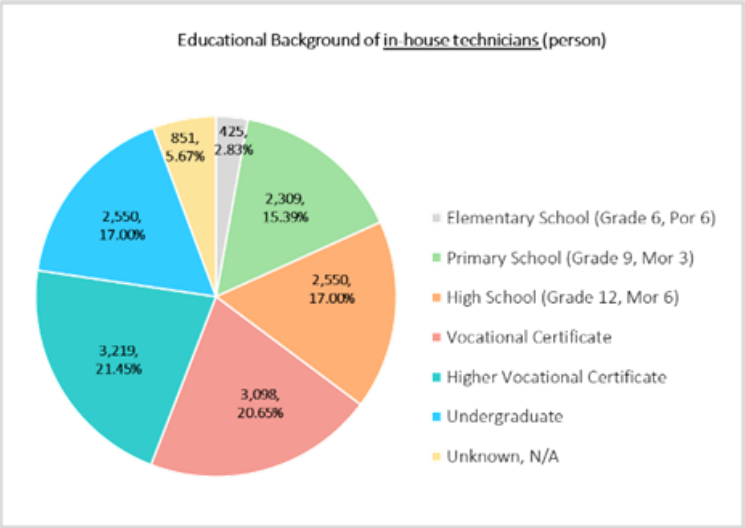

Figure 19 Educational Background of in-house technicians

Regarding to the technicians' educational background, it can be seen that there are technicians who are **graduated from the higher vocational certificate the most with 21.45%** and followed by vocational certificate (20.65%), senior high school and undergraduate (17.00%), junior high school (15.39%), and primary school (2.83%), respectively as shown in **Figure 19.**

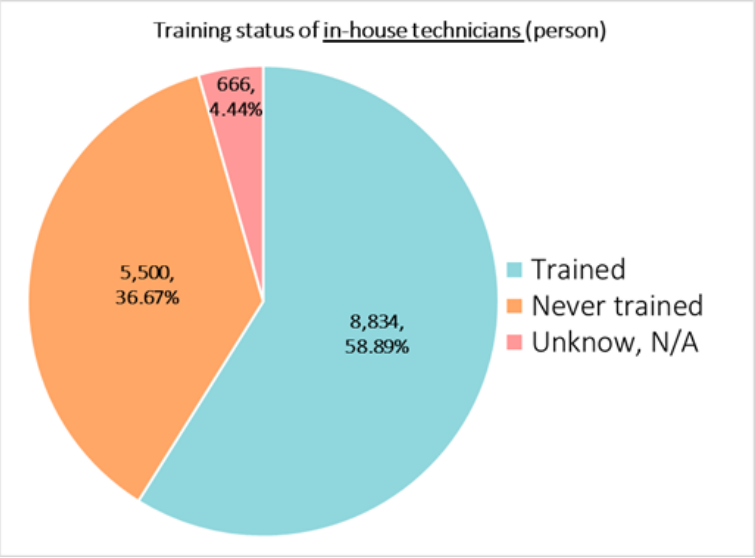

Figure 20 Training status of in-house technicians

Regarding to the training status of in-house technicians, it can be seen that there are **trained technicians up to 58.89%** from all courses of refrigeration and air conditioning systems (which is approximately 8,834 persons and in accordance with information from the DSD which will be shown in the next topic) and **those who have never been trained for 36.67%** as shown in **Figure 20.**

Task 2 (sub-task 2/3): Analyze the Commercial Refrigeration and AC servicing operation in terms of the correspondence among the existing and potentially required skills/certifications (e.g., capacity development, national training curriculum, training centers/institutions) of Thai technicians, the sufficient number of trained technicians from both formal and informal system, and/or additional requirements needed for the service

To review the training, certification, and licensing mechanism for RAC technicians, the Consultant has conducted desk reviews of the available information from relevant sources. The relevant agencies are in the government sector, private sector, and educational sector. In addition, there were bilateral discussions (via online) from the previous result of activities (*Task 1*) to obtain more details and update status beyond the consultant's reviews. There is a schedule for bilateral discussions as shown in Table 28.

Table 28 Bilateral Discussions with relevant agencies on Training, Certification, and Licensing Scheme

No.	Date	Time	Type	Organization
1	27 January 2022	2 – 3 PM	Private Sector	Mitsubishi Electric Kang Yong Watana Co., Ltd.
2	28 January 2022	9 – 10 AM	Educational Institute	Rajamangala University of Technology Isan (RMUTI)
3	28 January 2022	10 – 11 AM	Government	Department of Skill Development (DSD)
4	28 January 2022	1.30 – 2.30 PM	Educational Institute	King Mongkut's University of Technology North Bangkok (KMUTNB)
5	1 February 2022	9 – 10 AM	Private Sector	Siam Daikin Sales Co., Ltd.
6	4 February 2022	10 AM – 12 PM	Educational Institute	Office of the Vocational Education Commission (OVEC)

According to the bilateral discussions, there are relevant data from DSD such as training centers, training courses, sub-courses (subjects), number of trainees, and number of trained technicians as shown in Table 29 as well as numbers of those who passed the NOSS/NISS testing as shown in Table 30 regardless of taking a skill assessment.

The mapping of technicians' skills corresponding to the training certification requirements will be evaluated against the number of technicians that match the labor market. The obtained data is planned to estimate both demand of technicians in the labor market and supply capacities from training centers as follow.

Table 29 Number of trained technicians from existing training centers (by DSD)

Training Course	Year						Accumulation Year 2019 - 2021	
	2019		2020		2021			
	No. of trainees	No. of trained technicians	No. of trainees	No. of trained technicians	No. of trainees	No. of trained technicians	No. of trainees	No. of trained technicians
Upgrade Training	4,115	3,992	6,452	6,263	5,796	5,359	16,363	15,614
Pre-employment Training	651	482	699	510	757	580	2,107	1,572
Re-Training	1,374	1,358	959	941	739	711	3,072	3,010
Total	**6,140**	**5,832**	**8,110**	**7,714**	**7,292**	**6,650**	**21,542**	**20,196**

Remark: Training centers and their sub-courses (subject), see **Annex D**

Table 30 Number of technicians who passed the NOSS/NISS testing

Occupation Field	Level	Year						Accumulation Year 2019 - 2021	
		2019		2020		2021			
		Registered	Passed	Registered	Passed	Registered	Passed	Registered	Passed
Technician of Home Air Conditioners and Small Commercial Use	1, 2	3,329	2,746	4,949	3,989	5,579	4,077	13,857	10,812
Technician of Home and Commercial Refrigeration	1	-	-	-	-	19	18	19	18
Technician of Large Air-Conditioning	1	-	-	-	-	17	17	17	17
Total		**3,329**	**2,746**	**4,949**	**3,989**	**5,615**	**4,112**	**13,893**	**10,847**

Remark: Regardless of those who received and/or passed the skill assessment.

In addition, there are relevant data from the OVEC such as colleges, majors, sub-majors, and numbers of graduated students from both vocational and higher vocational certificates in relevant fields such as Electrical, Mechanical, Automotive, and Refrigeration and Air-Conditioning which will be able to work as RAC technicians as shown in **Table 31.**

Table 31 Numbers of graduated students from the colleges under OVEC in relevant fields

Year	Number of graduated students					
	Government College		Private College		Total	
	Vocational Certificate	Higher Vocational Certificate	Vocational Certificate	Higher Vocational Certificate	Vocational Certificate	Higher Vocational Certificate
2015	13,395	13,413	-	-	13,395	13,413
2016	13,833	24,476	7,704	3,234	21,537	27,710
2017	14,299	14,381	7,076	4,410	21,375	18,791
2018	13,626	13,282	8,752	4,569	22,378	17,851
2019	15,037	15,186	8,994	3,230	24,031	18,416

Regarding to the desk reviews, there is a result from the National Statistical Office (NSO) that there are technicians in many fields as 4.09 million persons in 2020, while the data from the OVEC has shown that there are **approximately 40,947 persons per year who graduated from the direct or other relevant fields** by averaging from 2017 to 2019. However, it does not mean that all the students who have graduated with vocational education are entering the labor market as a technician for the RAC sector in actuality.

The analysis has provided the relevant information for this approach such as servicing times of products available in the market through its lifetime, the number of available products in the current market and its accumulation (estimate), and numbers of technicians in the service market (estimate from number of products and servicing times).

According to *Task 1 (sub-task 3/3)*, there are results from the questionnaire provided by EGAT which have shown the number of RAC production and its available in the current market. These numbers are able to determine the average of RAC production in each year, as well as there are default values of its lifetime from ***2006IPCC*** (2006IPCC, IPPU, Chapter 7, Volume 3, Table 7.9, Page 7.52) as shown in **Table 32** which can be used to estimate the demand on servicing technicians.

Table 32 Default values of RAC appliance's lifetime

Appliance	Default Lifetime (years)
Residential AC	10 – 20
Chillers	15 – 30
Stand-alone Commercial Refrigeration	10 – 15

Remark: Lower value for developed country and higher value for developing country

According to **Table 17** in *Task 1 (sub-task 3/3)* [page 38], it can be assumed that there are average numbers of RAC production annually as 4,000,000 ACs and 70,000 Commercial Refrigerators. Regarding to the appliance's default lifetime, it can be assumed the demand on servicing technicians as shown in **Table 33.**

Table 33 Estimation on numbers of demanded servicing technicians through appliances' lifetime

Appliance	Averaged Annual Production (units)	Default Lifetime (years)	Assumed accumulation (units)	Daily demand on servicing (units/day)	Demand on servicing technicians (persons)
AC	4,000,000	10	40,000,000	109,589	27,397
Com. Ref.	70,000	15	1,050,000	2,877	288
Total	**4,070,000**		**41,050,000**	**112,466**	**27,685**

According to the **Table 33,** it has shown that the current demand on servicing technicians is up to 27,685 technicians which means there are insufficient servicing technicians in the current labor market and it is in accordance with the information from stakeholders' interviews in *Task 2 (sub-task 1/3)*.

Task 2 (sub-task 3/3): Identify technical, institutional, and regulatory gaps/ barriers to the Commercial Refrigeration and AC servicing and the use of cooling appliances with natural refrigerants in Thailand

As all information and studied, the approach to this task is to identify and elaborate on gaps and barriers in accordance with the 3 categories. The policy and regulatory framework as well as the institutional framework, that might obstruct or slow the extension of natural refrigerant use. To find any potential gaps and barriers which might be also related to the market needs in terms of relevant standards from the service providers.

1. Policy and regulatory framework;

1.1 Standardized products

Regarding to the standardized products, it refers to some appliances which have been standardized by TISI such as air conditioners, plug-in cabinets, heat pumps, domestic refrigeration, etc. but there are other products in the RAC sector in accordance with *2006IPCC* such as vending machines, centralized refrigeration systems in supermarket, etc.

The analysis has focused on Air Conditioning and Commercial Refrigeration products. In this regard, the Thai Industrial Standards Institute (TISI) has revised relevant standards such as TIS 1155-2557 (Air-cooled split type room air conditioners) standard which the flammable refrigerants can be used. According to this standard, there are limits on the appliance's size which must be less than 18,000 W (60,000 BTU/h) as well as only for split type air conditioners. However, there are other types of air conditioners such as wall type, ceiling or floor type, HVAC, package type, movable type, window type, etc. in various sizes which have not been covered with regards to using natural refrigerants.

In addition, there is TIS 2738-2559 (Cabinet blast chiller and freezer) standard which flammable refrigerants can be used. According to this standard, there are various types of this kind of product that have not been covered such as vending machines, etc.

1.2 Safety regulation for using highly flammable substances in high-rise building

Although there are standards for both products and technicians, using natural refrigerants in high-rise buildings still be a strong barrier for eco-friendly refrigerants.

- According to Ministerial Regulations No. 33, B.E. 2535 (1992) Issued under the Building Control Act, B.E. 2522 (1979), the high-rise building means the building that can be accessed or used for living which has a height of 23 meters and higher.
- Item 10: Ventilation for high-rise or extra-large buildings with air-conditioners must follow its sub-item. The sub-item (2) has referred to refrigerant use which prohibited the hazardous or highly flammable refrigerants that are directly used in air-conditioners.
- For a new type of refrigerant, it must have relevant research in various to prove the safety (flammable status: fire spread) of that refrigerant as well as the refrigerant must be proved and approved by the relevant ministries (including the Hazardous Substances Management Division under the Department of Industrial Works (DIW), Ministry of Industry), then propose to the Department of Public Works and Town & Country Planning (DPT) to amend the regulations.

2. Institutional framework;

2.1 Standardized service providers

There is a National Occupational Skill Standard (NOSS)/National Industry Skill Standard (NISS) under the Department of Skill Development (DSD) for technicians regards to Refrigeration and Air Conditioning Systems since 2019 which has shown in **Table 30** of *Task 2 (sub-task 2/3)* [page 64]. Those training courses regard to air conditioners have covered the use of R32 and R410A as refrigerants but not covered the use of natural refrigerants.

However, developing a new training course or adding some techniques of Safe Use and Handling of Flammable Refrigerants into the course is limited and not widespread. Therefore, there are some knowledgeable technicians who have been trained by the producers or trained from the 8 training centers under the RAC NAMA project which are able to handle natural refrigerants such as R290, R600a, etc.

In addition, there are limits on training centers and training facilities for the courses regard to natural refrigerants such as safety devices, specimens, training centers, trainers, and public relations are insufficient. Regard to insufficient training centers, distance is one of the biggest obstacles for trainees.

According to the Ministerial Announcement of the Ministry of Labour (B.E.2558) which have been described in *Task 1 (sub-task 2/3)* [page 30 and 35], there is an issue of "Specification of Occupations which may constitute danger to public safety", thus, those occupations should be carried out by those who possessed a certificate of competence or licenses. In this regard, only the technicians for Home Air Conditioning and Small Commercial Refrigeration have been required to possess the license. However, other relevant issues regard to Technicians for Home and Commercial Refrigeration as well as Technicians for Large Air Conditioning should have been included in the Ministerial Announcement due to these occupations might constitute danger to public safety as well. In addition, this matter is able to close the gap of knowledge and skill for all technicians in any relevant fields of refrigeration and air conditioning.

3. Market requirements

According to the information of requesting label No.5 provided by EGAT, the trend of demand on commercial refrigeration using natural refrigerants has been increased every year which opposite to air conditioning that there is no amount of production due to the COVID-19 pandemic. Although the producers have changed the production line for green cooling technology products, there is still lacking of order both domestic and export. Besides, the price of materials has been increased due to its logistics both at national and international levels.

However, law and regulation are one of the strongest barriers for transitioning to using natural refrigerants. In addition, lacking of public relations cause a misunderstanding of using natural refrigerants and their safety.

Task 3: Develop and Elaborate Recommendations and Potential Linkage

As initiated the green cooling technology by supporting climate-friendly and energy-efficient cooling technologies, the RAC NAMA project assists Thailand in reaching its energy-saving as well as its climate targets as pledged in Nationally Appropriate Mitigation Action (NAMA) and Nationally Determined Contribution (NDC) submitted to UNFCCC. The project aims to support the industry in staying competitive and will bring international climate finance to the country.

To assist Thailand in reaching its pledged goal of emission reduction by working with the Thai Refrigeration and Air Conditioning (RAC) sector to develop and promote products that use climate-friendly natural refrigerants and also have high energy efficiencies. In addition, the Kigali Amendment which Thailand will soon ratify is directly relevant to policymakers in relation to the climate-friendly and energy-efficient cooling technologies.

Task 3 (sub-task 1/2): Identify the existing/potential linkage and also the feasible direction/ channel for the sustainable expansion/enhancement of green cooling technology for Commercial Refrigeration and AC servicing, from the formal sector (policy-makers, government agencies responsible for the skill-training topics) to the informal sector (private servicing company);

To link and direct the green cooling technology expansion for Com. Ref. and ACs servicing, the needs and benefits when deploying regulations from the formal sector to the informal servicing sector needs to be realized. Below are some issues to be addressed prior to the identification of the link between the formal sector and informal sector, then the potential recommendations for improving or shaping the policies will be provided at the end.

There are 4 key elements have been identified as shown in **Figure 21,** which has shown the potential to enhance the adoption of green cooling technology;

1. Standardize the existing training curriculum in addition to alternative refrigerants;
2. Enhance the existing certified & licensed technician scheme incorporating the natural refrigerants;
3. Enhance policies/regulations and coordination of government agencies;
4. Public awareness and capacity building.

Standardize the existing training curricula in addition to natural refrigerants and expand the training centers

1. Standardize the existing training curricula emphasis on HCFC and HFC to the natural refrigerants for green cooling technology and other alternative that linked to Montreal Protocol
   Good servicing practices (GSP) and standard on Safety on handling, filling & re-filling refrigerant, etc. and on high quality of workmanship on services when Cleaning, Installation, Maintenance, Repair, etc.
2. Private sector curricula should align with the NOSS based on the focused areas
3. Increase the number of training centers that related natural refrigerants

Enhance policies/ regulations and co-ordination of government agencies

1. Enhance policies and regulations to promote green cooling technology
2. Develop value chain for green cooling technology
3. Improve product and technician standard toward to green cooling technology
4. Ensure co-ordination between the government agencies and industry associations so that all aspects of skill development and greenhouse gas emission reduction are included

Ensure co-ordination between the government agencies and industry associations to so that all aspects of knowledge and skill development and greenhouse gas emission mitigation

Enhance policies/ regulations to promote green cooling technology
- Ban the use high GWP HFC refrigerants
- De-regulate the building code to allow safely use of flammable refrigerants with improved high level of safety standard
- Enforce to have certified technicians to ensure good practices, knowledge and skill when deal with highly flammable refrigerant

Develop value chain on green cooling technology
- Green public procurement strategy
- Funding – subsidy or tax incentive for green cooling technology

Improve product and technician standard toward to green cooling technology
- Improve rate of Energy Efficiency - Minimum Energy Performance Standard (MEPS) and labelling
- Improve Safety Standard for appliances
- Develop installation standard for flammable refrigeration in appliances
- Increase the number of testing facilities to train the service technicians

Enhance the existing certified & licensed technician scheme incorporating the use of natural refrigerants

1. Extend certification and licensing scheme to cover natural refrigerant for green cooling technology in the focused areas as follows
   - Air-conditioning Technician (Home and Small Commercial Use)
   - Home and Commercial Refrigeration Technician
   - Large Air-conditioning Technician
2. Improve the government programme that are already NOSS compliant to consider incorporating green cooling technology for future upgradation as follows
   - Pre-employment training
     Pre-employment training refers to skill training for people prior to employment to enable them to work in accordance with the skill standards. This includes students or people sent for training by government agencies.
   - Labour skill enhancement
     Labour skill enhancement is additional training provided by the employer to employees to enhance their knowledge and skills relevant to their job fields.
   - Training for an occupational change
     Training for an occupational change refers to additional training provided by the employer for the employees to have additional training outside of the professional field to enable the employee to have knowledge and ability to also work in other fields.

Public awareness and capacity building

1. Raise the awareness, skills and capacities for alternative refrigerants related to green cooling technology
   - Awareness building measures, such as (nation-wide) awareness campaigns and knowledge sharing for green cooling technology.
   - Enhancement of skills and capacities/training of technicians and officials.

Figure 21 The potential to enhance green cooling technologies

Task 3 (sub-task 2/2): Develop and elaborate recommendations for addressing the remaining gaps/barriers and for establishing/strengthening the linkage identified for Commercial Refrigeration and AC servicing sector

Hence as identified potential linkage from the previous task, there might have the remaining gaps and barriers that can be addressed in relation to technical knowledge, policy and regulation that could have barred the progress of green cooling technologies in the service sector. In addition, the market mechanism is driven by policy instruments, financial instruments shall be considered as the potential gap and barriers.

- Recommendations

1. Standardize the existing training curricula in addition to alternative refrigerants

   - Standardize the existing training curricula that emphasize on high GWP (HCFC and HFC) refrigerant used in appliances to the natural refrigerants for green cooling technology and other alternatives that linked to Montreal Protocol. There are 4 available channels for the training programmes landscape in Thailand as shown in Figure 22;
     (1) Academic Education;
     (2) Public Training Curriculum;
     (3) Private Training Curriculum;
     (4) GIZ Training Programme.

Academic Education	Public Training Curriculum	Private Training Programme	GIZ Training Programme under RAC NAMA Project
Academic education programme issued by the government – a formal diploma from Office of the Vocational Education Commission, Ministry of Education and a formal degree from college and/or universities, Ministry of Higher Education, Science, Research and Innovation, are typically comprehensive, of long-duration, and vocational in nature. These programmes are designed to educate individuals who are interested in a career in air conditioning and refrigeration.	Training programme are designed and run by the government agency – Department of Skill Development (DSD). The training programmes are intended for individuals with required qualification to increase their knowledge, competence and skills. Those trained individuals can be certified to increasing the wages and use for the qualification purposes.	Typically, skill upgradation training is restricted to service engineers and managers employed in companies. Company specific equipment training is often provided to service technicians and probably the dealers and retailers, for handling a specific company's appliance. This form of training may be appropriate for troubleshooting or understanding other unique features of the equipment. However, as service technicians may be involved in servicing of appliances from different companies in their everyday work, this kind of training could be insufficient.	This training programme was instituted through a bilateral partnership between GIZ and the Ministry of Natural Resources and Environment, (MNRE) under the RAC NAMA Project. GIZ determines the number of training sessions to be held in multi-project year. In collaboration of KMUTNB, the Office of Vocational Education Commission (OVEC), the Department of Skill Development (DSD), the Electricity Generating Authority of Thailand (EGAT) and GIZ, KMUTNB is the main training partner that has been appointed across the country and they hold responsibility for the implementation of training. The training is provided free of cost to technicians. Practical training is an important aspect of the training course, and equipment is financially supported and available at the site of training. This is a skill upgradation training; therefore, technicians with substantial experience can attend the training course.

Figure 22 The training programme landscape

(1) Academic Education

The formal education programme from the government that is related to the air conditioning and refrigeration subjects such as electrical, and mechanical branches, can offer the technical knowledge in addition to conventional refrigerant usage. The existing curricula shall be reviewed and integrated the green cooling technology using natural refrigerant or other low GWP refrigerant at vocational education and university.

(2) Public Training Programme

DSD, the government agency, plays an important role to develop and provide the training curricula at different levels – entry-level and higher level in AC and Com. Ref servicing sector.

The training programme for the servicing sector focuses on the use of refrigerants in the market during the HCFC phase-out period and the coming period of the HFC phase-down. In addition to the trend of new low GWP refrigerants introduced to the future under the Kigali Amendment, Montreal Protocol, the trend includes the use of natural refrigerants i.e., hydrocarbon (R290, R600a) and others which are flammable as well as non-flammable refrigerants available in the market and future development. Therefore, service technicians will tend to have more skills in practicing regard to all types of refrigerants.

Natural refrigerants such as hydrocarbon require special design, equipment, and technique for installation and servicing. Therefore, it is crucial the existing training curricula are standardized and provided with sufficient knowledge and skills to the service technician. The Good servicing practices (GSP) and standards on Safety on handling, filling & re-filling refrigerant, etc. and on the high quality of workmanship on services when Cleaning, Installation, Maintenance, Repair, etc. for non-flammable and flammable which are co-exist in the servicing fields shall be required for technicians to lower the risk of misconducts.

To standardize the existing training curriculum developed by DSD including the following topics – installation, maintenance, repair, cleaning, and decommissioning. The existing curriculum shall include the natural refrigerant knowledge, not limited to the procedures, equipment and ancillary components when do the servicing.

(3) Private Training Programme

The training programme is typically developed and trained by the private sector, generally producers and/or service providers, for in-house training on their products and services and/or sometimes for their products dealers or retailers. The training programme is designed for specific purposes and the training needs, for example new product design, new technology, or new type of refrigerant that require the additional technical knowledge.

(4) RAC NAMA Training Programme

Under the RAC NAMA, GIZ had initiated the green cooling technology. The natural refrigerant use in AC and Com. Ref. was introduced for some products. In attempt to develop the training curriculum and training partners, the project has also established networks with academic institutions and government agencies to provide training curricula and training facilities for the green cooling technology. The training curriculum has been adopted by DSD as part of the training programme to whom would like to extend their knowledge on natural refrigerant.

- Private sector curricula should align with the NOSS based on the focused areas.
  Companies in the private sector play important roles that provide training on servicing of their products to their service technicians including outside service technicians of dealers and/or retailers. Due to their company equipment, the training is provided shall also comply with the NOSS to measure the knowledge and skill. On the contrary, the NOSS committee shall review and update the new technology for re-skilling the service technicians.

- Increase the number of training centers that are related to natural refrigerants.
  In addition to the training curricula, the number of training centers shall be established to sufficiently train the trainees to improve knowledge and skill prior to providing the services in the market.

  The training facilities for natural refrigerants shall sufficiently be established to serve the increasing demand of trainings. Due to its flammable property of natural refrigerants, the facilities shall be appropriately equipped with safety tools in accordance with safety standards.

2. Enhance the existing certified & licensed technician scheme incorporating the knowledge and skill on servicing the natural refrigerants

- Extend certification and licensing scheme to cover natural refrigerant for green cooling technology in the focused areas as follows;
  - Air-Conditioning (Home and Small Commercial Use);
  - Home and Commercial Refrigeration;
  - Large Air-conditioning.

  The existing certification and licensing scheme covers the above three categories. The training programme for green cooling technology is not well-integrated. To ensure the workmanship in the service field, it is important to develop sufficient skills as well as an attitude on safety during the services through the enhanced certified and licensed technicians.

- Improve the government programme that is already NOSS compliant to consider incorporating green cooling technology for future up-gradation as follows;

  These 3 training programmes are conducted by DSD at different levels to improve knowledge and skill for service workers and/or technicians. The knowledge and skill training of natural refrigerants for green cooling technology shall be added to each existing training programme. Due to the variety of refrigerant types in use and available in the market, the technicians shall have sufficient knowledge and skill on handling, filing, re-filling during the servicing.

  (1) Upgrade Training
  Labour skill enhancement is additional training provided by the employer to employees to enhance their knowledge and skills relevant to their job fields.

  (2) Pre-employment Training
  Pre-employment training refers to skill training for technicians prior to employment to enable them to work in accordance with the skill standards. This includes students or people sent for training by government agencies.

(3) Re-Training

Training for an occupational change refers to additional training provided by the employer for the employees to have additional training outside of the professional field to enable the employee to have knowledge and ability to also work in other fields.

3. Enhance policies/ regulations and coordination of government agencies

- Enhance policies and regulations to promote green cooling technology

  The overlapping schedules of HCFC phase-out and HFC phase-down present an opportunity to develop an integrated, cost-effective, and sustained strategy that addresses the reduction of both groups of substances, in particular in the refrigeration servicing sector. This integrated strategy would make use of the already established institutional framework to phase out HCFCs and ensure that activities being implemented are at the same time directed at reducing the potential increase in the use of high-GWP HFCs.

-

  The government policies and regulations shall be promoting the green cooling technologies. To be in line with national mitigation under NDC for climate change and Montreal Protocol, some barriers under the regulations that prohibit the use of natural refrigerant shall be removed such as the building code for high rise buildings. In addition, the ban of some high GWP of HFC is also one of the policy measures to accelerate the use of green cooling technology.

- Develop value chain for green cooling technology

  The shift to green cooling technology requires a change in the supply chain of equipment components. To drive the market transformation may require technical and financial support for production line conversion for producers while at end-users the cost of appliances shall not be increased. The green procurement is one of the strategies that can promote the use of green cooling technology that is energy-efficient and climate-friendly (low GWP potentials).

- Improve product and technician standards toward the green cooling technology

  Improving the standards in addition to current technology toward to green cooling technology. The industry standard and practices regard to safety requirements shall be improved. In addition, the high-efficiency labeling for green cooling technology shall be rated incorporating the energy savings and environmental benefits.

- Enforce the certification and licensing scheme for the service technicians

  There is no current regulation for service technicians to be certified or licensed prior to providing service. The service technicians are likely to gain their experiences and practices on the fieldwork and many are classified as an informal sector. The informal sector is at risk of misconduct especially dealing with natural refrigerants due to a lack of proper knowledge and skill to gain more confidence from the end-users.

- Ensure coordination between the government agencies and industry associations so that all aspects of skill development and greenhouse gas emission reduction are included

  The cross-ministerial function and coordination help promote the green cooling technology. The industrial standard of appliances, energy efficiency, low emissions from low GWP refrigerants use, and people knowledge and skill through training programme and certification scheme shall be developed in parallel. These require good coordination and integration.

Department of Skill Development (DSD), Department of Alternative Energy Development and Efficiency (DEDE), Thai Industrial Standards Institute (TISI), Department of Industrial Works (DIW), Electricity Generating Authority of Thailand (EGAT), and Department of Public Works and Town & Country Planning (DPT) are the main government agencies that shall be involved in enhancing the policies and regulations for green cooling technology.

4. Public awareness and capacity building

   - Raise the awareness, skills, and capacities for alternative refrigerants related to green cooling technology
     - Awareness building measures, such as (nationwide) awareness campaigns and knowledge sharing for green cooling technology.
     - Enhancement of skills and capacities/training of technicians and officials.