

**MASTER OF SCIENCE IN TECHNICAL EDUCATION  
SPECIALIZATION IN MECHANICAL ENGINEERING**



**The Relations of TVET Curricula to Skills  
Required for Refrigeration and Air-Conditioning  
Servicing Technicians in Bangladesh.**

by

**Md. Naem Hossain**

Student No. 201031101

M.Sc.T.E. (ME)

Supervisor

Prof. Dr. Md. Faruque Ahmed Haolader

Department of Technical and Vocational Education (TVE)

Faculty of Science & Technical Education

Islamic University of Technology (IUT)

Gazipur, Bangladesh.

January 2024

**MASTER OF SCIENCE IN TECHNICAL EDUCATION  
SPECIALIZATION IN MECHANICAL ENGINEERING**



**The Relations of TVET Curricula to Skills  
Required for Refrigeration and Air-conditioning  
Servicing Technicians in Bangladesh.**

by

Md. Naem Hossain

Student No. 201031101

M.Sc.T.E. (ME)

A thesis submitted  
in Partial Fulfillment of the Requirement for the Degree of  
Master of Science in Technical Education (MSc. TE)  
with Specialization in Mechanical Engineering

The thesis titled "**The Relations of TVET Curricula to Skills Required for Refrigeration and Air-conditioning Servicing Technicians in Bangladesh**" submitted by Md. Naem Hossain, Student Number 201031101 of Academic year 2021-2022 has been found satisfactory and accepted as partial fulfillment of the requirement for the degree of Master of Science in Technical Education (MScTE) with Specialization in Mechanical Engineering on 12 January 2024.

### **BOARD OF EXAMINERS**

- .....  
**1. Prof. Dr. Md. Faruque Ahmed Haolader** Chairman  
Professor (Supervisor)  
Department of Technical and Vocational Education (TVE)  
Islamic University of Technology (IUT)
  
- .....  
**2. Prof. Dr. Md. Shahadat Hossain Khan** Member  
Professor & Head (Ex-Officio)  
Department of Technical and Vocational Education (TVE)  
Islamic University of Technology (IUT)
  
- .....  
**3. Prof. Dr. Md. Abu Raihan** Internal Member  
Professor,  
Department of Technical and Vocational Education (TVE)  
Islamic University of Technology (IUT)
  
- .....  
**4. Dr. Dilruba Sultana** External Member  
Assistant Professor  
BRAC IED, BRAC University

## **Declaration of Candidate**

It is hereby declared that this thesis report or any part of it has not been submitted elsewhere for the award of any degree or diploma.

.....

Name of the Candidate: Md. Naem Hossain

Student No.: 201031101

Academic Year: 2021-2022

Date:

## Dedication

I dedicated this thesis to my beloved parents for their moral and financial support during my study period. May Almighty Allah (SWT) reward them abundantly, Ameen.

## Abstract

Qualified servicing and manufacturing technicians for Refrigeration and Air-Conditioning (RAC) equipment are in high demand due to socio-economic development, global temperature rise as well as the increasing integration of new technologies, such as artificial intelligence (AI) and green awareness. This study investigates the skills gap between occupational competences (qualification) required for today's RAC servicing technicians and the existing TVET curricula in Bangladesh. Besides, it also examines how environment-friendly (Green) and safety practices are in RAC servicing sector. In this study mixed method, both qualitative and quantitative, research approach was used and field level primary data was collected through a survey questionnaire, observation and key informants' interviews (KIIs), and the supply-side data was gathered by desk study. The desk study includes the following documents: curriculum materials/ documents such as industry competency standards, syllabi, green policies and guidelines related to environment and SDG(s), et. cetera. A total of 52 RAC servicing technicians from 52 servicing centers in the formal and informal sectors were visited to collect field-level data. It is found that there are discrepancies between the knowledge and skills (taught) in the curriculum and the essential skills required in the field. Basic Trade course curriculum significantly matches the occupational competences of a RAC servicing technician. National Skills Certificates at BNQF Level-1 to 4 curricula focus more on practical skills along with the development of self/ human competences and social competences. Besides, a Diploma in Engineering (BNQF Level -6) specializing in RAC curriculum focuses sufficiently on theoretical knowledge (high cognitive abilities) in all occupational dimensions but lacks practical skills. In the case of RAC servicing sectors, environment-friendly (Green) and safety practices are relatively well maintained in the formal RAC servicing centers compared to the informal RAC servicing centres. This study findings will contribute to reducing the skills gap. For example, policymakers and educators could take corrective action, like updating the RAC curricula with workplace-relevant content so that TVET curricula adequately prepare graduates for Bangladesh's RAC servicing sector.

## **Acknowledgement**

Firstly, I am very grateful to the most powerful, the gracious almighty Allah, for giving me knowledge, energy, and patience to complete the thesis work successfully.

I want to express my deepest indebtedness and gratitude to my thesis supervisor, Prof. Dr. Md. Faruque Ahmed Haolader, Professor, Department of Technical and Vocational Education (TVE), Islamic University of Technology (IUT), OIC, for his continuous guidance, invaluable suggestions, constructive comments, and endless encouragement throughout the progress of this research work and the preparation of this thesis.

I am very thankful to all the participants for their cordial support and cooperation in providing me with the respective information, valuable time, and great support during the survey and implementation phase while I was working on my thesis work.

Further, I am thankful to the reviewer of the Thai-German TVET Conference on Research Cooperation in Southeast Asia held in Bangkok, Thailand in 25-26 September 2023 for reviewing and giving valuable input to the paper presented there based on this thesis-work. I also want to thank all members of the board of examiners for their valuable inputs.

Finally, I would like to convey my sincere gratitude to my parents, whose continuous inspiration, sacrifice, and support encouraged me to complete the thesis successfully.

Thank You.

Md. Naem Hossain

## Table of Contents

<b>Abstract</b> .....	<b>v</b>
<b>Acknowledgement</b> .....	<b>vi</b>
List of Figures .....	ix
List of Tables.....	x
List of Abbreviation .....	xi
<b>CHAPTER 1 INTRODUCTION</b> .....	<b>1</b>
1. Background of the study .....	1
1.1 Problem statement .....	4
1.2 Objectives of the study .....	5
1.3 Significance of the study .....	5
1.4. Limitations .....	5
1.5 Challenges .....	6
1.6 Arrangement.....	6
<b>CHAPTER 2 LITERATURE REVIEW</b> .....	<b>7</b>
2. Introduction .....	7
2.1 The Concept of RAC Servicing Technology .....	7
2.2 Relationship between TVET Curricula and Industries .....	7
2.3 Skills Gap between Curriculum and Industries.....	8
2.4 Environment-Friendly Green and Safety Practices .....	10
<b>CHAPTER 3 RESEARCH METHODOLOGY</b> .....	<b>12</b>
3. Introduction .....	12
3.1 Design of the Study .....	12
3.2 Instrument for Data Collection and the Data Collection Process.....	12
3.3 Delimitation of the Study .....	15
3.4 Sample of the Study .....	15
3.5 Other Participants of the Study .....	16



3.6 Data Analysis Technique .....	16
<b>CHAPTER 4 DATA ANALYSIS AND DISCUSSION .....</b>	<b>18</b>
4. Introduction .....	18
4.1 Identifying Skills Gap .....	18
4.1.1 Educational qualifications of the employees of the RAC servicing centers.....	18
4.1.2 The Skills Gap between Occupational Competencies Required for RAC Servicing Technicians and the Existing TVET Curricula in Bangladesh.....	21
4.2 Environment-friendly (Green) and safety practices at RAC servicing centers in Bangladesh. ....	31
4.3 Observation .....	37
<b>CHAPTER 5 CONCLUSION AND RECOMMENDATIONS .....</b>	<b>39</b>
5.1 Introduction .....	39
5.2 Major Findings .....	39
5.2.1 Research Objective I.....	39
5.2.2 Research Objective II .....	40
5.3 Conclusion.....	40
5.4 Recommendations .....	41
5.5 Future Works.....	42
<b>REFERENCES.....</b>	<b>43</b>
<b>APPENDIX - A.....</b>	<b>48</b>
<b>APPENDIX - B .....</b>	<b>54</b>
<b>APPENDIX - C.....</b>	<b>55</b>
<b>APPENDIX - D.....</b>	<b>56</b>
<b>APPENDIX - E .....</b>	<b>59</b>
<b>APPENDIX - F .....</b>	<b>60</b>
<b>APPENDIX - G.....</b>	<b>64</b>
<b>APPENDIX – H.....</b>	<b>66</b>

## List of Figures

Figure 3.1 Schematic diagram showing data collection process using various methods for objective (i).....	13
Figure 3.2 Schematic diagram showing data collection process using various methods for objective (ii).....	14
Figure 3.3 Flowchart qualitative data analysis.....	17
Figure 4.1 Distribution of employees (in %) according to educational qualification (working at formal and informal RAC servicing centers) .....	19
Figure 4.2 Distribution of employees (in %) according to educational qualification levels (working at formal VS informal RAC servicing centres).....	20
Figure 4.3 Percentage of employees (working at formal and informal RAC servicing centers) have TVET certificate. Source: Authors' own compilation.....	21
Figure 4.4 Category of courses (in %) of Diploma in Engineering (BNQF Level-6) with specialization in RAC curriculum .....	25
Figure 4.5 Category of courses (in hours) of National Skills Certificates (BNQF Level -1 to 4) with specialization in RAC curriculum. ....	26
Figure: 4.6 Emissions of refrigerant during servicing and maintenance operations.....	38

## List of Tables

Table 3.1 Sample of RAC servicing Technicians.....	16
Table 4.1 Number of employees (working at formal and informal RAC servicing centers) according to educational levels.....	19
Table 4.2 The RAC technicians' (participants') response on the occupational competences.	22
Table 4.3 Skills gap between occupational competencies required for an RAC servicing technician and Diploma in Engineering- specialization in RAC curriculum.....	28
Table 4.4 Skills gap between occupational competencies required for an RAC servicing technician and National Skills Certificates (BNQF Level -1 to 4) specialization in RAC curriculum.....	29
Table 4.5 Skills gap between occupational competencies required for an RAC servicing technician and of Basic Trade (360 hours) course with specialization in RAC curriculum...	30
Table 4.6 interview results of the Key informants interviewees (KIIs) .....	34

## List of Abbreviation

<b>AI</b>	Artificial Intelligence
<b>BNQF</b>	Bangladesh National Qualifications Framework
<b>BTEB</b>	Bangladesh Technical Education Board
<b>DACUM</b>	Developing a Curriculum
<b>DOE</b>	Department of Environment
<b>IoT</b>	The Internet of Things
<b>KII</b>	Key Informant Interview
<b>NGTP</b>	National Green Technology Policy
<b>NTVQF</b>	National Technical and Vocational Qualification Framework
<b>OIC</b>	Organization of Islamic Cooperation
<b>RAC</b>	Refrigeration and Air-conditioning
<b>ROAP</b>	Regional Office for Asia and the Pacific
<b>SDG</b>	Sustainable Development Goals
<b>STEP</b>	Skills and Training Enhancement Project
<b>TVET</b>	Technical and Vocational Education and Training
<b>UNEP</b>	United Nations Environment Programme
<b>UNESCO</b>	United Nations Educational, Scientific and Cultural Org

## CHAPTER 1 INTRODUCTION

### 1. Background of the study

The use of refrigeration and air-conditioning (RAC) has been increasing rapidly due to economic growth, the rise in people's living levels, and rising global temperature. When an air conditioning system is properly maintained and serviced regularly, it will perform better in terms of energy efficiency, have a longer operational life, and have reduced total maintenance costs (New-Air, 2022). RAC servicing technicians play a substantial role here by providing the required services. An RAC servicing technician must possess a set of competencies that allow them to be able to install, maintain, troubleshoot, service, and repair household and industrial RAC devices (TESDA, 2022). There is increasing demand for skilled service experts in the field of RAC. According to the findings of the survey conducted in 2011, over 15 thousand RAC servicing centers exist in Bangladesh, each of which employs approximately 3-4 service technicians. These technicians are estimated to be approximately 50 thousand, mostly from the informal sector (DOE, 2017). According to the general secretary of the Bangladesh Refrigeration and Air Conditioning Owners Workers Welfare Council (BRAOWWC), this number has rapidly increased over the last decade in Bangladesh. In 2023, the informal sector of RAC servicing centers comprises a substantial number, with over 120 thousand RAC servicing centers. Furthermore, the president of the Bangladesh Refrigeration and Air Conditioning Merchants Association (BRAMA), in his personal communication on August 22, 2023, expressed the opinion that this industry provides employment opportunities for a significant workforce, engaging over 1 million individuals in this field.

New technologies like artificial intelligence (AI) and nanotechnology are being integrated to RAC equipment. The IoT technology makes it easier to control AC. For example, voice control AC and inverter technology are assimilated into RAC technology which helps AC control easier and power save up to 70%. In the past 20 years, 18 AI tools for HVAC control have been developed to do three main things: predict the weather, improve efficiency, and predictive controls (Cheng & Lee, 2019). Cloud-based artificial intelligence (AI) allows users to control air conditioners from their homes remotely. AI programs in the cloud can be changed anytime to provide good control performance without changing the control hardware. Cloud control improved energy efficiency using AI based on two conditions: (1) a constant room cooling rate and (2) a set stable temperature control range (Lee & Tsai, 2020).

As more RAC businesses rely on advanced cooling systems, there is an increasing need for qualified technicians who can effectively service these systems. RAC service technicians require a combination of technical and practical skills, troubleshooting skills, environmental regulations, and customer service skills. According to the Bureau of Labor Statistics, HVAC technicians also need to stay updated on industry advancements, emphasizing the importance of continuous learning and adaptability (EPA, 2021).

TVET Institutes (public and private) provide the knowledge and skills required for RAC servicing technicians. Although many donor organizations such as the World Bank, EU, ADB, UNESCO, UNEP, ROAP, CIDA, and JICA work in Bangladesh's Technical and Vocational Education and Training (TVET) sector, but there is a huge lack of competent TVET graduates in this country. BTEB has formulated 34 diverse curricula to facilitate various engineering courses, technologies, and specializations. As of October 2023, the board established affiliations with 777 public and 10341 private institutes (BTEB, 2023a). There is a notable prevalence of private sector participation in institutes affiliated with the BTEB, underscoring the crucial role of non-governmental entities in providing engineering education and vocational training in Bangladesh (BTEB, 2016). BTEB has formulated 34 diverse curricula to facilitate various engineering courses, technologies, and specializations. Around 1,000 students register annually for the Diploma in Engineering with a specialization in Refrigeration and Air Conditioning program (BTEB, 2021). In 2022, the total number of enrolled students under BTEB was 239,378 in the short course (360 hours), 70,401 in the NTVQF, 300,701 in SSC Vocational (Class IX), 12,523 in HSC Vocational (Class XI), and 89,323 in the first semester of Diploma in Engineering (BTEB, 2023a).

The TVET curricula should focus on providing students with the technical knowledge and practical skills required to work in their respective fields. The curriculum helps to ensure that every student has access to learning experiences that are sufficiently demanding (Mizan, 2022). The TVET curriculum is designed to equip students with the technical knowledge and practical skills essential to their respective fields. The curriculum is both a static item and a dynamic process (Zhao, 2014). Skill training makes people more productive and keeps them competitive in the world economy. (Alhasan & Tyabo, 2013). TVET institutions must work with the industry to bridge the skills gap (Itohan Oviawe, 2017). The OIC-TVET Strategic Roadmap for (2020-2025) has been emphasizing the strengthening links between industry and institute (OIC, 2019). On the other hand, the United Nations Sustainable Development Goal-8 (Decent Work and Economic Growth) emphasizes green skills for environmental sustainability (UNEVOC, 2016). Montreal Protocol highlighted the destructive potential of

refrigerants on the ozone layer, and the 1997 Kyoto Protocol revealed that most of the refrigerant contributes to the greenhouse effect (Poggi et al., 2008). Thus, the occupation of RAC service technicians is becoming more challenging. But TVET curricula in the field of RAC are not being updated so frequently.

In Bangladesh, National Technical and Vocational Qualification Frameworks NTVQF developed by the Technical Sub Committee (TSC) established under The Project for Enhancing the Vocational Training Program of TTC, Chittagong, and implemented by KOICA (Korea International Cooperation Agency) with funding from the Government of Korea. These Competency Standards adhere to the rules of the Skill Development Policy (BTEB, 2023). The TSC comprises members primarily from the industry, complemented by representatives from TTC Chittagong. Their collaboration aims to create a curriculum foundation that aligns with industry needs. Based on the established competency standards, completing these programs earn students a qualification within the (NTVQF). This framework recognizes individuals' accomplishments and signifies their readiness to contribute effectively to the workforce.

"Green skills" encompass the cognitive, psychomotor, and affective dimensions of knowledge, talents, and attitudes required for promoting sustainable development across social, economic, and environmental domains (Setiawan, 2017). These skills are vital for fostering sustainability; encompass technical and interpersonal proficiencies (Setiawan, 2017). Referred to as skills for sustainability, they comprise professional, vocational, and general competencies, such as sustainable practices, creativity, and problem-solving, essential for emerging green occupations and the transformation of existing jobs across diverse industrial sectors.

In alignment with UNESCO's 2030 education agenda, developing green skills is essential for Technical and Vocational Education and Training (TVET) (Pavlova, 2022). This underscores the necessity of integrating educational initiatives that cultivate green skills, ensuring a workforce capable of addressing the challenges posed by sustainable development. As industries evolve towards environmental responsibility, incorporating green skills becomes imperative for professionals to navigate and contribute to the global shift towards sustainability.

Green skills constitute a multifaceted framework encompassing technical proficiency, interpersonal abilities, and a mindset conducive to sustainable development. Recognized as a linchpin in UNESCO's education agenda, cultivating these skills is instrumental in preparing individuals to meet the demands of evolving industries and contribute meaningfully to a

greener, more sustainable future.

The development of hard skills and soft skills in the areas of knowledge, abilities, and attitudes is necessary to integrate green skills into TVET programs successfully. TVET institutions play an essential role in generating green skills employees since TVET is linked to economic and social development. So, green skills must be incorporated into all stages of education. Besides, green skills are gaining attention in many countries because of their potential to enhance people's living standards via a more sustainable, low-carbon economic model. So, green skills must be integrated into the TVET curriculum by developing hard and soft skills in knowledge, abilities, and attitudes (Setiawan, 2017). TVET, a key supplier of skilled workers, must incorporate green skills into teaching and learning to achieve a sustainable future.

Moreover, accepting environment-friendly methods in the formal and informal economic sectors is crucial to achieving the 2030 Sustainable Development Goals (SDG) approved at the September 2015 United Nations Summit. However, Green skills should be integrated into the TVET curriculum by developing hard and soft skills (Setiawan, 2017). In the workplace, maintaining safety and environment-friendly practices is very important. The skills gap and environment-friendly green and safety practices research have never been conducted in the field of RAC servicing sector in Bangladesh TVET context. Therefore, this study will be shown with the aim and objectives stated in section 1.2 below.

### **1.1 Problem statement**

As our economy has risen, the living standard of Bangladesh is also significantly improving. Nowadays, RAC equipment is not only used for the luxury of life but has become a necessary part of daily life. As a result, the demand for RAC equipment has increased. So, in the servicing of RAC enterprise, skilled labor is required (Malabago et al., 2015). Under BTEB, thousands of fresh graduates took RAC-related courses like the National Skills Certificates (BNQF Level-1 to 5), Basic Trade Courses, HSC (VOC), and Diploma in Engineering. So, it is essential to identify any skills gap between the occupational qualifications required for RAC servicing technicians and the existing TVET curriculum in Bangladesh. Also, we need to find how environmentally friendly (Green) and safe practices are in RAC servicing industries. This study attempts to identify the skills gap between occupational qualifications required for RAC servicing technicians and the existing TVET curriculum in Bangladesh. Furthermore, Environment-friendly (Green) and safety practices in RAC servicing industries are being examined.



## **1.2 Objectives of the study**

The main purpose of this study is to identifying the gap between required skills of RAC servicing technicians and existing TVET curriculum and access environment-friendly (Green) practices and safety in RAC servicing.

The Specific objectives of this study are:

- (i) To identify the skills gap (if any) between occupational qualifications required for RAC servicing technicians and the existing TVET curriculum (Diploma in Engineering, Basic Trade Course, BNQF Level 1-5) in Bangladesh;
- (ii) To examine environment-friendly (Green) and safety practices in RAC servicing industries/ enterprises.

## **1.3 Significance of the study**

The study findings played a pivotal role in guiding policy makers and curriculum developers to formulate curriculum content tailored to the dynamic needs of the workplace. The study's impact extends to Technical and Vocational Education and Training (TVET) institutions, enhancing their ability to produce graduates equipped with the latest industry-relevant skills. This not only fosters a seamless transition from education to employment but also bridges the skill gap in the workforce.

Furthermore, by specifically addressing environment-friendly (green) practices in Refrigeration and Air Conditioning (RAC) servicing, the research provides crucial insights to policymakers, empowering them to design and implement strategies that mitigate the greenhouse effect and combat global warming. This targeted approach ensures a sustainable future and aligns with the broader societal goal of achieving the Sustainable Development Goals (SDGs).

## **1.4. Limitations**

This research was conducted exclusively for the Diploma in Engineering (BNQF Level-6), National Skills Certificates (BNQF Level-1 to 5), and the Basic Trade course (360 hours) with specialization in Refrigeration and Air Conditioning (RAC) curriculum. The researcher aimed to gather data from RAC servicing centers nationwide; however, due to logistical constraints, data could only be collected from 52 centers in Dhaka, Barisal, Gazipur, Tangail, and Narsingdi districts. Additionally, while a focused group discussion could have been impactful for identifying skills gaps, the researcher, constrained by time limitations, was unable to conduct.

## **1.5 Challenges**

In the process of gathering data from the RAC servicing sector, the researcher had to obtain management approval before initiating the survey. This necessitated multiple instances of written and verbal communication between the researcher and the management authority of the RAC servicing centers. Furthermore, numerous formal RAC servicing enterprises declined to participate in the survey with the specified organization.

Among the individuals who granted permission, a significant number imposed the condition that the names of the servicing centers would not be published. The study was then conducted in accordance with this condition.

## **1.6 Arrangement**

This report is structured with chapters dedicated to various relevant content types, including introduction, literature review, research objectives and methodology, data analysis and results, discussion on results, conclusion, recommendations, and future study.

Chapter 1 includes the introduction of the research report, importance of the study, research objectives, limitations and challenges.

Chapter 2 covers a literature review of the related study, the concept of RAC servicing technology, relationships between TVET curricula and industries, the Skills gap between curriculum and industries, and environment-friendly green and safety practices.

Chapter 3 includes research methodology and various types of data collection and its analysis with required graphs.

Chapter 4 discusses the results found after analyzing the data which is collected from RAC servicing centers.

Chapter 5 contains the research summary, conclusion, recommendation and the future work of the study.

## **CHAPTER 2 LITERATURE REVIEW**

### **2. Introduction**

In the literature review chapter, the following study covered the background of the literature review on the subject of RAC servicing technology, TVET curriculum, the relationships between TVET curricula and industries, and the concept of green skills environment (Green) and safety practices in the RAC industries.

#### **2.1 The Concept of RAC Servicing Technology**

An RAC servicing technician must possess a set of competencies that allow them to be able to install, maintain, troubleshoot, service and repair household and industrial RAC devices (TESDA, 2022). When an air conditioning system is properly maintained and serviced regularly, it will perform better in terms of energy efficiency, have a longer operational life, and have reduced total maintenance costs (New-Air, 2022).

The expertise of experienced service technicians, working in both formal and informal RAC servicing centers is pivotal in providing effective solutions for the upkeep and repair of RAC equipment. Their role extends beyond routine maintenance to include installing new systems and troubleshooting complex issues. By leveraging their skills and knowledge, these technicians contribute significantly to the seamless functioning of air conditioning units in both domestic and industrial settings. In essence, their proficiency ensures that RAC systems operate optimally, minimizing energy consumption, extending equipment life, and ultimately reducing the economic burden associated with maintenance (TESDA, 2022; New-Air, 2022).

#### **2.2 Relationship between TVET Curricula and Industries**

Technical and Vocational Education and Training (TVET) plays a pivotal role in a nation's development by equipping individuals with practical skills necessary for employment and economic growth. Despite its significance, TVET grapples with persistent challenges, including an outdated and confining curriculum, a disconnect between acquired skills in TVET institutions and those demanded by industries, and an absence of robust systems for quality assurance (Maina et al., 2017). A noteworthy issue lies in the limited involvement of industrial stakeholders in curriculum formulation and development processes, leading to a substantial gap between educational content and industry needs.

The predicament is exacerbated when TVET curricula are devised by academics lacking a profound understanding of industry dynamics and local requirements. This disconnection results in a noticeable misalignment between the skills nurtured in TVET programs and the

actual demands of the job market, notably in Bangladesh, where the integral role of TVET in the nation's development is acknowledged (Siddiky & Uh, 2020).

Raihan (2014) advocates for a solution by emphasizing the industry's responsibility to educate employees on current skills and foster collaborations with TVET institutions to narrow the existing gaps. Bridging the divide between TVET and industries necessitates a concerted effort, emphasizing the need for employers and TVET schools to form strategic alliances. The call for collaboration gains further traction as Itohan Oviawe (2017) underscores the imperative for joint efforts in closing the resultant skills gap.

Effective collaboration between employers and TVET schools is posited as a potent strategy for aligning educational content with industry needs. By involving industry professionals in curriculum development, TVET programs can be tailored to address current skill demands, ensuring graduates are well-prepared for the workforce. Establishing networks and partnerships between industries and TVET institutions becomes instrumental in maintaining relevance and responsiveness to evolving industry requirements (Raihan, 2014).

Furthermore, the collaborative approach extends beyond curriculum development to encompass ongoing dialogue and engagement between industry representatives and educational institutions. This dynamic interaction enables real-time adjustments to curricular content, ensuring that TVET graduates possess the latest and most relevant skills demanded by the job market (Joke et al., 2016).

The multifaceted challenges TVET faces, including curriculum limitations and the mismatch between acquired skills and industry needs, necessitate a proactive and collaborative approach. Involving industry stakeholders in curriculum development and fostering partnerships between employers and TVET schools emerges as a strategic imperative. This concerted effort is essential for enhancing the employability of TVET graduates and promoting sustained economic growth and development (Itohan Oviawe, 2017).

### **2.3 Skills Gap between Curriculum and Industries**

The skills gap is the difference between what a company expects of its employees and what they have. This mismatch makes it challenging for employers to fill open positions. The TVET curricula focus on providing students with the technical knowledge and practical skills required to work in their respective fields. The curriculum is an introductory guide for all educators regarding what is required for effective teaching and learning. It helps to ensure that every student has access to academic experiences that are sufficiently demanding

(Mizan, 2022). The curriculum is both a static item and a dynamic process (Zhao, 2014). Skill training makes people more productive and keeps them competitive in the world economy. (Alhasan & Tyabo, 2013). TVET institutions must work with the industry to bridge the skills gap (Itohan Oviawe, 2017). The OIC-TVET Strategic Roadmap for 2020-2025 has been emphasizing the strengthening links between industry and institute (OIC, 2019). On the other hand, the United Nations Sustainable Development Goal-8 (Decent Work and Economic Growth) emphasizes on green skills for environmental sustainability (SDG, 2016). Montreal Protocol highlighted the destructive potential of refrigerants on the ozone layer, and the 1997 Kyoto Protocol revealed that most of the refrigerant contributes to the greenhouse effect (Poggi et al., 2008). Thus, the occupation as RAC service technicians are becoming more and more challenging. But TVET curricula in the field of RAC are not being updated so frequently.

Several studies have been conducted in various fields to determine the skills gap between academic curricula and industries. For example, Alin & Ermac (2019) conducted a study to find the skill gap between industry standards and essential competencies in the TVET curriculum in the field of RAC in the Philippines. In order to determine the TVET skills gap perspectives from academicians and industry players, a survey and systematic literature reviews (SLR) were used to identify the necessary occupational skills (including both soft and hard skills) required for the electrical and electronic industry (Rodzalan et al., 2022). Moreover, a qualitative study was conducted to identify the skills gap in employability skills needed for TVET graduates in Malaysia. The study found that social and communication skills, technological literacy, collaboration, and leadership are necessary employability skills for graduates of TVET programs (Halik & Noor, 2023). Furthermore, qualitative methods and tools, including desktop studies, focus group interviews, and secondary sources of information, were used for skill gap analysis and training needs in the Indian aerospace industry. The result of the study reflects on the current scenario of aerospace industry potentials for India and its likely impact on the skills gap and training needs (Balaraman & Kamalakannan, 2016).

Moreover, another questionnaire-based survey study has been conducted to analyze the skills gap between managers and business graduates in the financial industry. The study revealed that graduates' employability skills fall short of what managers anticipate. Listening, problem-solving, communication, leadership, interpersonal, analytical, self-management, numeracy, and critical thinking were found to have significant skill disparities (Abbasi et al., 2018). A survey was conducted to determine the satisfaction and expectations of engineering

education from Malaysian public universities regarding engineering graduates. The skill gap of 18 non-technical skills pertinent to engineers was measured using satisfaction and expectation. The research findings revealed that 50% of engineering educators are only satisfied with the skill levels of their graduates (Kamaruzaman et al., 2019).

#### **2.4 Environment-Friendly Green and Safety Practices**

The term "green skills" refers to the knowledge (cognitive dimension), talents (psychomotor dimension), and attitudes (affective dimension) that employees need to foster sustainable development across the social, economic, and environmental spheres. Green skills include technical and interpersonal proficiency (Setiawan, 2017). Green skills, or skills for sustainability, are the professional and vocational abilities and the general skills (such as sustainable methods, creativity, and problem-solving) necessary for new green occupations and the greening of current jobs across all industrial sectors. Developing skills is essential for Technical and Vocational Education and Training (TVET) in UNESCO's 2030 education agenda (Pavlova, 2022). The development of hard skills and soft skills in the areas of knowledge, abilities, and attitudes is necessary to integrate green skills into TVET programs successfully.

Recent research activities have underscored the significance of incorporating environment-friendly, green, and safety practices across various industries. A study by Smith et al. (2023) investigated the environmental impact of sustainable manufacturing processes, emphasizing the reduction of carbon emissions and resource conservation. Their findings highlight the positive correlation between eco-friendly practices and long-term business sustainability. Furthermore, Johnson and Garcia (2022) explored the safety aspects of green technologies in the workplace, elucidating how adopting environmentally friendly measures can enhance employee well-being. The study revealed that implementing safety measures alongside green initiatives safeguards the workforce and contributes to a positive organizational culture. In the realm of construction, Chen et al. (2024) delved into sustainable building practices, presenting evidence that eco-friendly construction materials not only mitigate environmental harm but also foster safer and healthier living environments.

TVET institutions play an essential role in generating green skills employees since TVET is linked to economic and social development. So, green skills must be incorporated into all stages of education. Besides, green skills are gaining attention in many countries because of their potential to enhance people's living standards via a more sustainable, low-carbon economic model. So, green skills must be integrated into the TVET curriculum by developing

hard and soft skills in knowledge, abilities, and attitudes (Setiawan, 2017). In contemporary education, formal training is increasingly augmented by specialized attachment programs like job training, industrial training, and vocational subjects, as noted by Misko (2008). Tilak (2002) emphasized the significance of non-formal on-the-job learning over traditional formal vocational and technical secondary school education across various East Asian nations. The primary objective of these initiatives is to acquaint trainees with the dynamic and evolving landscape of the professional realm. TVET, a key supplier of skilled workers, must incorporate green skills into teaching and learning to achieve a sustainable future.

The sustainability of economic activity across the globe is impacted by pollution and climate change. An economic shift toward a greener model, including creating jobs and greening existing enterprises, may help mitigate environmental problems. “McKinsey's, (2020) research predicts the creation of six million new jobs by 2030, and these positions will necessitate skilled and semi-skilled workers who possess generic green skills. This underscores the increasing need for a capable workforce to support a transition towards a more environmentally friendly economy.” Ismail et al. (2022). Malaysia and the Philippines are developing green skills by passing particular policies. The Malaysian government promoted green skills via policies, acts, legislation, and guidelines for specific economic sectors. An important initiative directly dealing with green skills is the National Green Technology Policy (NGTP). Bangladesh has a vast array of environmental laws, acts, rules, and regulations, as well as policies for coping with climate change, that all address water, soil, and air pollution from industry. It has begun various policies and projects to adapt to climate change and reduce its Haolader and Khan (2022) suggest that the first step in tying green skills recognition to green skill standards should be to look at actual workplace responsibilities. A coherent policy for developing skills for green jobs in all potential sectors should be implemented (Pavlova, 2018).

## **CHAPTER 3 RESEARCH METHODOLOGY**

### **3. Introduction**

This chapter describes the process that was followed to complete the study. It contains information on the study's design, its geographic scope, and the study population and sample, the data collection tools/ techniques, and the technique of data analysis employed.

### **3.1 Design of the Study**

This is a descriptive type of research. Mixed methods, both qualitative and quantitative research approaches, were used in this study. Balaraman & Kamalakannan, (2016) conducted a study to identify the skills gap analysis and training needs in the Indian aerospace industry using qualitative methods and tools, including desktop studies, focus group interviews, and secondary sources of information. Alin & Ermac (2019) conducted a survey to find the skill gap between industry standards and essential competencies in the TVET curriculum in the field of RAC in Philippines. Abbasi et al. (2018) used a questionnaire-based survey in their research to identify the gap between skills expected by managers and skills possessed by business graduates in the banking industry.

Mixed methods research is a research approach combining qualitative and quantitative methods within a single study. In this study, mixed methods were used because of their ability to provide a more comprehensive understanding of the research problem by triangulating data from different sources. Mixed methods research facilitates triangulation, a process where data from different sources are compared and contrasted to converge on a more accurate understanding of the research problem. This convergence can produce more substantial and nuanced conclusions (Teddlie & Tashakkori, 2009). As Creswell and Plano Clark (2018) emphasize, combining qualitative and quantitative data allows researchers to corroborate findings and enhance the study's overall validity. Integrating both qualitative and quantitative methods can enhance the validity and reliability of research findings. The strengths of one method can compensate for the limitations of the other, leading to a more robust and credible study (Creswell & Creswell, 2017).

### **3.2 Instrument for Data Collection and the Data Collection Process**

A survey questionnaire was used for collecting data. It consists of three parts: Part-A: General information about the participants, Part-B: Occupational competences (Job responsibilities/ duties and tasks) required for RAC servicing technicians, and Part-C: Environmental policies and regulations, respondents' conception about green skills and their



demand, and work-place learning and training programmes. Part-A and Part-B were developed by the researcher himself, whereas Part-C was adapted from Haolader and Khan (2022). In total there were 18 items in the survey questionnaire. The complete questionnaire is attached in Appendix – A.

**For objective (i)** *Identify the skills gap (if any) between occupational competences required for RAC servicing technicians and the existing TVET curricula in Bangladesh*, Part-B of the survey questionnaire was used to gather occupational responsibilities/ duties and tasks. This part of the questionnaire consists of comprehensive list of duties and tasks of RAC technician in different categories such as domain-specific skills, self/ human and social competencies, occupational safety, and other competencies. In this part there were 30 statements describing duties and tasks. During the survey the list was presented to the participants. After reading each statement, if the statement matches with their occupational task and duties participants put tick mark under ‘Yes’ and if it does not match their duties and tasks they put tick under ‘No’ marks. At the end of the list blank space was provided to allow technicians to list their duties which were not stated in the list. The list of duties and tasks were prepared by studying different sources such as RAC TJR, (2023) and AC TJR, (2023).

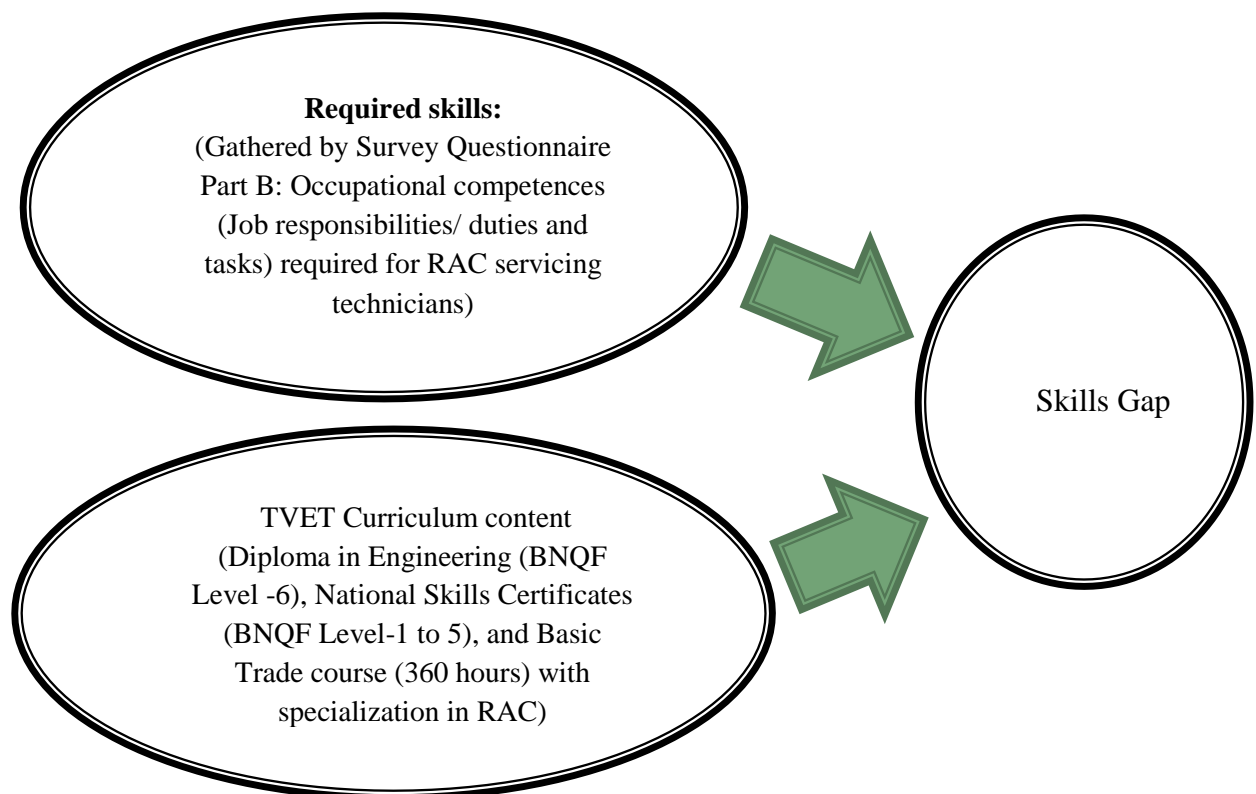


Figure 3.1 Schematic diagram showing data collection process using various methods for objective (i)

Desktop study was used to identify curriculum contents/ topics. The curricula include the Diploma in Engineering (BNQF Level -6), National Skills Certificates (BNQF Level-1 to 5), and Basic Trade course (360 hours) with specialization in RAC. Thus, the skills gap between the occupational competences required for RAC servicing technicians and the existing TVET curricula in Bangladesh was determined.

**For objective (ii),** *Examining environment-friendly and safety practices in RAC servicing sector, a survey questionnaire, Part-C of the survey questionnaire was used. The Part-C of the questionnaire consists of one ‘Yes’/or ‘No’ question and four open ended questions. It was used to know RAC service centers related environmental policies and regulations. A 10-point rating scale where used to identify the importance of green skills and environmentally friendly practices in RAC servicing centers, where 'one' indicates this issue is ignored and 'ten' means "close attention is paid to green skills and environmentally friendly practices and MCQ type question item was used for conception about green skills and their demand, and work-place learning and training programmes.*

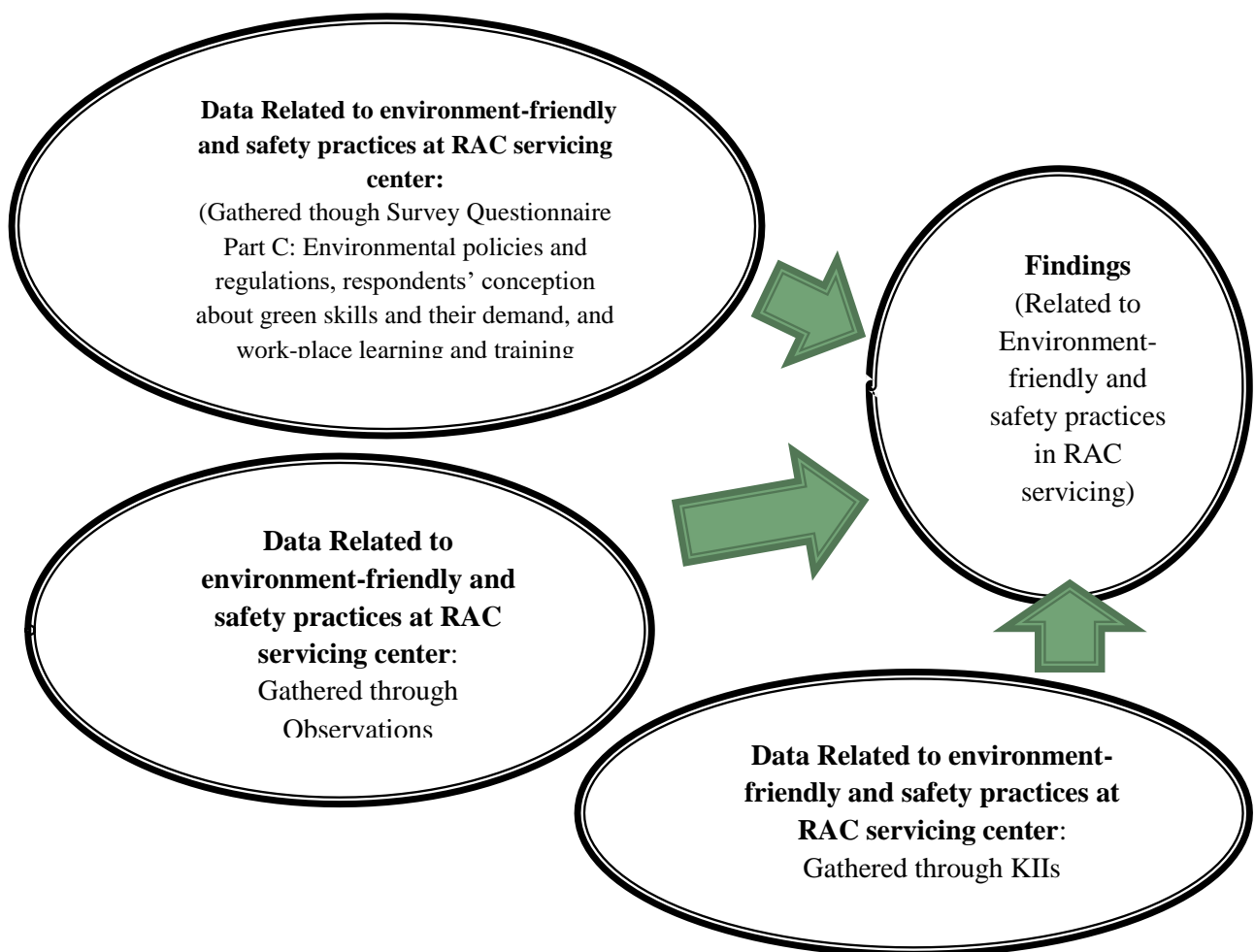


Figure 3.2 Schematic diagram showing data collection process using various methods for objective (ii)

A few key informants interviews (KIIs) were used. KIIs were a kind of in-depth interview, which is used to complement the data set, gathered using the survey questionnaire. The guiding question for conducting KIIs is attached in Appendix – B.

In addition, Naturalistic observation technique is used. The detailed observation schedule is attached in Appendix – H. The following observations were made when the researcher visited RAC servicing centers during the observation period at the RAC servicing centers.

01. Are they following any environmental regulation at RAC servicing centers?
02. Do RAC servicing centers record environmental risk information, or do they utilize brochures and events to disseminate environmental awareness?
03. Is there any refrigerant recovery machine available at servicing centres?
04. During servicing and maintenance operations at RAC servicing centers, is the refrigerant used recovered or released into the atmosphere?

### **3.3 Delimitation of the Study**

The study focused specifically on the RAC servicing industries within Bangladesh, narrowing its scope to Technical and Vocational Education and Training (TVET) curricula ranging from BNQF Level-1 to 6. It specifically explored into the Basic Trade course (360 hours), NSCs (Level 1 to 5) and Diploma in Engineering with a specialization in Refrigeration and Air Conditioning (RAC). Other servicing industries/ occupational field were not considered.

### **3.4 Sample of the Study**

The population of the study was the technicians of RAC servicing centers in Bangladesh. In Bangladesh approximately 120,000 RAC servicing centers are available and over one million RAC servicing technicians work in this field (BRAMA, 2023). As the researcher cannot access the entire population for this study, the researcher took samples of RAC servicing technicians from the RAC servicing centers, who are serving as the population's representatives. The purposive sampling technique was used in this research. Thus, the sample size or the participants in this study were 52 technicians from 52 RAC servicing centres in Dhaka, Barisal Gazipur, Tangail, and Narsingdi districts (please see Table 3.1). (Having not obtained any new data following the collection of 35 participants' responses, researcher proceeded to involve 52 participants. Subsequently, he did not pursue further collaboration with RAC technicians for additional data collection). These RAC technicians were considered integral to the research due to their expertise and experience in the field, making them suitable representatives for the broader population under investigation. This targeted approach aimed to capture diverse perspectives and insights from technicians

operating in different geographic locations, thereby enhancing the study's representativeness and applicability to the wider context of RAC servicing practices.

Table 3.1 Sample of RAC servicing technicians

Name of the district	Number of RAC servicing technicians
Dhaka	17
Barishal	10
Gazipur	15
Tangail	5
Narsingdi	5

### 3.5 Other Participants of the Study

As mentioned above, in this study, the participants were 52 technicians from 52 RAC servicing centres in Dhaka, Barisal, Gazipur, Tangail, and Narsingdi districts. In addition to these above-mentioned participants, 2 key informant interviews (KIIs) were conducted. One was the General Secretary of Bangladesh Refrigeration and Air Conditioning Owners Workers Welfare Council (BRAOWWC) and the other was the President of Bangladesh Refrigeration and Air Conditioning Merchants Association (BRAMA). KIIs provided RAC sector related narrative data from where statistical information was extracted.

### 3.6 Data Analysis Technique

As mentioned in Section 3.5, all the 52 participants responded by filling in the supplied questionnaire. These responses were tabulated and summarized by the researcher. Data analysis was conducted to interpret the research data, which has been collected through a survey questionnaire, key informant interviews (KIIs), observation and desk study. The desk study included the curricula of the Diploma in Engineering (BNQF Level -6), National Skills Certificates (BNQF Level-1 to 5), and Basic Trade course (360 hours) with specialization in RAC.

#### Quantitative Data Analysis:

The quantitative type of data was tabulated and analyzed using MS Excels and the results were reported in this thesis.

### **Qualitative Data Analysis:**

Qualitative data analysis was carried out using interpretive descriptive method (Miles, Huberman, & Saldaña, 1994, 2014), which consists of data collection, data display, data reduction, and conclusion visualization. A flowchart of the qualitative data analysis is shown in Figure 3.3.

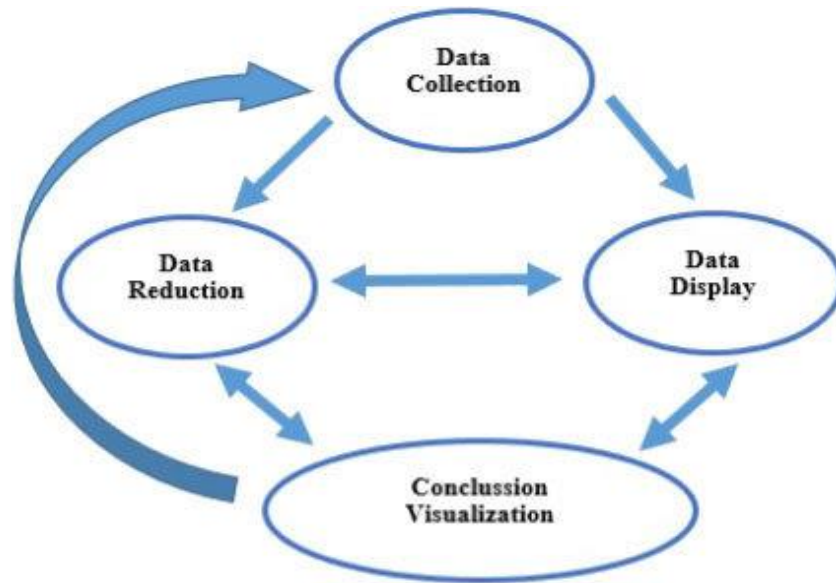


Figure 3.3 Flowchart of qualitative data analysis. Source; Burhaein et al., 2022, w.r.t. Miles, et al., 1994, 2014.

## CHAPTER 4 DATA ANALYSIS AND DISCUSSION

### 4. Introduction

This chapter analyzes the skills gap between the occupational qualifications required for RAC servicing technicians and the existing TVET curriculum in Bangladesh and environment-friendly (Green) and safety practices in RAC servicing industries. The results presented in the following sub-sections address the employees' educational qualification levels working at the RAC servicing centres in Bangladesh, the skills gap between occupational competencies required for RAC servicing technicians and the existing TVET curricula, environment-friendly (Green) and safety practices in RAC servicing industries in Bangladesh, and observations results. The study goals were considered while designing the questionnaires. After analyzing the raw data in each table, the researcher analyzed the results.

### 4.1 Identifying Skills Gap

This study has examined 52 refrigeration and air conditioning (RAC) servicing technicians from 52 servicing centers, of which forty-five are informal and seven are formal enterprises in Bangladesh. Firstly, the educational qualifications of the employees were surveyed. The findings are presented in the following section 4.1.1. Secondly, the desk study has been conducted to analyze the course content (theoretical and practical) of the Diploma in Engineering (BNQF/ NTVQF Level -6) -specialization in RAC, National Skills Certificates (BNQF Level-1 to 5) with specialization in RAC, and Basic Trade Course (360 hours) with specialization in RAC.

#### 4.1.1 Educational qualifications of the employees of the RAC servicing centers

The educational qualifications of the employees working in 52 RAC servicing centres (45 are informal & 7 formal) are shown in Figure 4.1. A total of 414 employees are working in these centres, of which 194 worked in the formal and 220 in informal RAC servicing centres. In the formal RAC servicing centres, the number of employees in a centre varies from 9 to 47, whereas in the informal RAC servicing centres, it varies from 2 to 30 employees. The study discovers that employees have a wide range of educational backgrounds: 8% have a Bachelor's degree or higher qualification in Arts, 5% have a BSc in Engineering (these employees hold managerial positions), 14% have Diploma in Engineering, 16% have Higher Secondary School Certificate (HSC), 3% have HSC (Vocational), 17% Secondary School

Certificate (SSC), 1% SSC (Vocational), below SSC certificate level are 30%, and 6% have Trade course certificates. Table 4.1 shows the percentage of employees (working at formal and informal RAC servicing centres) according to educational levels.

**Table 4.1 Number of employees (working at formal and informal RAC servicing centers) according to educational levels**

Categories	BA/ B.Sc or Higher Education	BSc Engineering	Diploma in Engineering	HSC Vocational	Higher Secondary School Certificate (HSC)	SSC (Vocational)	Secondary School Certificate (SSC)	Below Secondary School Certificate	Trade Course
<b>Formal</b>	28	13	52	4	45	0	32	20	0
<b>Informal</b>	4	6	8	8	22	6	39	103	24
<b>Total</b>	32	19	60	12	67	6	71	123	24

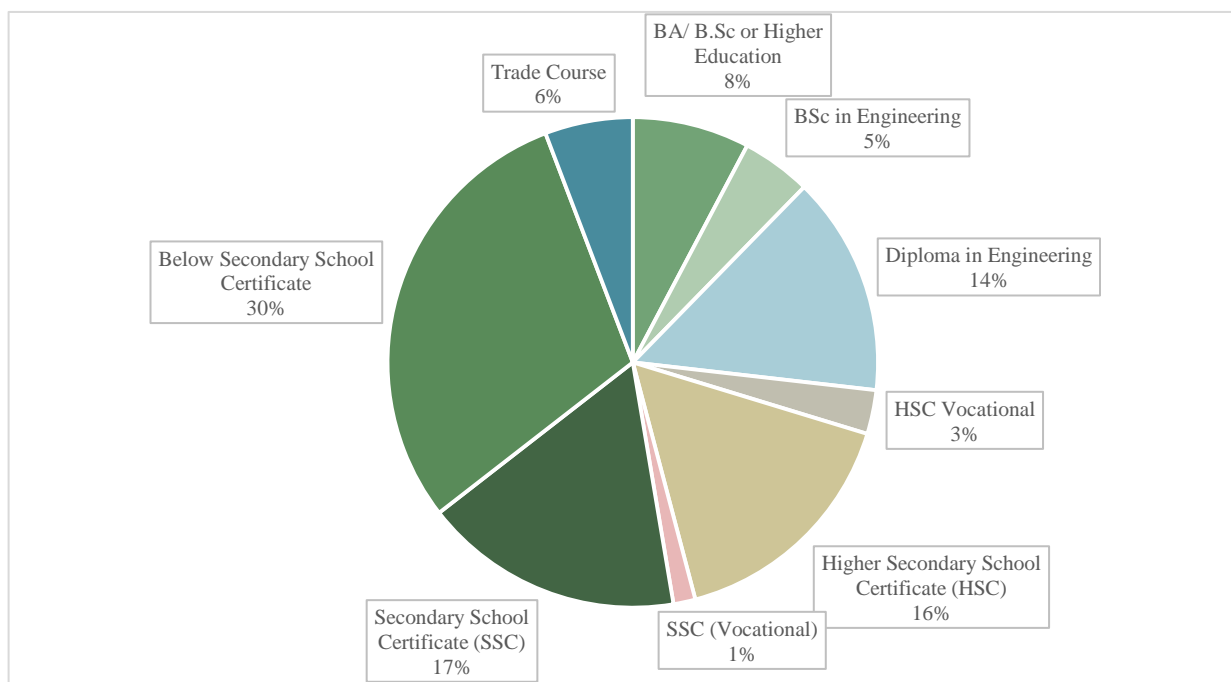


Figure 4.1 Distribution of employees (in %) according to educational qualification (working at formal and informal RAC servicing centers). Source: Authors' own compilation

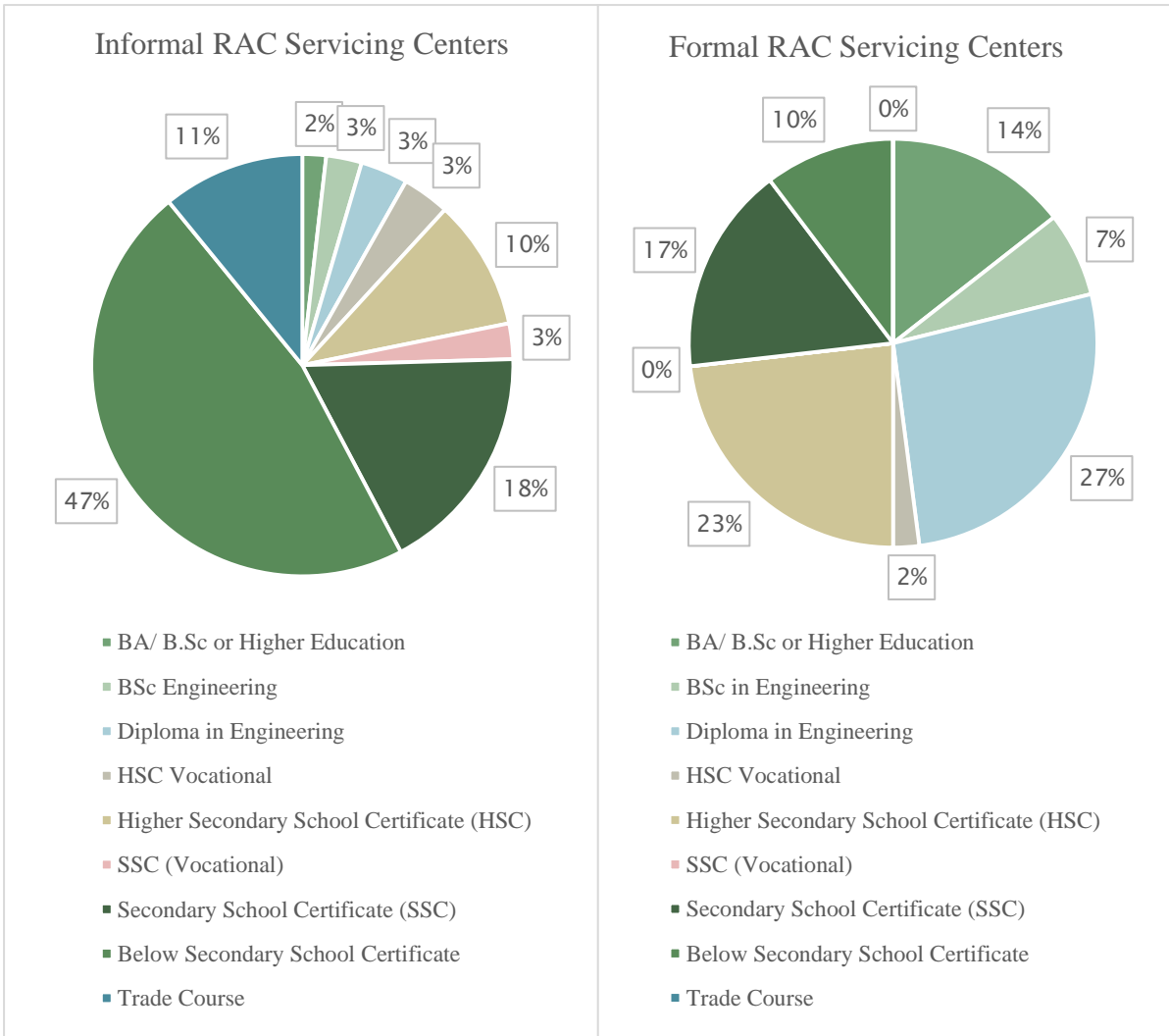


Figure 4.2 Distribution of employees (in %) according to educational qualification levels (working at formal VS informal RAC servicing centres). Source: Authors' own compilation.



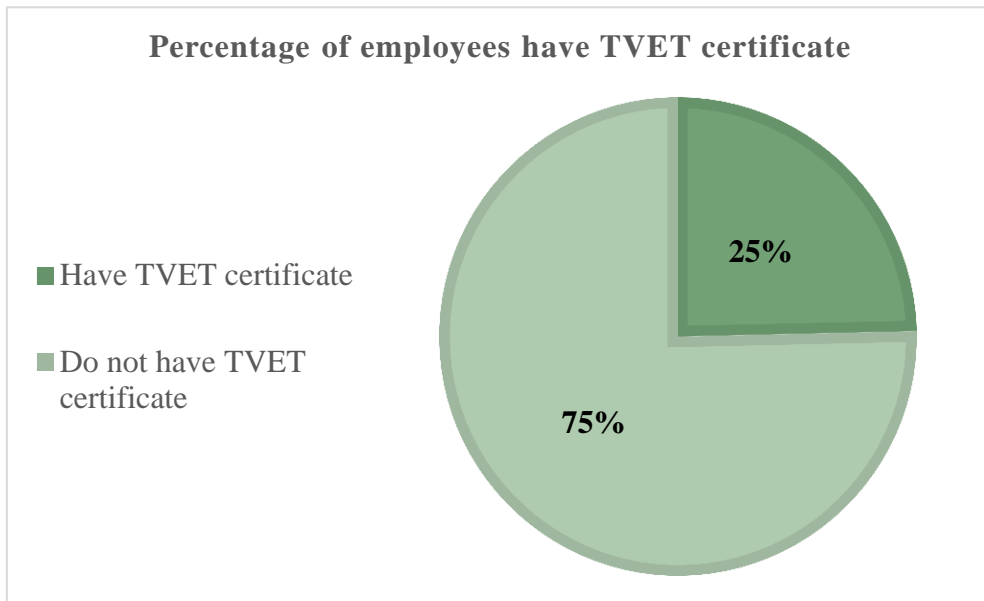


Figure 4.3 Percentage of employees (working at formal and informal RAC servicing centers) have TVET certificate. Source: Authors' own compilation.

#### **4.1.2 The Skills Gap between Occupational Competencies Required for RAC Servicing Technicians and the Existing TVET Curricula in Bangladesh.**

Firstly, occupational competencies (the duties and tasks) of a RAC servicing technician were identified by using the survey questionnaire from technicians of the RAC servicing centres (Table 4.2). By analyzing the survey results, occupational competencies (duties/ responsibilities and tasks) of an RAC servicing technician were determined. The findings of an RAC service technician's occupational competencies (duties/ responsibilities and tasks) are classified according to domain-specific skills, self/ human and social competencies, occupational safety, and other competencies (please see Box 4.1), which are illustrated in the following.

Secondly, the desk study has been conducted to analyze the course content (theoretical and practical) of the Diploma in Engineering (BNQF Level -6) -specialization in RAC, National Skills Certificates (BNQF Level-1 to 5) - specialization in RAC, and Basic Trade Course (360 hours) -specialization in RAC. And the following Figure 4.4 illustrates the percentage of course credits of a Diploma in Engineering (BNQF Level-6) with specialization in the RAC curriculum.

Table 4.2 The RAC technicians' (participants') response on the occupational competences

Categories	SL	Occupational competences (Duties and tasks of a RAC servicing technician)	Yes	No
Domain specific competencies	a	Install, inspect, maintain, and repair refrigerators, fridges.	52 (100%)	0 (0%)
	b	Install new air-conditioning systems and equipment.	51 (98%)	1 (2%)
	c	Install, replace, or repair equipment that has been damaged.	52 (100%)	0 (0%)
	d	Carry out maintenance checks on heating, ventilation, and air conditioning systems; clean evaporator drain pans, coils, and filters; lubricate fan and motor bearings; compressors, thermostats, fans, floating elements, and defrost timers etc.	48 (92%)	4 (8%)
	e	Carry out repair and routine maintenance duties on equipment, building facilities and offices, building systems, grounds, and cooling units.	42 (81%)	10 (19%)
	f	Diagnose electrical and mechanical defects and malfunctions.	47 (90%)	5 (10%)
	g	Perform inspection, maintenance, repairs, and installation of air conditioning systems, building control and pneumatic systems, cooling systems, refrigerators, ice machines, refrigerated water coolers, and similar equipment	32 (62%)	20 (38%)
	h	Make sure the adjustment and calibration of thermostatic controls.	49 (94%)	3 (6%)
	i	Ventilate equipment and controls making sure they operate efficiently and continuously.	45 (87%)	7 (13%)
	j	Clean blowers and coils, check tensions of belts and motors.	33 (63%)	19 (37%)
	k	Place airflow controls to occupants' preference by adjusting dampers, splitter, diffusers, and fans speeds; take away, clean, and change filters and strainer; the remake, repair, and paint metal and wood cooling fans and towers; add the right amount of chemicals to water towers to prevent corrosion and rust	09 (17)	43 (87%)
	l	Run equipment operation, and read instruments and gauges, including Volt-ohm meters; find out temperature gauges and adjust mechanisms, including valves, pumps, and controls to direct levels of fluid, temperature, and pressure; charge with specified types and amounts of refrigerant, and bleed contaminants from systems; inspect gauges and carry out periodic preventive maintenance checks	41 (79%)	11 (21%)
	m	Take away pumps and motors, change bearings and shafts, repacks and perform reinstallations; perform an adjustment on expansion valves; change, fix, and re-calibrate humidistats and thermostats, change hinges, gaskets, and hardware	14 (27%)	38 (73%)
	n	Inspect and maintain refrigerators and ice machines, and chilled water supply systems.	46 (88%)	6 (12%)
	o	Make plans and designs of new air-conditioning systems including their installation and maintenance.	44 (85%)	8 (15%)
	p	Perform repairs or adjustments on piping, connections, valves,	47 (90%)	5 (10%)

		couplings and fitting, by riveting, bolting, welding, brazing, and soldering by applying hand tools, drill press, Presto lite torch, and acetylene torch		
	q	Carry out minor masonry, painting, and carpentry work	33 (63%)	19 (37%)
	r	Carry out minor electrical maintenance work, such as repair or replacement of fixtures, including wall switches and outlets, fluorescent tubes and bulbs, fuses, sockets, etc., by applying the right tools	43 (83%)	9 (17%)
	s	Carry out minor plumbing maintenance work, including change or repair of leaks in faucets and drains, trenching and laying of new lines, unclogging of drains, etc.	8 (15%)	44 (85%)
Self / Human competencies / Social Competencies	t	Coordinate efforts with the company's contracted HVAC vendors to ensure company HVAC systems are functioning perfectly	47 (90%)	5 (10%)
	u	Provide assistance to supervisor in planning new installation and modification projects, preparation of specification, and major reconditioning and overhauling projects, applying knowledge of refrigerating systems, engineering specific Assistants	52 (100%)	0 (0 %)
	v	Provide assistance to colleagues in the department to effectively maintain, and repair equipment, buildings, and municipal properties	52 (100%)	0 (0 %)
	w	Provide support after work hours if required in works workshop meetings, and other company functions	52 (100%)	0 (0 %)
	x	Participation in the work of project teams.	52 (100%)	0 (0 %)
Occupational Safety or Others Competencies	y	Matching, installing and testing of fire protection	31 (60%)	21(40%)
	z	Organizing , operation and maintenance of clean job with the principles of occupational health and safety, fire protection and environmental protection	44 (85%)	8 (15%)
	a	Making settlements maintenance costs and repairs.	52 (100%)	0 (0 %)
	b	Checking the quality of the service and repairing work	52 (100%)	0 (0 %)
	c	Using the computer technology	28	24
	d	Perform related duties that may be assigned by management.	52 (100%)	0 (0 %)
Please, Add more which is not mentioned above		Maintenance package type AC	1 (2%)	0 (0 %)
		Maintenance of central AC	1 (2%)	0 (0 %)

## **Box 4.1 Occupational competencies that are required for a RAC servicing technician.**

### **Domain-specific Skills**

- Install, inspect, maintain, and repair refrigerators, fridges and air-conditioners, humidifiers, dehumidifiers, ice machines, chilled water supply systems, and central air-conditioning systems.
- Able to maintain and test heating ventilation, and air conditioning systems.
- Clean evaporator drains, pans, coils, filters, compressors, thermostats, fans, floating elements, and defrost timers.
- Carry out repair and routine maintenance duties on RAC equipment, cooling units, ice machines, refrigerated water coolers, and similar equipment.
- Capable to charge with specified type and amount of refrigerant, remove contaminants from systems, inspect gauges, and carry out periodic preventive maintenance checks.
- Diagnose and repair electrical and mechanical malfunctions of RAC equipment.
- Make plans and designs for new air conditioning systems, including installation and maintenance.
- Make sure the adjustment and calibration of thermostatic controls.
- Perform repairs or adjustments on piping, connections, valves, couplings, and fitting by riveting, bolting, welding, brazing, and soldering by applying hand tools, drill press, Presto lite torch, and acetylene torch.
- Run equipment operation and read instruments and gauges, including volt-ohm meters; find temperature gauges and adjust mechanisms, including valves, pumps, and controls, to direct fluid, temperature, and pressure levels.

### **Self / Human Competencies and Social Competencies**

- Provide assistance to supervisor in planning new installation and modification projects, preparation of specification, and major reconditioning and overhauling projects, applying knowledge of refrigerating systems, engineering specific assistants.
- Coordinate efforts with the company's contracted HVAC vendors to ensure company HVAC systems are functioning perfectly.
- Assist colleagues in the department to effectively maintain and repair equipment and buildings.
- If required, provide support after work hours in works workshop meetings and other company functions.
- Participation in the work of project teams.

### **Occupational Safety or Other Competencies**

- Organizing, operating, and maintaining clean jobs with occupational health and safety principles, fire protection, and environmental protection.
- Proficient to determine, maintenance and repairs costs.
- Capable of the maintaining quality in servicing and repair work.
- Proficiency in using computer technology (digital competency).
- Perform related duties that are assigned by management.

Authors, based on the study questionnaire (RAC TJR, 2023; AC TJR, 2023).

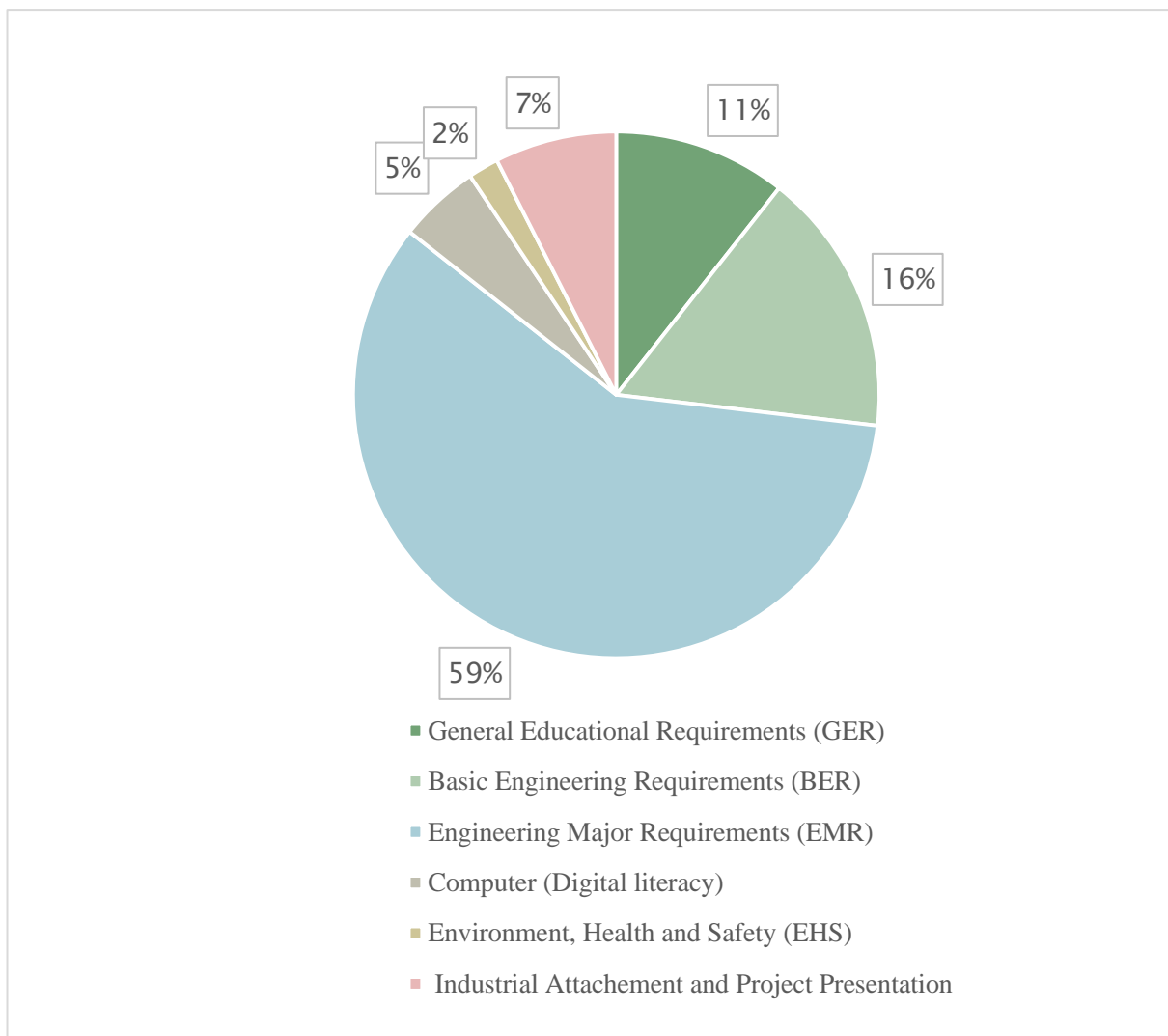


Figure 4.4 Category of courses (in %) of Diploma in Engineering (BNQF Level-6) with specialization in RAC curriculum. Source: (BTEB, 2022)

Figure 4.4 illustrates the percentage of course credits of a Diploma in Engineering (BNQF Level-6) with specialization in the RAC curriculum. The Diploma in Engineering (BNQF Level-6) is a four-year programme with an SSC entry qualification. It follows the semester system to conduct instructions and examinations. An academic year consists of two semesters. Each semester consists of sixteen weeks. The total number of credits in a Diploma in Engineering with specialization in RAC curriculum is 160 credits. The courses credits of the programme can be categorized as General Educational Requirements (GER) (i.e., humanities, social sciences etc.) courses 17 credits, Basic Engineering Requirements (BER) (i.e., natural sciences, mathematics) courses 26 credits, Engineering Major Requirements (EMR) courses 94 credits; Computer (Digital literacy) courses 8 credits, Environment,

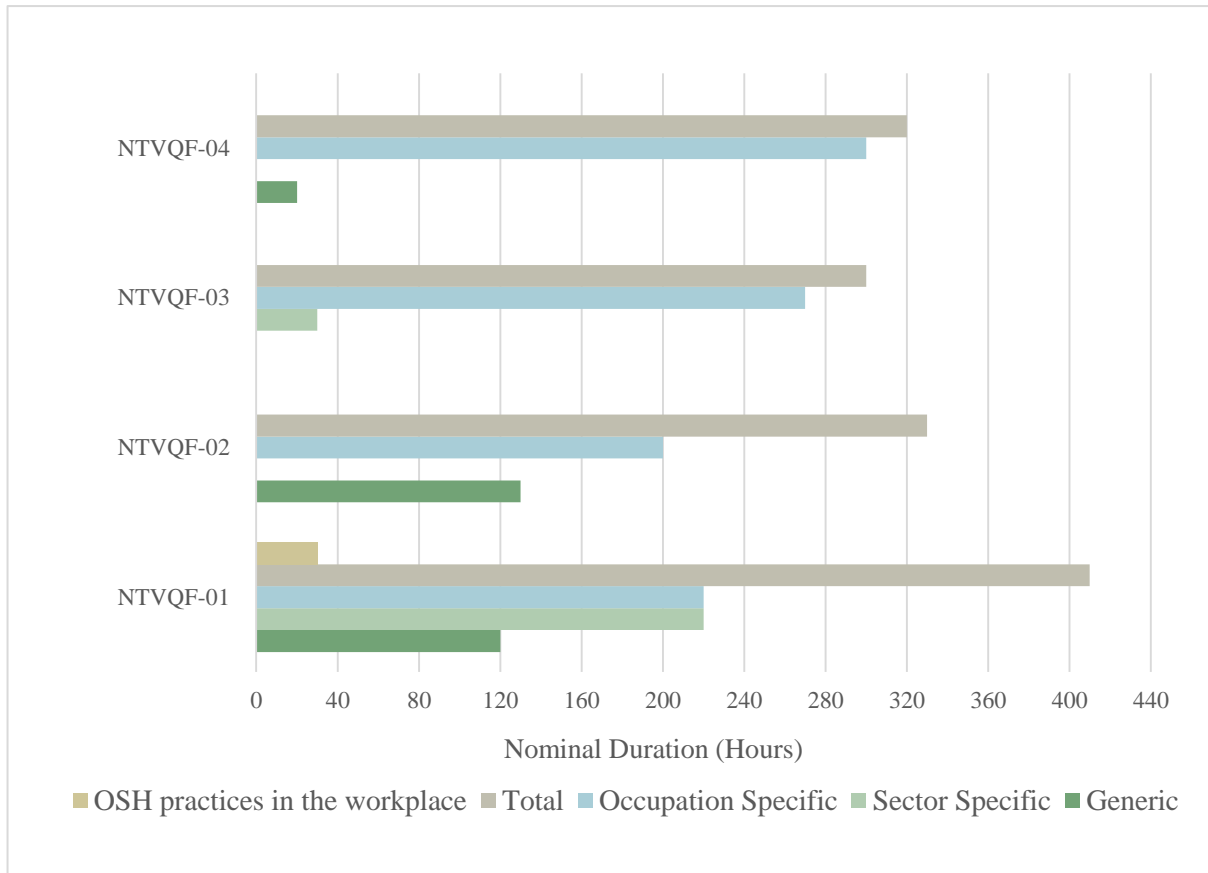


Figure 4.5 Category of courses (in hours) of National Skills Certificates (BNQF Level -1 to 4) with specialization in RAC curriculum. Source: (BTEB, 2023).

Health and Safety (EHS) course is 3 credits, and industrial attachment 12 credits. One course (Environmental Studies) focuses on environmental aspects in the Diploma Engineering curriculum. The course covers the fundamentals of environmental issues, various forms of pollution, their effects, controls, and appropriate solutions. A person with a BNQF Level 6 qualification (Diploma in engineering) is expected to work as a supervisor/ middle-level manager/ sub-assistant engineer (RAC diploma course, 2023). However, among the RAC servicing centres, about 14 % have a Diploma Engineering qualification and work as a servicing technician.

The National Skills Certificates (BNQF Level 1 to 4) courses are categorized as generic, sector-specific, and occupation-specific. Figure 3.5 shows National Skills Certificates (BNQF Level -1 to 4) with specialization in RAC course's nominal hours. In the competency standards at BNQF Level -1, one module, 'Occupational Safety and Health in the workplace' (30 nominal hours), is there, which includes OSH hazards, work safety, emergency response procedures, health and safety in the workplace. The Basic Trade Course (360 hours), with specialization in RAC, consists of theory (60 hours), practical (240 hours), and basic

competency and communicative English (60 hours). The entry qualification for this course is Grade 8 or above. Graduates of this course should have the knowledge, practical skills, and attitude (Please see box 4.2) necessary for inspecting, servicing, and repairing mechanical and electrical components and parts of residential air conditioning units. The content of this course includes measurement techniques, fitting procedures, tubing installation, leak testing, evacuation methods, refrigerant charging, servicing protocols, repair techniques, and installation procedures for various cooling appliances, i.e., refrigerator-freezers, deep fridges, window-type air conditioners, and split type air conditioners. A person with this trade certificate can work as a RAC technician (BTEB, 2023).

**Box 4.2 The intended competence profile of a Basic Trade (360 hours) course graduate with specialization in RAC.**

**Basic Competences**

- Receive and respond, Participate and Lead to workplace communication.
- Work with others, Team Environment and Lead small Teams.
- Demonstrate work values, Practice career professionalism and Develop & Practice Negotiation skills.
- Practice housekeeping procedures, Occupational health and safety procedure and Solve problems related to work Activities.
- Use Mensuration & required calculation in Relevant Trades.
- Personal Manner.
- Efficiently communicate in English and Speak and write in English with confidence
- Communicate with target persons effectively
- Understand the speech of English users.
- Achieve better professional performance

**Common competences**

- Identify tools, equipment and materials used in RAC works
- Know about Tubing and Piping used in RAC works.
- Check and make decision about performance of compressors and machines
- Recognize electrical circuits used in RAC works and their functions
- Test winding and find terminals of components used in RAC machines

**Core competences**

- Install, Service, and Maintain Shoot troubles of RAC's small units machines (Specially Window AC, Split type Ac and Car Ac)
- Recover Refrigerants and charge compressor oil in RAC's machines
- Detecting faults, Repair, Replace, Service & Maintain mechanical and electrical Components used in RAC works

Table 4.3 Skills gap between occupational competencies required for an RAC servicing technician and Diploma in Engineering- specialization in RAC curriculum

Occupational competencies that are required for a RAC servicing technician. (Please see details in Box 4.1)	Curriculum Content of Diploma in Engineering (BNQF-6) specialization in RAC.  (Please see details in Appendix - D)	Skills gap between occupational competencies required for an RAC servicing technician and Diploma in Engineering curriculum
Domain-specific Skills	The curriculum content encompasses Engineering Drawing, Mechanical Engineering Materials, RAC Cycles & Components, Cooling & Heating Load Calculation, Circuits and Electrical Machine in RAC, RAC system design, RAC Plant Installation Maintenance & Operation, Heating Ventilation & Air Conditioning.	The curriculum adequately emphasizes theoretical content concerning RAC systems, fundamentals, and analysis, Yet it lacks practical skills related to RAC servicing and trouble shooting and maintenance.
Self / Human Competencies and Social Competencies	The curriculum content includes Physical Education, Life skills Development, Principle of Marketing, Business Communication, Project Presentation, Social Science related contents.	The curriculum needs to integrate problem-solving, customer service, critical thinking, leadership, and ethical standards with professional integrity to enhance student proficiency.
Occupational Safety or Other Competencies	In the curriculum found contents which is focuses on environmental aspects, covering fundamentals, pollution forms, effects, controls, and solutions, define greenhouse effect, global warming & Ozone Depleting Substances (ODS), causes of global warming, importance of the ozone layer and the effects of ozone depletion. Additionally, in the curriculum founds computer-related courses like Computer Office Application, Programming in C, CAD & CAM, which is emphasizing digital literacy on RAC technology.	The curriculum fails to incorporate practical applications concerning Environment, Health, and Safety (EHS), fire protection, and quality control essential for maintaining standards in servicing and repair work.



Table 4.4 Skills gap between occupational competencies required for an RAC servicing technician and National Skills Certificates (BNQF Level -1 to 4) specialization in RAC curriculum

Occupational competencies that are required for a RAC servicing technician. (Please see details in Box 4.1)	Curriculum content of National Skills Certificates (BNQF Level -1 to 4), with specialization in RAC. (Please see in details Appendix-E)	Skills gap between occupational competencies required for an RAC servicing technician and (BNQF Level -1 to 4) curriculum
Domain-specific Skills	The curriculum content encompasses servicing and repairing refrigerators and deep freezers, installing window and split-type air conditioners, performing refrigerant recovery, recycling, and retrofitting, as well as fabricating and installing ducting and piping.	The curriculum content lacks practical skills related to servicing and maintenance of ice machines heating ventilation, and air conditioning systems, central air-conditioning systems.
Self / Human Competencies and Social Competencies	The curriculum lacks content addressing self/ human competences and social competences, essential for holistic development.	This curriculum lacks content addressing self and human competencies such as communication, leadership, cooperation, and team work and negotiation skills.
Occupational Safety or Other Competencies	In the competency standards at BNQF Level -1, module, found 'Occupational Safety and Health in the workplace' (30 nominal hours), which includes OSH hazards, work safety, emergency response procedures, health and safety in the workplace.	The curriculum content lacks practical application related to fire protection. Additionally, the curriculum content lacks computer fundamentals skills particularly for digital literacy.

Table 4.5 Skills gap between occupational competencies required for an RAC servicing technician and of Basic Trade (360 hours) course with specialization in RAC curriculum

Occupational competencies that are required for a RAC servicing technician. (Please see details in Box 4.1)	Curriculum content of Basic Trade (360 hours) course with specialization in RAC. (Please see details in Box 4.2, Appendix– F & G)	Skills gap between occupational competencies required for an RAC servicing technician and Basic Trade (360 hours) course curriculum
Domain-specific Skills	The curriculum content encompasses measurement techniques, fitting procedures, tubing installation, leak testing, refrigerant charging, servicing protocols, repair techniques, and installation procedures for various cooling appliances, including refrigerator-freezers, deep fridges, window-type AC units, and split-type AC units.	The curriculum content lacks practical skills related to servicing and maintenance of ice machines heating ventilation, and air conditioning systems, central air-conditioning systems.
Self / Human Competencies and Social Competencies	Curriculum includes content related to communication skills, leadership skills, cooperation skills, and negotiation skills.	The curriculum content lacks customer service.
Occupational Safety or Other Competencies sides	Curriculum includes content like Define, Classify and explain Occupational health and safety List of First aids box.	In curriculum giving comparatively less attention occupational health and safety related content and lacks its practical application related to Environment, Health, and Safety (EHS) and fire protection. Besides, It lacks content related to computer fundamental skills, particularly for digital literacy.

After comparing the curriculum content with the identified occupational competences (Please see Box 4.1) of an RAC servicing technician, we found that the Basic Trade course curriculum content (Box-4.2) significantly matches the competences required for a RAC servicing technician. In contrast, a Diploma in Engineering (BNQF Level-6) with specialization in RAC curriculum content focuses sufficiently on theoretical knowledge (high cognitive abilities) but practical skills. Although it has one Environmental Studies course in the curriculum, but it lacks sufficient content related to Environment, Health and Safety (EHS) and fire protection. While the National Skills Certificates (BNQF Level-1 to 4) with specialization in RAC curriculum content focus more on practical skills of RAC servicing but less on self/ human competences, and social competences. National Skills Certificates BNQF Level- 5 with specialization in RAC curriculum are not implemented anywhere in Bangladesh but have a pedagogic level-5 curriculum. In addition, the content related to AI, nanotechnology, and IoT is not included in the Diploma in Engineering with specialization in RAC curriculum content. Those who start a career in the RAC servicing sector after completing a Diploma in Engineering they could quickly acquire domain-specific practical skills at servicing centres/ on-the-job training within the first few months of their employment.

#### **4.2 Environment-friendly (Green) and safety practices at RAC servicing centers in Bangladesh.**

As mentioned above, a survey was conducted at RAC servicing centers to determine how well RAC servicing centre technicians adhere to environmental policies and know workplace safety regulations. Participants (technicians) were asked whether their employers and employees knew of environmental regulations/ policies and safety practices at their workplace. The study found that most participants were familiar with environmental legislation, regulations, and green and safety practices in the RAC serving sector. The researchers found that all participants from the formal RAC servicing centre were familiar with environmental laws, regulations, and workplace green and safety practices. However, 42% of participants from informal RAC servicing centers are unaware of environmental law and green safety practices in their workplaces. Another question was asked in that survey: "Can you mention the name of the following regulations or policies?" the responders of formal RAC servicing centres mentioned that they followed environmental acts, maintained regulations like ISO 9001:2015 and have plans to soon implement ISO 14000 and ISO 45001 standards in their workplaces during servicing and maintenance operations on RAC

equipment. On the other hand, according to the employees of the informal RAC servicing centre statement, even though environmental policies and regulations were known to most of them. None of the informal RAC servicing centre employees could mention the environmentally relevant rules, regulations, and green and safety practices. In response to the survey question "Who is responsible for implementing/ monitoring these regulations/ policies at your enterprise, how is your environmental compliance assessed, and by whom?" the research participants shared that the owner/ manager of the informal RAC servicing centre takes the responsibility and monitoring whether employees follow environmental related regulations/ policies and safety practices while working at RAC servicing or maintenance. But, environmental compliances are not assessed by any authority, including the Department of Environment (DoE). On the contrary, some companies in the formal sector have a particular department (compliance department) that implements and monitors whether employees properly follow the environmental regulations/ policies and safety practices in their workplace. In addition, environmental rules, regulations, and safety practices in the workplace are assessed during the Audit activities conducted by these companies.

In the survey question regarding the importance of green skills and environmentally friendly practices, the participants of RAC servicing centres responded using a 10-point rating scale where 'one' indicates this issue is ignored and 'ten' means "close attention is paid to green skills and environmentally friendly practices. The participants' replies ranged from 1 to 6 for informal servicing centers and 5 to 8 for formal RAC servicing centers. The result indicates that informal RAC servicing enterprises are not adopting adequate environmentally friendly measures, and inadequate attention is being given.

The participants in this study were provided with the following list of skills/ competences (Please see Box 4.3): cognitive competences, interpersonal skills, technological skills, and intrapersonal competences (understood in a broad sense) (Pavlova, 2015, 2018; Haolader and Khan, 2022) that may be necessary to maintain environmentally friendly practices in RAC servicing sector. Almost all participants across all the formal and informal RAC servicing sectors agreed on the significance of these competences.

**Box 4.3 Skills/ competencies that need to maintain for environmentally friendly practices in RAC servicing industries.**

Cognitive competencies

- Environmental awareness and a willingness to learn about sustainable development;
- Systems and risk analysis skills to assess, interpret, and understand both the need for change and the measures required;
- Innovation skills to identify opportunities and create new strategies to respond to green challenges;

Interpersonal skills and technological skills

- Strategic and leadership skills to enable policymakers and business executives to set the right incentives and create conditions conducive to cleaner production and cleaner transportation;
- Coordination of business skills to facilitate holistic and interdisciplinary approaches that encompass economic, social, and ecological objectives;
- Communication and negotiation skills to discuss conflicting interests in complex contexts;
- Marketing skills to promote greener products and services
- Networking, IT, and language skills to enable participation in global markets; consulting skills to advise consumers about green solutions and to spread the use of green technologies;

Intrapersonal competencies

- Adaptability and transferable skills to enable workers to learn and apply the new technologies and processes required to green their jobs;
- Entrepreneurial skills to seize the opportunities of low-carbon technologies

Authors, based on the study questionnaire (Pavlova, 2015, 2018; Haolader Faruque A. and Khan, S. H. 2022).

Informal RAC servicing centers do not appropriately follow environmental regulations and safety practices [A2, P2]. Because Bangladesh has no RAC servicing sector-specific environmental policies, regulations, and laws, particularly for the RAC servicing sector, but general environmental policies, regulations and rules are available. These are known to workforces in the formal sectors, but a significant portion of the workforce is unaware of environmental policies, regulations, and laws in the informal RAC servicing sector [A2, P2].

Table 4.6 Interview results of the Key informants interviewees (KIIs)

SL	Question	Participant-1 (P1)	Participant-2 (P2)
1	<p>Could you please tell about the current size and future development of RAC servicing centres in Bangladesh?</p>	<p>The informal sector of RAC servicing centers is comprised of a considerable 120 thousand establishments. This industry serves as a major source of employment, offering opportunities to a significant workforce, with more than 1 million individuals actively involved in this field. The sector plays a crucial role in supporting livelihoods and contributing to the economy, reflecting its substantial impact on job creation and sustainability within the RAC servicing domain. [ A1, P1]</p>	<p>The RAC servicing centers' informal sector boasts a considerable presence, encompassing a substantial 110,000 to 130,000 establishments. This dynamic industry serves as a key source of employment, engaging a significant workforce of over 1 million individuals. [A1, P2]</p>
2	<p>Would you please share the current working environment of RAC sector?</p>	<p>Informal RAC servicing centers in Bangladesh operate without adhering to proper environmental regulations and safety practices, exacerbated by the absence of sector-specific policies, regulations, and laws.</p> <p>The Bangladesh National Building Code (BNBC) does not provide any guidelines for designing buildings with regard to AC installation in high-rise structures. This loophole contributes to the poor implementation of environmentally friendly regulations and safety practices in the informal RAC servicing sector. The consequences are dire, with frequent accidents occurring during AC installations on high-rise buildings. Tragically, these accidents result in fatalities or debilitating injuries to the workforce.</p> <p>More than 200 RAC servicing technicians lose their lives annually, while over 500 technicians suffer disabling injuries. Shockingly, the</p>	<p>The informal RAC servicing centers in Bangladesh operate without adherence to environmental regulations and safety protocols. Unlike other sectors, there are no specific environmental policies, regulations, or laws tailored to the RAC servicing industry. While general environmental guidelines exist, they are primarily known and followed by formal sector employees. Unfortunately, a significant portion of the informal workforce remains unaware of these policies due to their lack of formal education or training certificates, which stands as a significant obstacle to ensuring environmental compliance. [A2, P2]</p>

		<p>affected employees or their family members receive no financial assistance from the owners of these informal RAC servicing centers, the government, or any other organization. This lack of support is largely due to the absence of policies, regulations, or life insurance coverage in place. [A2, P1]</p>	
3	<p>What actions are being taken by Department of Environment (DOE) to increase environmental awareness and safety practices for RAC servicing technicians?</p>	<p>Within the RAC servicing sector, environmental awareness and safety practices are pivotal, yet only a mere 5,000 out of the 1 million RAC servicing technicians have undergone training in best practices facilitated by the Department of Environment (DOE) and UNEP/ROAP.</p> <p>This training encompassed crucial aspects such as environmental consciousness and safety protocols during the installation and maintenance of refrigeration and air-conditioning (RAC) equipment. Surprisingly, post-training, there has been an absence of assessment or monitoring by the DOE or any other relevant organization to gauge the adherence to environmental practices within the technicians' workplaces. [A3, P1]</p>	<p>The Department of Environment (DoE) or any similar organization has not conducted assessments or monitoring of environmental practices within their workplace.</p> <p>This oversight raises concerns about the efficacy of environmental compliance within the RAC servicing sector. The absence of ongoing evaluation mechanisms leaves the industry unchecked in terms of its commitment to environmental sustainability and safety standards. It is imperative for the DoE or relevant organizations to institute regular assessments and monitoring procedures to ensure that RAC servicing technicians adhere to established environmental practices, fostering a culture of responsibility and sustainability within the industry. [A3, P2]</p>

In the informal RAC sector, a substantial portion of the workforce, e.g., 47% of the technicians, do not have formal education or training certificates, which is the root cause of being unaware of environmental policies and regulations. Beside, another reason of informal RAC servicing centers do not appropriately follow environmental regulations and safety practices. Because Bangladesh has no RAC servicing sector-specific environmental policies, regulations, and laws, particularly for the RAC servicing sector, but general environmental policies, regulations and rules are available [A2, P1]. These are known to workforces in the formal sectors, but a significant portion of the workforce is unaware of environmental policies, regulations, and laws in the informal RAC servicing sector [A2, P1]. In the informal RAC sector, a substantial portion of the workforce, e.g., 47% of the technicians, do not have formal education or training certificates, which is the root cause of being unaware of environmental policies and regulations. In addition, the Bangladesh National Building Code (BNBC) has no rule regarding designing buildings for AC installation in high-rise buildings [A2, P1]. Consequently, environmentally friendly regulations and safety practices are poor in the informal RAC servicing sector. As a result, frequent accidents occur, e.g., during AC installation on high-rise buildings, frequent accidents occur, causing death/ disabling its employees. Over 200 RAC servicing technicians die, and 500+ RAC servicing technicians become disabled per year [A2, P1]. Employees/ family members of the victims (who died or disabled) do not receive any financial help from the owner of the informal RAC servicing centre, government, or any other organization, as there is no policy, regulation, or (life) insurance [ A3,P1].

The term "caring for the environment" does not carry the same significance to workers/employees in the informal sector as it does to workers in the formal sector. According to the general secretary of the Bangladesh Refrigeration and Air Conditioning Owners Workers Welfare Council (BRAOWWC), in Bangladesh, the informal sector of RAC servicing centres comprises a substantial number, over 120 thousand establishments. Furthermore, the president of the Bangladesh Refrigeration and Air Conditioning Merchants Association (BRAMA), in his personal communication on August 22, 2023, this industry provides employment opportunities for a significant workforce, with over 1 million individuals engaged in this field [A1, P1]. Several organizations exist to work for the welfare of RAC servicing sector, such as Bangladesh Refrigeration and Air Conditioning Merchants Association (BRAMA) and Bangladesh Refrigeration and Air Conditioning Owners Workers Welfare Council in the RAC servicing sector. These organizations are trying to increase



environmental awareness and safety practices for RAC servicing technicians. Besides maintaining environmental awareness and safety practices for RAC servicing sector, only 5,000 out of 1 million RAC servicing technicians received training on good practices in refrigeration and air-conditioning organized by the Department of Environment (DOE) and UNEP/ ROAP [ A3, P1]. The number is insufficient; only 0.5% of total RAC servicing technicians. In this training, they learned how harmful CFC refrigerant is for the Environment and how it impacts global warming and the greenhouse effect. In that training, environmental awareness and safety practices during RAC equipment installation and maintenance were also included. After training the RAC servicing technician, the DoE or any other organization has never assessed or monitored how environmental practices are followed in their workplace [A3, P2]. In Bangladesh, various government departments and agents are assigned under various ministries to monitor the industry's impact on the surrounding Environment. The most important of which is the Directorate of Environment. These agencies evaluate and monitor the environmental damage caused by industries' economic operations. However, research findings indicate that oversight is non-existent in all informal RAC servicing enterprises and very rare (almost non-existent) in the formal sector.

#### **4.3 Observation**

The formal RAC servicing centre participants maintain environmentally friendly practices for positive environmental work. They also maintain the standard practice in the workplace to minimize the environmental impacts and dispose of waste in an environmentally friendly way. Most of the formal RAC servicing centers record data for minimizing ecological risks and use brochures to improve environmental awareness. For example, most of the formal RAC servicing centres follow 5S (sort, set in order, shine, standardize, and sustain) in their workplace for waste management and energy saving that deal with green practices. On the other hand, most of the informal RAC servicing centres do not follow positive environmental work practices and standards. In addition, informal RAC servicing centers do not record environmental risk information or use brochures and events to spread environmental awareness.

Nevertheless, informal RAC servicing centres, in most cases, do not correctly maintain or practice waste management and energy saving that deal with green practices. In both formal and informal RAC servicing centres, during servicing/ maintenance operations, i.e., changing the compressors/ condensers and evaporators or charging refrigerants, the refrigerant used is not recovered but released into the atmosphere.



Figure: 4.6 Emissions of refrigerant during servicing and maintenance operations.

Source: Authors' capture photo during observation.

The refrigerant recovery machine was not found in any servicing centres. Many refrigerants, such as chlorofluorocarbons (CFCs) and R410a, are released into the atmosphere, which has a significant environmental impact. For example, it causes global warming, ozone layer depletion, and the greenhouse effect. One kilogram of refrigerant R410a has a greenhouse effect equal to two tons of carbon dioxide, equivalent to driving a car for six months (RAC Consumers, 2022).

## **CHAPTER 5 CONCLUSIONS AND RECOMMENDATIONS**

### **5.1 Introduction**

This chapter summarizes the study, highlighting significant findings, conclusions, recommendations, and potential areas for future work. The study's primary objective was to identify any skills gap between the occupational qualifications required for RAC servicing technicians and the existing TVET curriculum in Bangladesh. The secondary objective aimed to investigate environmentally friendly (Green) and safety practices in RAC servicing industries. To achieve these objectives, the study conducted research across 52 Refrigeration and Air-conditioning (RAC) servicing centers in Bangladesh, comprising 45 informal and 7 formal RAC servicing centers. The following discussion will describe the study's major findings, conclusions, recommendations, and future works.

### **5.2 Major Findings**

#### **5.2.1 Research Objective I**

In order to identify the skills gap (objectives i), the researcher first identified the duties and tasks of a RAC servicing technician. The findings show that the occupational tasks of RAC servicing technicians are repairing and servicing RAC equipment, installing new RAC equipment, and checking RAC equipment to ensure that it performs smoothly and properly to ensure good working order.

The analysis found that the Diploma in Engineering (BNQF Level -6) - specialisation in RAC course content focuses sufficiently on theoretical knowledge (high cognitive abilities) but lacks practical experience in RAC servicing domain-specific skills, self/ human competencies, and social competencies, and occupational safety or other competencies. On the other hand, it has been observed that after analyzing the National Skills Certificates (BNQF/ NTVQF Level-1 to 4) - specialisation in RAC course content, more focus is on practical skills of RAC servicing domain-specific competencies but self/ human competencies and social competencies as well as occupational safety or other competencies are lacking. National Skills Certificate course at BNQF Level-5 with specialization in RAC has not yet been implemented.

### **5.2.2 Research Objective II**

It has been observed that the formal RAC servicing industry participants maintain environmentally friendly practices for positive environmental work. They also maintain the standard practice in the workplace to minimize the environmental impacts and dispose of waste in an environmentally friendly way. On the other hand, the informal RAC servicing industries' environmental regulations and safety practices are not appropriately followed because the government of Bangladesh does not implement environmental policies, regulations, and laws, particularly for the RAC servicing sector, but has a general environmental policy, regulations, and laws. The informal RAC servicing centers do not adhere to environmental work practices and standards, do not record environmental risk information, or use brochures and events to promote environmental consciousness. None of the informal RAC servicing centres participants could mention the environmentally friendly rules, regulations, and green safety procedures that follow their workplace.

In most cases, informal RAC service centers do not correctly maintain and implement workplace waste management and energy-saving practices. Furthermore, the Department of Environment in Bangladesh oversees the environmental consequences and ecological harm resulting from industrial operations and economic activities. However, based on research findings, it has been observed that there is a lack of oversight in all informal RAC servicing centers.

### **5.3 Conclusion**

In conclusion, it can be said that the research successfully accomplished its primary goals, and it is possible to reach these conclusions after analyzing the research's data and examining its findings. The alignment between TVET curricula and the competences required for RAC servicing technicians is crucial for the success of both TVET graduates and the industry. By updating and aligning the TVET curriculum with industry demands, Bangladesh can ensure that RAC servicing technicians are adequately trained to meet the evolving needs of the industry. Collaboration between TVET institutions and industry is vital in achieving this alignment. This study finds that National Skills Certificates (BNQF Level-1 to 4) and Basic Trade course (360 hours) curriculum significantly match the occupational competences of RAC servicing technician skills/ competences, and focus more on practical skills of RAC servicing but less on self/ human competences and social competences as well as EHS. Diploma in Engineering (BNQF Level-6) with specialization in RAC curriculum content focuses sufficiently on theoretical knowledge (high cognitive abilities) but lacks practical

skills. National Skills Certificate course at BNQF Level-5 with specialization in RAC has not yet been implemented. In the case of environment-friendly (Green) and safety practices, the formal RAC servicing sector employees usually maintain environmentally friendly practices for positive environmental work. But informal RAC servicing centers often neglect environmental regulations and safety practices. This is primarily due to the absence of sector-specific policies, regulations, and laws tailored explicitly for the RAC servicing sector in the country. While general environmental policies and regulations exist, they do not address the unique challenges and requirements of RAC servicing. As a result, informal RAC servicing centers operate without appropriate guidelines, potentially leading to environmental hazards and safety concerns. In addition, Bangladesh's DoE monitors industrial environmental impact, but this study found that oversight is non-existent in all RAC servicing centers.

#### **5.4 Recommendations**

Bangladesh can strengthen its workforce and contribute to the growth and development of the RAC servicing industry by implementing the following measures.

- TVET institutions should have adequate facilities for practical classes and regular monitoring by the management so that each student can have enough facilities to improve practical/ psychomotor skills.
- TVET curriculum should be updated as frequently as possible to keep pace with rapidly changing technology.
- Environment-friendly green and safety practices skills must be taught clearly in every training course or curriculum offered by TVET institutions, and they ought to be included in every certification process, especially RAC Technology.
- TVET curriculum, particularly BNQF/ NTVQF Level-5 & 6, should include artificial intelligence (AI), IoT, and nanotechnology-related curriculum content.
- RAC servicing industries should hold regular training sessions on environmentally friendly skills for their employees and communicate the most recent environmental safety and health policies, statutes, and laws. On the other hand, Environmental organizations, like DoE, should carefully monitor RAC servicing industries and analyze the ecological effect of their economic operations transparently.
- The government should establish rules and regulations for RAC servicing industries' employees and environmental safety practices.

- CFC and other refrigerant gas which is harmful to the environment need to be permanently banned. Instead of CFC refrigerant, the RAC equipment should use environment-friendly refrigerant. On the other hand, RAC servicing industries must use refrigerant recovery machines to reuse refrigerant so that no refrigerant is released into the atmosphere.
- It is necessary to take the appropriate steps to cut emissions of greenhouse gases and progress toward waste prevention, recycling, and resource recovery in the field of RAC servicing industries.
- More research needs to be conducted on professional qualification criteria for green professions and safety practices in Bangladesh.

### **5.5 Future Works**

Future research in this field should delve into the effectiveness of implementing recommended measures in enhancing the alignment between TVET curricula and the evolving demands of the RAC servicing industry in Bangladesh. A focused group discussion approach can be employed to gather insights from stakeholders, including TVET institutions, industry professionals, and environmental organizations. This qualitative method will provide a nuanced understanding of the challenges and successes in incorporating green practices and safety measures in RAC servicing training. Additionally, future studies could assess the impact of potential regulations on environmental safety practices within both formal and informal RAC servicing centers. Continuous investigation into the evolving technologies such as AI, IoT, and nanotechnology in the context of RAC servicing is also essential for sustaining a skilled and environmentally responsible workforce.

## REFERENCES

- AC Technician Job Responsibilities (AC TJR), (2023). The Duties and Responsibilities of AC Technician. <https://www.velvetjobs.com/job-descriptions/ac-technician> Accessed on 10 July 2023
- Alhasan, N. U., & Tyabo, A. (2013). Revitalizing Technical and Vocational Education (TVET) for Youth Empowerment and Sustainable Development. *Journal of Educational and Social ZResearch*. <https://doi.org/10.5901/jesr.2013.v3n4p149>
- Alwi, A., Kamis, A., & Ismail, B. L. H. (2018). Effects of Green Skills Module in Design and Technology Subjects on The Student's Knowledge in Primary School. *International Journal of Academic Research in Business and Social Sciences*, 8(11). <https://doi.org/10.6007/ijarbss/v8-i11/5343>
- Balaraman, P., & Kamalakannan, P. (2016). Skill gap analysis and training needs in Indian aerospace industry. *Journal of Airline and Airport Management*, 6(2), 115-132.
- Bangladesh Technical Education Board, (BTEB), (2023). RAC Basic Trade Course (360hrs) 2023. [https://drive.google.com/drive/folders/0BynIJ2cATXt3R0dxRVo1ZEJYYUU?resourcekey=0-z7VfHCUElfyFyn3J\\_PxX1w](https://drive.google.com/drive/folders/0BynIJ2cATXt3R0dxRVo1ZEJYYUU?resourcekey=0-z7VfHCUElfyFyn3J_PxX1w). Accessed on 25 August 2023
- Bangladesh Refrigeration & Air-Conditioning Merchants Association (BRAMA), (2023). Dhaka. [https://www.bangladeshyp.com/company/5761/Bangladesh\\_Refrigeration\\_Air\\_Conditioning\\_Merchants\\_Association\\_BRAMA](https://www.bangladeshyp.com/company/5761/Bangladesh_Refrigeration_Air_Conditioning_Merchants_Association_BRAMA)
- BTEB, (2016). Enrollment Analysis in TVET under Bangladesh Technical Education Board. <https://drive.google.com/file/d/1IUoRXZ3uHFpTtf7IDdIsiVPyZmP2XX4Y/view> . Accessed on 26 October 2023.
- BTEB, (2018). Matching of NTVQF Qualification with the Occupations of Present Employment Market. [https://drive.google.com/file/d/1G74kuByXkvjV\\_AcDnmUZVryv7Cep4kMf/view](https://drive.google.com/file/d/1G74kuByXkvjV_AcDnmUZVryv7Cep4kMf/view)
- BTEB, (2021). Shift and Seat Capacity for Diploma -in-Engineering and Tourism and Hospitality. [https://bteb.portal.gov.bd/sites/default/files/files/bteb.portal.gov.bd/page/84dc01b3\\_d072\\_48f9\\_8aaa\\_aca776301210/diploma\\_engg\\_seat\\_capacity.pdf](https://bteb.portal.gov.bd/sites/default/files/files/bteb.portal.gov.bd/page/84dc01b3_d072_48f9_8aaa_aca776301210/diploma_engg_seat_capacity.pdf)
- BTEB, (2022). Refrigeration and Air-conditioning syllabus (1<sup>st</sup> to 7<sup>th</sup> semester). 2022. <https://drive.google.com/drive/folders/1SudXnIpeg37RyhPeW75C63USnr-cqq9r>

- BTEB, (2023a). Annual Report (p.44) 2022-2023,  
[https://drive.google.com/file/d/1\\_tPDq0bZnEneMEjydAY9LvqtZkEmBxfI/view](https://drive.google.com/file/d/1_tPDq0bZnEneMEjydAY9LvqtZkEmBxfI/view)  
Accessed 23 December 2023.
- BTEB, (2023b). Competency Based Training & Assessment (NTVQF) (I- IV)  
<http://btebcbt.gov.bd/utility/searchUser?sector=&occupation=37&level=&btnSearch=Search>. Accessed on 22 August 2023
- Burhaein, Erick & Tarigan, Beltasar & Budiana, Dian & Hendrayana, Yudy & Phytanza, Diajeng Tyas. (2022). Profile of changes in adaptive physical education learning during the Covid-19 pandemic. 10.1201/9781003265061-3.
- Chen, L., et al. (2024). "Building the Future: Integrating Safety into Sustainable Construction Practices." *Sustainable Architecture Journal*, 20(1), 45-62.
- Creswell, J. W., & Creswell, J. D. (2017). *Research design: Qualitative, quantitative, and mixed methods approaches*. Sage publications.
- Creswell, J. W., & Clark, V. P. (2011). *Mixed methods research*. SAGE Publications.
- Cumath, (2023). *The 3 Types of Education | Formal, Informal, Non-formal | Advantages | Disadvantages*. <https://www.cuemath.com/learn/3-types-of-education/> Accessed 6 June 2023.
- Dib, C. Z. (2008). *Formal, non-formal and informal education: concepts/applicability*. 300–315. <https://doi.org/10.1063/1.37526>
- Dlimbetova, G., Zhylbaev, Z., Syrymbetova, L., & Aliyeva, A. (2016). Green skills for green economy: Case of the environmental education role in Kazakhstan's economy. *International Journal of Environmental and Science Education*, 11(8), 1735–1742. <https://doi.org/10.12973/ijese.2016.550a>
- Department of Environment (DOE). (2017). Report on Training Workshop on Good Service Practices on RAC.  
[https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwjh0aeY1q6DAXWUTWwGHTq7BQgQFnoECBcQAQ&url=https%3A%2F%2Fdoe.portal.gov.bd%2Fsites%2Fdefault%2Ffiles%2Ffiles%2Fdoe.portal.gov.bd%2Fpublications%2Fe77b70b3\\_995d\\_4183\\_bbaa\\_cfbb05722bfc%2FReport\\_Feni\\_November\\_2017%2520\(1\).pdf&usg=AOvVaw37Xx\\_DW-ESPKKzBVEDfZJn&opi=89978449](https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwjh0aeY1q6DAXWUTWwGHTq7BQgQFnoECBcQAQ&url=https%3A%2F%2Fdoe.portal.gov.bd%2Fsites%2Fdefault%2Ffiles%2Ffiles%2Fdoe.portal.gov.bd%2Fpublications%2Fe77b70b3_995d_4183_bbaa_cfbb05722bfc%2FReport_Feni_November_2017%2520(1).pdf&usg=AOvVaw37Xx_DW-ESPKKzBVEDfZJn&opi=89978449). Accessed 27 Dec 2023
- Halik Bassah, N. S., & Mohd Asri Mohd Noor. (2023). Employability Skills Needed for TVET Graduates in Malaysia: Perspective of Industry Expert. *Online Journal for*



- TVET Practitioners*, 8(1), 52–59. Retrieved from <https://publisher.uthm.edu.my/ojs/index.php/oj-tp/article/view/12178>
- Haolader, F. A. and Khan, S. H. (2022). Case Study: Bangladesh. The Demand Side of Environmental Sustainability Through Skills Recognition. In M. Pavlova Margarita and Singh (Ed.), *Recognizing Green Skills Through Non-formal Learning: A Comparative Study in Asia* (pp. 65–79). Springer Nature Singapore. [https://doi.org/10.1007/978-981-19-2072-1\\_4](https://doi.org/10.1007/978-981-19-2072-1_4)
- Ismail, S., Suhairom, N., Musta'mal, A., Saud, M., Kamin, Y., & Noordin, M. (2022). *Case Study: Malaysia. Recognising Green Skills in Non-formal Learning Settings* (pp. 167–188). [https://doi.org/10.1007/978-981-19-2072-1\\_9](https://doi.org/10.1007/978-981-19-2072-1_9)
- Itohan Oviawe, J. (2017). Bridging Skill Gap to Meet Technical, Vocational Education and Training School-Workplace Collaboration in the 21<sup>st</sup> Century. *International Journal of Vocational Education and Training Research*, 3(1), 7. <https://doi.org/10.11648/j.ijvetr.20170301.12>
- Joke M. Voogt, Jules M. Pieters & Adam Handelzalts (2016) Teacher collaboration in curriculum design teams: effects, mechanisms, and conditions, *Educational Research and Evaluation*, 22:3-4, 121-140, DOI: [10.1080/13803611.2016.1247725](https://doi.org/10.1080/13803611.2016.1247725)
- Johnson, B., & Garcia, M. (2022). "Green Technologies and Workplace Safety: A Comprehensive Analysis." *Environmental and Occupational Health Review*, 8(2), 87-104.
- Jr, M., & Ermac, E. (2019). *Skills Gap Identification of RAC TVET-Based Curriculum among Practitioners: Enhanced Module*. 3, pp.1128-1132. <https://doi.org/10.31142/ijtsrd29224>
- Kamis, A., Mustapha, R., Wahab, N. A., Limuna, B., & Ismail, H. (2016). Green skills Work Environment View project Professional development needs of interim teachers in Malaysian vocational colleges View project Green Skills as an Added-Value Element in Producing Competent Students. In *Journal of Engineering Research and Application www.ijera.com* (Vol. 6). [www.ijera.com](http://www.ijera.com)
- Malabago, Nolasco & Ermac, Eugenio. (2015). REFRIGERATION AND AIR CONDITIONING (RAC) TECHNOLOGY: UNRAVELLING ITS STATUS AT WORK. *European Scientific Journal* October 2015 edition vol.11, No.29 ISSN: 1857 – 7881 (Print) e - ISSN 1857- 7431
- Miles, M. B., Huberman, A. M. and Saldana, J. (2014) *Qualitative data analysis: A methods sourcebook* (3<sup>rd</sup> ed.). Thousand Oaks, CA: Sage.

- Miles, M. B., Huberman, A. M. and Saldaña, J. (1994) *Qualitative Data Analysis*.
- Misko, J. (2008). *Combining Formal, Non-Formal and Informal Learning for Workforce Skill Development*. National Centre for Vocational Education Research Ltd. PO Box 8288, Stational Arcade, Adelaide, SA 5000, Australia.
- Mizan, M. R. (2022). *What Is Curriculum? Definition and Importance of Curriculum*. <https://www.mizanurrmizan.info/what-is-curriculum-definition-and-importance-of-curriculum/>
- Muya Maina, T. (2016). Curriculum Content Relevancy in Integration of ICTs in Kenya TVET Institutions in Readiness to Industry Needs. *International Journal of Secondary Education*, 4(6), 58. <https://doi.org/10.11648/j.ijsedu.20160406.11>
- New-Air. (2022). *The Benefits of Servicing Your Air Conditioning Regularly - New-Air*. New-Air (Southern) Ltd, the UK. <https://www.newair.co.uk/benefits-servicing-air-conditioning-regularly/> Accessed
- Pavlova, M. (2018). Fostering inclusive, sustainable economic growth and "green" skills development in learning cities through partnerships. *International Review of Education*, 64(3). <https://doi.org/10.1007/s11159-018-9718-x>
- Pavlova, M. (2022). *Introduction: Unpacking Greening and Skills Recognition in Micro, Small, and Medium Enterprises* (pp. 3–22). [https://doi.org/10.1007/978-981-19-2072-1\\_1](https://doi.org/10.1007/978-981-19-2072-1_1)
- Poggi, F., Macchi-Tejeda, H., Leducq, D., & Bontemps, A. (2008). Refrigerant charge in refrigerating systems and strategies of charge reduction. In *International Journal of Refrigeration* (Vol. 31, Issue 3, pp. 353–370). <https://doi.org/10.1016/j.ijrefrig.2007.05.014>
- RAC Technician Job Responsibility (RAC TJR), (2023). *Air Conditioning Technician Job Description, Duties, and Responsibilities*. <https://jobdescriptionandresumeexamples.com/air-conditioning-technician-job-description-duties-and-responsibilities/> Accessed on 10 July 2023
- Raihan, A. (2014). Collaboration between TVET Institutions and Industries in Bangladesh to Enhance Employability Skills. In *International Journal of Engineering and Technical Research* (Issue 2). [www.erppublication.org](http://www.erppublication.org)
- Salleh, K. M., & Sulaiman, N. L. (2020). Reforming Technical and Vocational Education and Training (TVET) on Workplace Learning and Skills Development. *International Journal of Recent Technology and Engineering (IJRTE)*, 8(5), 2964–2967. <https://doi.org/10.35940/ijrte.E6553.018520>

- Smith, A., et al. (2023). "Towards Sustainable Manufacturing: Environmental Impact Assessment of Green Practices." *Journal of Sustainable Development*, 15(3), 123-145.
- UNEVOC, (2016). Generic Green Skills for TVET, Teaching and learning resources. <https://greenskillsresources.com/category/green-skills-for-sdgs>
- U.S. Environmental Protection Agency (EPA). (2021). Section 608 Technician Certification Exam: Type I, II, III, and Universal. <https://www.epa.gov/section608/section-608-technician-certification-exam-type-i-ii-iii-and-universal>
- Setiawan, A. (2017a). Identification of green skills acquisition in Indonesian TVET curricula. *AIP Conference Proceedings*, 1887. <https://doi.org/10.1063/1.5003557>
- Setiawan, A. (2017b). Identification of green skills acquisition in Indonesian TVET curricula. *AIP Conference Proceedings*, 1887. <https://doi.org/10.1063/1.5003557>
- Siddiky, M. R., & Uh, S. B. (2020). Linking tvet with industries in bangladesh: Need for supportive policies and an approach to tvet. *Journal of Technical Education and Training*, 12(3 Special Issue), 1–21. <https://doi.org/10.30880/jtet.2020.12.03.001>
- Teddlie, C., & Tashakkori, A. (2009). *Foundations of mixed methods research: Integrating quantitative and qualitative approaches in the social and behavioral sciences*. Sage.
- Tilak, J. B. (2001). *Building human capital in East Asia: What others can learn*. Washington: World Bank Institute.
- Training Regulation for RAC servicing (TESDA) (2022). *RAC SERVICING (DomRAC) NC II - TESDA COURSE MODULE* - <http://tesdatrainingcourses.com/rac-servicing-domrac-nc-ii.html> Accessed 17 June 2023.
- Zhao, Z. (2014). Curriculum Research. *Areas of Vocational Education Research* (pp. 189–214). Springer Berlin Heidelberg. [https://doi.org/10.1007/978-3-642-54224-4\\_10](https://doi.org/10.1007/978-3-642-54224-4_10)

**APPENDIX - A**

**Questionnaire**

Dear Respondents,

I am conducting a research study with the title "*Environment-Friendly (Green) and Safety Practices, and Skills Supply and Demand Gap in Refrigeration and Air-Conditioning Servicing Sector*", as part of my study for MSc in Technical Education degree. For this purpose, a survey questionnaire has been developed. It would be very much helpful if you could kindly take the time to fill in this questionnaire. Your input is valuable to me. You will remain anonymous and all the information will be treated confidentially. Therefore, you may feel free to provide all necessary information to the best of your knowledge and experience.

**Questionnaire**

**Part A**

**I. General information**

1. Name of respondent and position (e.g. Manager/ Technicians / Service Expert / Others):  
.....
2. Name and address of enterprise: .....  
.....
3. Nature of the enterprise: Formal sector                       Informal sector
4. Number of employees: .....
5. Educational levels of employees:

Educational Level	Number of Employees at this level (a)	Educational Level	Number of Employees at this level (b)	Total (a+b)
MSc Engineering		BSc Engineering		
BA/ BSc or Higher Education		Diploma in Engineering		
Higher Secondary Certificate (HSC)		HSC (Vocational)		
Secondary school certificate (SSC)		SSC (Vocational)		
Below secondary school certificate		Trade Course		

Part-B

**II. Occupational competences (Job responsibilities/ duties and tasks) required for RAC servicing technicians, (use extra page if required):**

Categories	SL	Duties and tasks of a RAC servicing technician	Yes	No
Domain specific competencies	a	Install, inspect, maintain, and repair refrigerators, fridges.		
	b	Install new air-conditioning systems and equipment.		
	c	Install, replace, or repair equipment that has been damaged.		
	d	Carry out maintenance checks on heating, ventilation, and air conditioning systems; clean evaporator drain pans, coils, and filters; lubricate fan and motor bearings; compressors, thermostats, fans, floating elements, and defrost timers etc.		
	e	Carry out repair and routine maintenance duties on equipment, building facilities and offices, building systems, grounds, and cooling units.		
	f	Diagnose electrical and mechanical defects and malfunctions.		
	g	Perform inspection, maintenance, repairs, and installation of air conditioning systems, building control and pneumatic systems, cooling systems, refrigerators, ice machines, refrigerated water coolers, and similar equipment		
	h	Make sure the adjustment and calibration of thermostatic controls.		
	i	Ventilate equipment and controls making sure they operate efficiently and continuously.		
	j	Clean blowers and coils, check tensions of belts and motors.		
	k	Place airflow controls to occupants' preference by adjusting dampers, splitter, diffusers, and fans speeds; take away, clean, and change filters and strainer; the remake, repair, and paint metal and wood cooling fans and towers; add the right amount of chemicals to water towers to prevent corrosion and rust		
	l	Run equipment operation, and read instruments and gauges, including Volt-ohm meters; find out temperature gauges and adjust mechanisms, including valves, pumps, and controls to direct levels of fluid, temperature, and pressure; charge with specified types and amounts of refrigerant, and bleed contaminants from systems; inspect gauges and carry out periodic preventive maintenance checks		
	m	Take away pumps and motors, change bearings and shafts, repacks and perform reinstallations; perform an adjustment on expansion valves; change, fix, and re-calibrate humidistats and thermostats, change hinges, gaskets, and hardware		
	n	Inspect and maintain refrigerators and ice machines, and chilled water supply systems.		
	o	Make plans and designs of new air-conditioning systems including their installation and maintenance.		

	p	Perform repairs or adjustments on piping, connections, valves, couplings and fitting, by riveting, bolting, welding, brazing, and soldering by applying hand tools, drill press, Presto lite torch, and acetylene torch		
	q	Carry out minor masonry, painting, and carpentry work		
	r	Carry out minor electrical maintenance work, such as repair or replacement of fixtures, including wall switches and outlets, fluorescent tubes and bulbs, fuses, sockets, etc., by applying the right tools		
	s	Carry out minor plumbing maintenance work, including change or repair of leaks in faucets and drains, trenching and laying of new lines, unclogging of drains, etc.		
Self / Human competencies / Social Competencies	t	Coordinate efforts with the company's contracted HVAC vendors to ensure company HVAC systems are functioning perfectly		
	u	Provide assistance to supervisor in planning new installation and modification projects, preparation of specification, and major reconditioning and overhauling projects, applying knowledge of refrigerating systems, engineering specific Assistants		
	v	Provide assistance to colleagues in the department to effectively maintain, and repair equipment, buildings, and municipal properties		
	w	Provide support after work hours if required in works workshop meetings, and other company functions		
	x	Participation in the work of project teams.		
Occupational Safety or Others Competencies	y	Matching, installing and testing of fire protection		
	z	Organizing , operation and maintenance of clean job with the principles of occupational health and safety, fire protection and environmental protection		
	a	Making settlements maintenance costs and repairs.		
	b	Checking the quality of the service and repairing work		
	c	Using the computer technology		
	d	Perform related duties that may be assigned by management.		
Please, Add more which is not mentioned above				

**Part-C**

**III. Policy and Regulations**

- 6. Are employers and employees aware of environmental regulations for your industry sector?  
Yes  No
- 7. Can you name regulations and/or policies that you follow?  
.....
- 8. Who is responsible for setting these regulations and policies?  
.....
- 9. Who is responsible at your enterprise for implementing/ monitoring these policies?  
.....
- 10. How is your environmental compliance assessed and by whom?  
.....

**IV. Concept of Green skills/Environmental aspects**

Green Skills helps to reduce the negative effects of economic activities on the environment.

**11.** I would like to know how much importance is attached to the theme of green skills and environmentally friendly practice in your enterprise. Could you rate yourself on a 1-10 scale:

Rating:

0.....1.....2.....3.....4.....5.....6.....7.....8.....9.....10.....

1: We do not take these issues into consideration when we organize our practices

10: We pay close attention to green skills and environmentally friendly practices and adjust our practices accordingly

**12.** What are environmentally friendly practices at your enterprise?

- a. Positive environmental work practices and the standard required to:
  - i. follow workplace procedures to minimize environmental impacts;
  - ii. minimize and dispose of waste in an environmentally responsible way;
  - iii. use nonrenewable resources responsibly and reuse them where possible;
  - iv. record data relating to environmental risks, impacts, and management
- b. Brochures and events to disseminate environmental awareness.

13. Do you have jobs in your enterprise that deal with green practices?

- a. waste management
- b. water management
- c. energy saving

**V. Skill requirements in the enterprise**

14. What Skills/ Competences (interpreted in a broad sense) are required to sustain environmentally friendly practices in **your enterprise**? Please tick on the statement below:

**I. Cognitive competencies**

- a. environmental awareness and a willingness to learn about sustainable development;
- b. systems and risk analysis skills to assess, interpret, and understand both the need for change and the measures required;
- c. innovation skills to identify opportunities and create new strategies to respond to green challenges;

**II. Interpersonal skills and technological skills**

- d. strategic and leadership skills to enable policymakers and business executives to set the right incentives and create conditions conducive to cleaner production, cleaner transportation, etc.;
- e. Coordination of business skills to facilitate holistic and interdisciplinary approaches that encompass, economic, social, and ecological objectives;
- f. communication and negotiation skills to discuss conflicting interests in complex contexts;
- g. marketing skills to promote greener products and services
- h. networking, IT and language skills to enable participation in global markets; consulting skills to advise consumers about green solutions and to spread the use of green technologies;

**III. Intrapersonal competencies**

- i. adaptability and transferable skills to enable workers to learn and apply the new technologies and processes required to green their jobs;
- j. Entrepreneurial skills to seize the opportunities of low-carbon technologies.

**IV. Specific skills** (e.g. use of specific equipment; following specific practices; application of New technology and processes required for the new task)

.....  
.....  
.....



**VI. Workplace learning and training programs (in general)**

15. Is your enterprise supporting staff development through training staff?

Yes  No

16. What are the purposes of this training?

- a. To deal with new technologies
- b. To deal with new regulations, legislation
- c. To deal with lacking skills as we were not able to recruit the appropriate person
- d. To meet the requirements of professional development that are set by our enterprise
- e. Other

17. What are the outcomes of the training program?

- a. At the individual level (salary, motivation, etc.)
- b. At the enterprise level
- c. At the national/community levels

18. Who awards the certificate? .....

Are there any more issues you would like to add concerning the Environmental aspects of TVET and current practices in the Refrigeration and Air-conditioning service sector in Bangladesh?

---

---

---

Thank you so much for your participation.

## APPENDIX - B

Key informant interviews (KIIs) guideline.

No.	Question
1.	Could you please tell about the current size and future development of RAC servicing centres in Bangladesh?
2.	Would you please share the current working environment of RAC sector?
3.	What actions are being taken by Department of Environment (DOE) to increase environmental awareness and safety practices for RAC servicing technicians?

## APPENDIX - C

### National Technical and Vocational Qualifications Framework in Bangladesh

Source (BTEB, 2023b)

NTVQF Levels	Education Sectors			Job Classification
	Pre Vocation Education	Vocational Education	Technical Education	
NTVQF 6			Diploma in Engineering or Equivalent	Middle level Manager/ Sub Assistant Engineer
NTVQF 5		National Skill Certificate 5 (NSC 5)		High Skilled Worker/Supervisor
NTVQF 4		National Skill Certificate 4 (NSC 4)		Skilled Worker
NTVQF 3		National Skill Certificate 3 (NSC 3)		Semi-Skilled Worker
NTVQF 2		National Skill Certificate 2 (NSC 2)		Medium Skilled Worker
NTVQF 1		National Skill Certificate 1 (NSC 1)		Basic Skilled Worker
Pre-Voc 2	National Pre-Vocation Certificate in NPVC 2			Pre-Vocation Trainee
Pre-Voc 1	National Pre-Vocation Certificate in NPVC 1			Pre-Vocation Trainee

## APPENDIX - D

The Curriculum Content of Diploma in engineering specialization in RAC.  
Source (BTEB, 2022)

Category	Course Code	Course Title	Period Per Week		Credit	Total Credit
			Theory	Practical		
General Educational Requirements (GER) Arts, humanities, social sciences., etc.	25711	Bangla-I	2	-	2	43.0
	25712	English-I	2	-	2	
	25721	Bangla -II	2	-	2	
	25722	English-II	2	-	2	
	25811	Social Science	2	-	2	
	25812	Physical Education & Life skills Development	-	3	1	
	25853	Innovation & Entrepreneurship	2	-	2	
	25851	Principle of Marketing	2	-	2	
	25831	Business Communication	2	-	2	
Total of Cat GER			16	3	17.0	
Basic Engineering Requirements (BER). Natural sciences, mathematics,	25912	Physics-I	3	3	4	
	25911	Mathematics -I	3	3	4	
	25913	Chemistry	3	3	4	
	25921	Mathematics-II	3	3	4	
	25922	Physics -II	3	3	4	
	25931	Mathematics-III	3	3	4	
	25841	Accounting	2	-	2	
Total of Cat BER			20	0	26.0	
Engineering Major Requirements	27011	Basic Workshop Practice	-	3	1	
	27211	RAC Fundamental	2	3	3	
	21011	Engineering Drawing	-	6	2	

	26711	Basic Electricity	3	3	4	94
	27021	Mechanical Engineering Drawing	1	6	3	
	27031	Mechanical Engineering Materials	2	-	2	
	26211	Automobile Fundamentals	2	3	3	
	26811	Basic Electronics	2	3	3	
	27131	Engineering Thermodynamics	3	3	4	
	27231	RAC Cycles & Components	2	3	3	
	27012	Machine Shop Practice I	1	6	3	
	27041	Engineering Mechanics	2	3	3	
	27241	Circuits and Electrical Machine in RAC	2	3	3	
	27242	Transport RAC	2	3	3	
	27043	Metallurgy	2	3	3	
	27051	Fluid Mechanics & Machineries	3	3	4	
	27052	Mechanical Estimating & Costing	2	3	3	
	27251	Heating Ventilation & Air Conditioning	2	3	3	
	27252	Commercial & Industrial RAC	2	3	3	
	25852	Industrial Management	2	-	2	
	27055	Manufacturing Process	3	-	3	
	27061	Strength of Materials	3	3	4	

	27065	Plant Engineering & Maintenance	2	3	3	
	27261	Cooling & Heating Load Calculation	3	3	4	
	27262	RAC Plant Installation Maintenance & Operation	2	3	3	
	27075	Production Planning & Control	3	-	3	
	27271	RAC System Analysis	2	3	3	
	27272	RAC Project	-	6	2	
	27273	Advance RAC	3	3	4	
	27274	RAC for Food Preservation	2	3	3	
	29231	Mechatronics & PLC	3	3	4	
Total of cat EMR			63	93	94	
Environment, health and safety (EHS)	29042	Environmental Studies	2	3	3	
Computer (Digital literacy)/ ICT	28511	Computer Office Application	-	6	2	11
	28567	Programming in C	2	3	3	
	27063	CAD & CAM	1	6	3	
Total of Cat ICT			3	15	8	
Industry Exp.	27081	Industrial Attachment	-	24	8	12
		Project Presentation	-	12	4	
Total of Cat Industry Exp.			-	36	12	
Total						160.0

## APPENDIX - E

The Curriculum Content of National Skills Certificates (BNQF Level -1 to 4, with specialization in RAC. Source (BTEB, 2023b)

SL	CONTENT	NTVQF LEVEL	NOMINAL HOURS
1	Perform Gas Welding , Brazing and soldering	1	30
2	Repair and maintain compressors	1	30
3	Service and repair refrigerators & Deep Freezers	1	50
4	Service and repair window and Split Type Air conditioners	1	50
5	Install window and split type air conditioners	1	60
6	Service and maintain Ice cream maker	2	40
7	Repair and maintain flakers ice maker	2	40
8	Repair and maintain soft drink cooler	2	30
9	Repair and service display units & bottle coolers	2	30
10	Service and Install Display Freezer Units	2	30
11	Repair and maintain humidifier and de-humidifier	2	30
12	Service and Maintain water cooler	3	20
13	Service and Maintain Mobile Refrigeration plant	3	70
14	Operate and maintain Water chiller unit	3	50
15	Perform Refrigerant Recovery, Recycling and Retrofitting	3	30
16	Repair and Install prefabricated Cold Rooms / Freezer Rooms	3	80
17	Prepare estimate for repair, installations and maintenance of Refrigeration and Air conditioning systems	3	20
18	Service and maintain automobile air conditioner	4	90
19	Service and Maintain package type air conditioner	4	60
20	Service and maintain Cassette Type Air Conditioner	4	30
21	Service and maintain Air Handling Unit (AHU)	4	40
22	Fabricate and install ducting and piping	4	80

## APPENDIX - F

The Curriculum content of Basic Trade Course (360 Hours) with specialization in RAC  
(Theory) (BTEB, 2023)

Unit of Competency	SL	Theoretical	Nominal Duration in Hour
1.Refrigeration and Air conditioning (RAC)	1.1	Introduce and define Refrigeration and Air-conditioning (RAC). Explain the importance and use of RAC equipment.	1
	1.2		
2. Occupational health and safety	2.1	Define, Classify and explain Occupational health and safety List of First aids box	1
	2.2		
3. Measurement	3.1	State Definition and unit of length, area, volume, mass, weight, thickness, and diameter. Relate among liter, cubic feet (cft.), and cubic meter. Define and relate among power, horsepower, watt	2
	3.2		
	3.3		
4. Heat and Temperature	4.1	Express Definition, effect, and units of heat. Define and state units of temperature Express Freezing and boiling temperature of water and Melting temperature of Ice	3
	4.2		
	4.3		
	4.4	Converse different Units of heat and Converse other Units of Temperature.	
5. Force and Pressure	5.1	State Definition and unit of force Express Definition and unit of pressure Converse Unit of pressure (viz P.S.I., Kg/cm <sup>2</sup> , Kpa, Bar)	1
	5.2		
	5.3		
6. Tools and Equipment	6.1	List standard hand tools, measuring tools, and special tools used in RAC. Mention Equipment used in RAC.	1
	6.2		
7. Copper tube	7.1	Express the Necessity and type of copper tube used in RAC works	1
8. Refrigeration Fittings	8.1	State Function and specify Refrigeration Fittings	1
9. Tubing	9.1	Define Measuring, Marking, Cutting, Reaming, Bending, Flaring, And Swaging.	1
	9.2		
		State Necessity of temporary and permanent joint	



10. Soldering, Brazing & Welding	10.1	State Necessity of Soldering, Brazing & Welding.	1
	10.2	Identify materials required for Soldering, Brazing & Welding.	
11. Basic Electricity	11.1	Define and state unit of Electricity, Current, Voltage and	2
	11.2	Resistance	
		Explain Conductor, semi-conductor, Non-conductor	
11.3	Explain Ohm's law and Electrical power		
12. Electrical circuits	12.1	Define and classify Electrical circuits	1
	12.2	Differentiate between Series and Parallel circuit	
	13.1	Define, state function, and classify Motor	
13. Motor in RAC	13.2	Discuss the Construction and operation of Split phase motor	3
	13.3	Explain Capacity and mention the application of the engine used in RAC.	
	13.4	Express Causes of overload of motor	
14. Electrical Components and Accessories	14.1	State Function and Use of Thermostat, Relay, OLP, Capacitor, Timer, Thermal fuse, defrost heater, Defrost Thermostat, Cooling fan, Door switch, Cabinet lamp, Selector switch, solenoid valve, Magnetic contactors etc.	3
	15.1	Mention the Refrigeration methods Discuss the Working principle of Vapor compression refrigeration system	
15. Refrigeration System	15.2	Express the Function of each component of	3
	15.3	Vapor compression refrigeration system	
	15.4	Explain the Capacity of the Refrigeration system (BTU/Hr, TR, Watt)	
	16.1	State Function and classify of Compressor used in RAC.	
16. Compressor	16.2	List the parts of hermetic Compressor	2
	16.3	Explain the Performance and Capacity of Hermetic Compressor	
17. Compressor Oil	17.1	Express Function, properties and mention grade number of Compressor Oil	2 1
18. Condenser	18.1	State Function and classify of Condenser	
19. Refrigerant flow Control device.	19.1	State Function and classify refrigerant flow control device	2
		Explain the Function and advantage of Capillary Tube	
	19.2	List Common sizes of Capillary Tube	
	19.3	State Function and Use Thermostatic expansion Valve and Orifice	
	19.4	Type flow controller	

20. Evaporator	20.1	State Function and classify with Use of Evaporator	1
21. Accessories	21.1	State Function, Construction and Use of Strainer, Drier and Accumulator	1
	22.1	Define, Classify and express properties of ideal Refrigerants (CFC, HCFC, HFC, HC and other environmentally friendly Refrigerant).	
22. Refrigerants	22.2	Explain Store and Transfer of Refrigerants	4
	22.3	Mention Type of Refrigerant's Cylinders and Cylinder color.	
	22.3	Explain effect of CFC & HCFCS	
	22.4	Mention good service practices in handling refrigerant.	
23. Defrosting	23.1	Define and Classify Defrosting	1
24. Leak Test	24.1	Explain Causes of leak in Refrigeration system	2
	24.2	Discuss appropriate methods of leak test	
25. Flushing	25.1	Mention necessity of Flushing	1
	25.2	Explain appropriate methods of flushing	
26. Evacuation	26.1	Explain Necessity of Evacuation	1
	26.2	Express appropriate methods of Evacuation	
27. Purging and Charging	27.1	Define and explain the method of Purging.	3
	27.2	Define and explain methods of Charging (domestic Refrigerator- freezer, Deep fridge, Window type AC and Split type AC.) Explain the symptom of proper refrigerant Charging.	
	27.3		
28. Domestic Refrigerator-freezer	28.1	Draw a refrigeration cycle of a domestic Refrigerator-freezer.	4
	28.2	Describe the working principle of a refrigeration cycle.	
	28.3	Mention the Electrical Components of the domestic Refrigerator- freezer.	
	28.4	State the function of each component	
	28.5	Mention the good service practices to be performed in handling, and repairing domestic refrigerator-freezer	
	28.6	Mention the safety and good practices to be done during installation and repair.	
29. Window type AC	29.1	Sketch a refrigeration cycle of Window type AC and show the Airflow cycles	3
	29.2	Mention the name and function of Electrical Components of Window type AC	
	29.3	Draw the electrical circuit of Window-type AC.	
30. Split type AC.	30.1	Draw a refrigeration cycle of Split type Ac.	

	30.2	State the function of each component of Split type AC.	4
	30.3	Draw the electrical circuit and explain the function of each component of Split type AC component of Split type AC.	
31. Trouble Shooting	31.1	State Causes and remedies of common troubles viz: Leakage, Failure of Compressor's pumping, Burnt out electrical motor, Short cycling of Compressor, Motor runs continuously, Less and no cooling, Excessive heating of Compressor, Abnormal sound from compressor, Motor dose not start etc.	3

## APPENDIX - G

The Curriculum content Basic Trade Course (360 Hours) - with specialization in RAC  
(Practical) (BTEB, 2023)

Unit of Competency	SL	Practical	Nominal Duration
1 1. Tools- Equipment and Materials	1	Identify common hand tools, common measuring tools and special hand tools, special measuring tools, and Equipment required to install, repair, and service the refrigerators, freezers, window AC, and split type AC.	4
	2	Identify tools and equipment used in RAC works Materials used in the RAC workshop	2
2. Pressure	3	Read the pressure units marked on the dial of the Compound and High-pressure Gauges.	2
	4	Perform evacuation with dual gauge manifold.	2
3. Copper tube	5	Select different sizes of copper tubes for different use	2
	6	Practice measurement and marking of copper tube	2
4. Refrigeration Fittings	7	Identify copper and brass fittings used in RAC works	2
5. Tubing	8	Practice Cutting, Reaming, Bending, Flaring, Swaging copper tube	4
	9	Make copper tube dimensional bend with a particular measurement	4
6. Soldering, Brazing & Welding	10	Select materials required for Soldering, Brazing, Welding	2
	11	Practice Soldering, Brazing, and welding by Oxy-acetylene set	3
	12	Braze with single-cylinder butane/ Propane or other suitable Flammable gas	2
	13	Make a copper tubing work having flaring, bending (1800), swaging, and flaring connection with brass Union and brass "T" for performing a leak test	4
	14	Make and install a charging line / Process tube with a hermetic compressor motor.	3
7. Basic Electricity	15	Verify Ohm's law with variable resistance	4
	16	Measure Current, Voltage, total Resistance of Series and Parallel ckt.	3
	17	Check resistance of burnt-out and grounded Hermetic Compressor motor	2

	18	Check the Current coil, potential, and PTC relay	2
	19	Test / Check Timers, Heaters, Thermal fuse, defrost thermostat and Door switch.	4
	20	Test / Check Thermostats of Refrigerators, Freezers, and type Window AC.	3
8. Electrical Circuits	21	Make Series and Parallel circuits and measure Voltage, Current and Resistances	4
9. Electrical Components and Accessories	22	Test/ Check Electronic Thermostat used in window type AC and Split type AC.	3
	23	Test or Check OLP and Capacitors,	3
10. Operation of Compressor Motor	24	Identify the compressor terminal and Start the Compressor motor without relay and capacitor	5
	25	Operate a hermetic compressor motor using a current coil relay and PTC relay separately and compare starting and running current	3
	26	Start the Compressor motor (125—160 watts) with the PTC relay and run the capacitor of 3 or 3.5 mfd.	3
	27	Start hermetic Compressor motor (150—170 watts) with current coil relay and relay with start capacitor of 40--70 mfd. and record the starting and running current.	3
11. Refrigeration System	28	Identify components of the Vapor compression refrigeration system	2
	29	Observe Pressure- Temperature with respective instruments of running refrigeration unit.	3
	30	Test Compressor motor of a Refrigerator-freezer.	2
12. Compressor	31	Remove Hermetic compressor motor from domestic unit (Refrigerator-freezer).	3
	32	Cut the dome of hermetic Compressor and disassemble all the parts of the Compressor	6
	33	Install a newly hermetic compressor motor in domestic Refrigerator-freezer.	3
	34	Test performance and capacity (watt) of hermetic Compressor	4
13. Compressor Oil	35	Charge appropriate compressor oil into a compressor motor.	4
14. Refrigerants	36	Identify Refrigerants in different cylinders like R22, R134a, R600a, R410A R290, R32, etc	3
15. Leak	37	Perform leak test of refrigeration unit using dry Nitrogen with two stage regulator	4

## APPENDIX – H

**Observation schedule: RAC servicing centers environmental practices.**

**Researcher Name:** Md. Naem Hossain

**Date of Observation:**

**Location:** RAC Servicing Center

**Observation Period:** 60 minutes

**Objective:** To assess environmental practices and procedures at RAC servicing centers.

<b>Observation Point:</b>	<b>Observation Criteria</b>	<b>Findings</b>
1. Environmental Regulation Compliance	- Are RAC servicing centers following any environmental regulations?	
	- Are there visible signs of adherence to environmental guidelines or standards?	
2. Environmental Awareness Efforts	- Do RAC servicing centers record environmental risk information?	
	- How do they disseminate environmental awareness?	
	- Do they use brochures, events, or other means for this purpose?	
3. Availability of Refrigerant Recovery Machine	- Is there a refrigerant recovery machine available at the servicing center?	
	- If available, is it being used during servicing operations?	
4. Handling of Refrigerant During Operations	- During servicing and maintenance, is refrigerant recovered or released into the atmosphere?	
	- Observe the actions of technicians and personnel regarding refrigerant handling.	

**Overall observations and comments:**

.....

.....

.....