Developing a Competency Model for Hong Kong Energy Engineers in Transition: A Mixed Methods Study

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Abstract

On the 13th of November 2021, the 26th United Nations Climate Change Conference concluded in Glasgow, United Kingdom, with representatives from nearly 200 countries promising further actions to limit global temperature rise to 1.5 degrees Celsius. Renewable energy has taken the place of traditional fossil fuels in the fight against global warming. World leaders have pledged to take actions in this regard, with President Biden of the United States promising to reduce greenhouse gas emissions by half by 2030 and President Xi of China committing to achieve peak carbon emissions before 2030 and carbon neutrality by 2060. This national policy posed significant challenges to the energy sector of Hong Kong, a Chinese special administrative region. In the context of the global energy transition, this study aims to develop a competency model for Hong Kong energy engineers to utilize in preparing for the challenges and opportunities ahead.

The study applied an explanatory sequential mixed methods approach, with quantitative research followed by qualitative research. In the quantitative phase, snowball sampling was employed to recruit 57 energy engineering practitioners to complete a questionnaire survey regarding their perceived competencies. Nineteen survey respondents were invited to participate in a qualitative phase to elaborate on their perceptions through online individual semi-structured interviewing.

By integrating quantitative and qualitative data, the outcome of this study is a competency model for Hong Kong energy engineers, reflecting the essential competencies to deal with the energy transition. The model comprises 24 competencies categorized into four layers: engineering and academic knowledge, professional abilities and skills, key qualities, and morality and ethics.

The competency model is valuable in a variety of ways: energy engineering professionals can use it as a guide for continuing professional development; energy enterprises can use it as a standard for hiring, training, and promoting; and tertiary education institutions can use it as a reference for developing competency-based curricula for "energy engineers-to-be."

Acknowledgments

Like Sahara Marathon, a doctoral study is a journey that is arduous but rewarding, and it is fraught with summits and troughs. In my case, it is impossible to finish my long research voyage without heaven's arrangement and many people's guidance and support. I want to express my sincere thankfulness to all of them.

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Chapter 1: Introduction

Overview

The United States re-joined the Paris Agreement on climate change (US Department of State, 2021), and the Chinese government committed to achieving carbon neutrality by 2060 (BBC, 22 September 2020). These commitments from two of the largest economies in the world (World Bank, 2020) have caused the energy transition issue to move centre stage. The world is moving away from a fossil fuel-based energy system towards a renewable energy system to minimize greenhouse gas (GHG) emissions and mitigate the worst effects of climate change. This shift has tremendously impacted the world, especially the energy sector. Currently, the energy sector is the leading emitter of GHG, accounting for two-thirds of global emissions (Intergovernmental Panel on Climate Change, 2020). Hence, the energy sector must rapidly decrease GHG emissions and achieve zero emissions by 2050 (International Energy Agency, 2021).

Hong Kong is a special administrative region of Mainland China; the Chinese national carbon neutrality policy also influences the energy sector in Hong Kong (Hong Kong SAR Government, 2017). Hence, Hong Kong's energy sector has to undergo a substantial transformation, such as expanding the renewable energy portion in power generation, promoting changes in power consumption patterns and lifestyle choices, and developing the infrastructure for renewable energy. These transformations include technological, economic, social, and cultural issues (Hong Kong SAR Government, 2017). Engineers in the Hong Kong energy sector must learn new competencies to cope with the energy transition; they will need a new set of knowledge, skills, and abilities to handle the issues related to renewable energy.

The overall purpose of this study is to develop a competency model appropriate for Hong Kong energy engineers to deal with the challenges of the energy transition. I undertook this research as I perceive the challenges and opportunities facing the Hong Kong energy industry resulting from the emerging consumer expectation, global environmental and climate awareness, and the energy transition.

Context of the Research

This first chapter outlines the research context, which covers my background; I explain some of the choices that were instrumental to pursuing my career in this field. These choices also influence who I am and my motivations for this study. I then explore the background of Hong Kong and its energy sector, the opportunities and challenges faced by the Hong Kong energy industry, and the story behind this research. This chapter also addresses the study's rationale and concludes with this thesis's organisation.

My Background

I have worked in the information and communication technology (ICT) industry for more than 30 years. I was the founder and principal consultant of a Hong Kong corporate consultancy firm that provided integrated technology and business solutions in the Greater China region. I was also an adjunct ICT lecturer and corporate mentor at Hong Kong and Mainland China universities. Through the University of Hong Kong School of Professional and Continuing Education (HKU SPACE), I was a corporate trainer for Hong Kong's largest power company, China Light and Power (CLP).

In the 1960s, my parents were mainland Chinese immigrants from Guangdong province who worked in the same small factory. Hong Kong was not prosperous at the time, and people had to work very hard to earn a living. A room of less than 200 square feet was standard for a family of four or five. I was the first son of a working-class Hong Kong family, and my brother was born seventeen months after me. My first impression of him was his crying during the frequent power blackouts.

In my early teens, I liked building motorized model aeroplanes, tanks, and boats. My parents took us to Victoria Park, Hong Kong's largest park, almost every weekend to play with my models. When I was 15, I grew tired of building models and bought some DIY electronic kits, an AM/FM radio, an LED lottery turntable, a transistor amplifier with speakers, etc. The satisfaction this hobby provided hooked me. At 18, I partnered with classmates to pass the City and Guilds' Radio Amateur Examination and obtained my radio licence. We all became addicted to communicating via amateur radio (‘ham’ radio), and we loved those times. These experiences inspired me to become an electrical engineer.

Electrical engineering was my preferred major when I applied to universities. Since my physics score was low, the electrical engineering department rejected my application, but the mathematics department accepted me. Despite not obtaining an electrical engineering offer, I did not give up on becoming an engineer. Computer science and statistics were my minors because I thought they could help me become a software engineer.

During my first two university summer breaks, I worked as a part-time technician trainee at a computer manufacturing firm. My summer job during my third summer break was the most memorable. In the 12 weeks at IBM, I experienced a lot about IT projects by observing and learning from my colleagues. I also learned that a work team at IBM included many talents, such as technical consultants, programmers, project managers, and sales representatives. Each team member had to coordinate with the others to finish a project. Every member was irreplaceable because they all had strong and unique competencies, constituting each team member's competency profile.

A fashion manufacturer offered me my first IT job after graduation. A year later, I resigned and took a computer programming job at my alma mater. Within six months, I realized there was a stark contrast between my two workplaces, which sparked my interest in competencies. After working for a few years, I lacked the business knowledge to complete the jobs successfully and started a part-time MBA to upgrade myself. The MBA programme broadened my vision, enriched my business knowledge, especially in human competencies, and triggered my research interests. Before graduating, I attended a seminar on contingency planning. The speaker told us that unexpected incidents could happen at anytime during a project, so managers must prepare several solutions in advance through scenario planning, especially in engineering projects. I agreed with him but did not realize that I should also have prepared a contingency plan for my career.

Hong Kong's return to China in 1997 represented another career crossroads for me. A friend asked me to help him expand the telecom markets in China, Hong Kong, and Taiwan. This idea made sense to me because China's economy was accelerating then, but I had to resign from my stable university job. The decision was difficult at the time, as my steady job offered me a comfort zone to develop myself and provided a secure income for my family. After careful consideration, I resigned in September 1997.

I faced enormous challenges after switching my career path. After a year, I could manage my job well but was unhappy with my team's performance. My team members reported that my instructions were unclear and caused confusion. It revealed my communication and expression weaknesses, representing another kind of competency. I accepted a part-time tutoring position at the Open University of Hong Kong (OUHK) to improve my communication and training skills. It could have been God’s will, and I was fortunate to meet my life-changing mentor at OUHK. Through his inspiration, I learned the value of education and the joy of teaching. I followed my mentor to the HKU SPACE when he left OUHK. Due to his considerate arrangement, I taught working adults, full-time students, and undergraduate and postgraduate students, which required different skills. In 2011, he assigned me to develop and present corporate training for CLP, the largest power company in Hong Kong.

The Story Behind My Research

The summer of 2014 brought a Saturday that I will never forget: My colleagues and I worked nonstop to finish two significant project proposals for my company by noon. After a quick lunch, I rushed to CLP's headquarters to judge the final project presentations. All the presenters were CLP engineers who had participated in a one-year part-time corporate training program, Dynamic Development Programme (DDP), developed by CLP and HKU SPACE. I have been a trainer and a curriculum developer of this programme for three years.

My position in this programme was ambiguous: I worked for HKU SPACE, collaborated with CLP staff members to develop the DDP curriculum, and taught two DDP courses. I was not a CLP employee but facilitated class discussions using CLP internal case scenarios. The trainees were also confused initially; they thought my position was between an insider and an outsider at CLP. Some trainees gradually shared their difficulties and job satisfaction with me after months of studying, observing, and trusting each other. Our trust also affected me because sometimes I treated myself as a CLP employee, which caused me confusion. When I needed to express my academic stance, I positioned myself as an outsider to maintain neutrality. Over three years, I became used to shifting between these two positions, and I noticed that my shifting role also confused the trainees.

The DDP curriculum covered technical know-how, project management techniques, regulatory compliance, and soft skills such as stakeholder management, systems thinking, and change management. The training aimed to equip the trainees with modern skills and nurture them to become CLP leaders. Hence, employees at the engineering level and above were targeted. The trainees were asked to study a job-related topic to integrate knowledge from different subjects. At the end of the programme, each trainee had to submit a written report and present their findings.

Except for the second-to-last presenter, most presenters' topic selection, research efforts, and presentation styles were average. The second-to-last presenter was a senior engineer in the planning office who spoke about disaster precautions using the Northeast blackout of 2003 as a case study. His presentation was outstanding and made me think deeply. He introduced the 14^{th} August 2003 blackout that affected the northeastern and midwestern parts of the US and Ontario in Canada. Ten million Ontario residents and 45 million US in eight states were affected. At the time, it was the second-greatest power outage of all time. The presenter shared some citizens' responses and feelings. This blackout had a significant and profound impact on many essential services: Backup generator systems failed; telephone networks were interrupted; major cellular networks lost service; cable television systems were disabled; all trains running into and out of New York City, Toronto, and Montreal were shut down; flights at regional airports were cancelled; gas stations, supermarkets, and banks, food dealers, and drug stores were unable to operate. The presenter noted that the US Department of Energy had estimated the total economic loss at US$6 billion and then discussed disaster precautions for Hong Kong.

As the presenter explained his blackout case, I recalled my infant brother's crying in Hong Kong, where blackouts occurred often. However, I could not imagine such a disaster happening in the US and Canada. Had these countries taken precautions? Had they created a warning system? Hong Kong has not experienced such a disaster despite having only two small electricity suppliers. Are there any differences between the US and Hong Kong energy industries? Are these related to the industrial structure, human error, systemic flaws, or staff competencies? If the world was embarking on an energy transition, would these energy engineers in front of me be ready for such an energy transition? Which competencies could help? The applause for the presenter refocused me. He claimed in his presentation that, as an energy engineer, he must protect Hong Kong from such serious incidents. He inspired me to work with Hong Kong’s energy engineers to identify the essential competencies to cope with the energy transition and to contribute positively to Hong Kong's energy sector.

Hong Kong and its Energy Sector

Modern societies consume a lot of energy, and Hong Kong's energy sector is crucial. Hong Kong residents rarely consider how important the energy industry is; they take it for granted that they can enjoy the energy. This study focuses on Hong Kong's energy sector in the context of the global energy transition.

The 2021 Global Financial Centres Index 30 report ranks Hong Kong as the third leading financial centre (Z/Yen and the China Development Institute, 2021). Hong Kong is a vital international traffic and logistics centre with an international airport, a cruise terminal, and a container port. For historical reasons, Hong Kong is now a special administrative region (HKSAR) of Mainland China. Hong Kong is governed under the ‘one country, two systems’ framework that allows the residents some freedoms, benefits, and advantages that their mainland counterparts do not enjoy. Hong Kong is also a regional logistics and transportation hub because of the Hong Kong-Zhuhai-Macau Bridge and high-speed rail network. The above three roles of Hong Kong have made it a gateway between China and the rest of the world. Many foreign businesspeople and investors can enter Mainland China via Hong Kong, and people in China can also visit other countries via Hong Kong. In addition, the Chinese government launched the Belt and Road Initiative in 2013, which refers to the Silk Road Economic Belt and the 21st Century Maritime Silk Road. The Silk Road and the Maritime Silk Road were historic trading routes connecting China with Europe, transporting goods between the two major civilizations of China and Rome. Silk was carried west, while woods, gold, and silver were carried east in the past. This initiative aims to promote economic cooperation among the countries along the Belt and Road Initiative routes. Hong Kong could export Mainland China's products and technologies and import investment and resources into Mainland China as an international hub of finance, logistics, and transportation.

The energy sector of a city is best understood when one has a clear picture of its geographical background and the application range of its energy outputs, the sources and who controls these. As of 2016, Hong Kong’s total land area was 1,106km^2, of which only 276 km^2 (or 25%) was developed. The current population of Hong Kong is around 7.5 million, but it is one of the most densely populated cities in the world, with approximately 6,300 people per square kilometre. Hong Kong has a humid, sub-tropical type of climate with an abundant amount of rain. Summers are hot, humid, and wet, with average high temperatures of about 32°C at the peak in July. Winters are mild, as average low temperatures hardly drop below 14°C and low temperatures below ten are rare. Such information is of great importance to the energy industry.

Hong Kong’s geographical conditions define its economic characteristics. Hong Kong Island, Lantau Island, and the deep-water Victoria Harbour shape a natural geographical port in Southeast Asia. This natural advantage contributes to Hong Kong is a commercial entrepot for regional and global trade and to its superiority as one of the most important international financial hubs today. Low taxes, lax employment laws, an independent legal system, free trade, and the free flow of capital are all pillars of the economic development of Hong Kong (Economic History Association, 2008). Hong Kong's economy is closely linked to its commercial activity, dominated by financial services, trading and logistics, professional and producer services, and tourism (Hong Kong SAR Government, 2019). These four traditional vital industries in Hong Kong are the driving forces behind other sectors, such as real estate and retailing, to meet the needs of the local population (Hong Kong SAR Government, 2015).

Another characteristic of Hong Kong's economy is its large percentage of small and medium-sized enterprises (SMEs). Companies employing fewer than one hundred workers constituted more than 98% of the total enterprises in 2021. Over 340,000 SMEs employ 45% of Hong Kong's workforce in the private sector. Their vitality and business performance are of crucial importance to the development of the economy (Hong Kong SAR Government, 2021).

Energy is the life blood of economies and acts as a solid social and political force. Moe (2010) and Varigonda (2013) have claimed that the energy industry is an important sector of a country or society and contributes to a solid foundation for economic growth and social stability. The energy industry is a vast and stable industry that contributes to all of the component companies involved in the manufacturing, refining, extraction, distribution and retailing of energy products. However, as there are no energy resources in Hong Kong, the energy sector's structure is simple, and its scale is small; it mainly covers electricity, petroleum-related energy, renewable energy and their associated equipment and services.

Many kinds of energy technologies are used in Hong Kong. Fossil fuels (coal, oil, or natural gas) generate significant pollution and carbon dioxide that aggravate global warming. However, renewable energy is an infinite resource and emits minimal greenhouse gases. It is still challenging to sustain this power supply due to weather limitations. Nuclear energy could produce a large amount of power with little carbon dioxide emissions, but the public is highly concerned about its safety issues. The Hong Kong government and power companies have their views and vested interests regarding individual energy development.

However, the sustainable development of energy depends not only on the efficiency of production but also on the degree of development of different technologies. While energy technology improves energy efficiency, it also increases energy use; people's dependence on energy affects the direction of energy technology. This interaction also affects the development of society: The use of energy affects the environment, and environmental changes also affect people's perceptions of the use of energy. Therefore, the use of energy, the development of society, and the development of energy technology are interdependent and pose challenges to the balance of the ecosystem and the living environment. Sustainability has become a target for reducing the impacts of global warming, climate change, and carbon disposal (Ahuja and Tatsutani, 2009).

Countries worldwide, including China, are actively developing renewable energy sources (Climate Council, 2019). Still, the supply of various renewable energy sources (solar, wind, and water), which are strongly affected by natural factors and technological bottlenecks, is not yet stable. As the power storage technology becomes mature, excess power generated from renewable energy sources can be stored and returned to the electricity system. Increasingly, power generated from renewable energy sources gradually complements the share generated by traditional sources. Until renewable energy sources dominated power generation in most countries, petroleum and natural gas were expected to be the most critical energy source for a certain period to obtain a stable and sufficient power supply. The above conditions contribute to the creation of an energy transition period.

Rationale of the Research

The impetus for my research arose from my past 30 years of multi-disciplinary work experience as a senior IT practitioner in various industries, including the government sector, energy, banking, manufacturing, and NGOs in the Asia Pacific region, as a corporate trainer/facilitator of CLP in Hong Kong and Fortune 500 companies in the Greater China region, as a corporate mentor/adjunct lecturer at postgraduate level at some universities and institutions in Mainland China, and as a freelance researcher for various semi-government and NGO projects in Hong Kong and Macau.

The challenges now faced by corporations in Hong Kong are multi-dimensional and novel (Liu, 2017), influenced by tsunamis and the interdependency that has emerged from globalization. Challenges such as destructive innovation, natural hazards, crude oil price fluctuations, changeable consumer tastes, high staff turnovers, decreasing customer loyalty, tightened regulations, increasing taxes, etc. (International Monetary Fund, 1999; Forbes, 2013; The Balance Small Business, 2019; Wikipedia, 2020). These challenges are only the tip of the iceberg of the ever-changing business environment. According to my observations, my customers' management and staff teams ultimately overcame difficulties, which left an unforgettable impression on me. While working with them to solve their issues, I positioned myself as a researcher identifying their capabilities and analysing how these capabilities resolved the problems. Discovering the competency components of a solution is fascinating to me since I believe that the solution with the set of competencies can be utilized by other organizations dealing with similar problems.

The distinctive competencies of an organization improve its performance (Snow and Hrebiniak, 1980). Taking CLP as an example, their engineers' competencies directly determined the power supply's continuity and stability. They also impacted our society because the power supply far exceeded the deliverables; their strategic significance, humanistic significance, environmental impacts, sustainability, and even ethical factors also needed to be considered (Moe, 2010). China Light and Power is facing a transitioning environment, and capable engineers with contemporary competencies can help the company to accommodate this situation. In its daily operations, engineers of high calibre always play a vital role in the quality of its operations, especially in such a large-scale enterprise (Harrington and Williams, 2004). The engineers play an integral role within the hierarchy of an energy enterprise, and they are the communication link between the management team and the frontline staff members. So, a study on competency modelling for engineers might positively impact the organization’s overall performance.

My original plan was to invite CLP, one of the two power utilities in Hong Kong, to be the research subject and contribute their engineers' working time to this study. In return, CLP would better understand their engineers' competency model so that they could fine-tune their recruitment, training, and development strategies. However, circumstances were against me, as my old friend, a senior human resources director at CLP, retired in 2018. I realized that, without his support, it was impossible to continue this study. To carry on with the research, I considered for a long time whether it was necessary to adjust the research topic. Having worked for more than three years as a trainer and curriculum developer in CLP's corporate training programme, I was sure that I still had the passion and curiosity to explore solutions to tackle the future opportunities and challenges of Hong Kong's energy industry. After consultation with my previous supervisor, he agreed to extend my research focus from CLP to Hong Kong's energy sector.

The Purpose of the Research

Today, Hong Kong is undergoing an energy transition, which has brought about turbulence that has never before happened in our energy sector. Many options to address the challenges are available for consideration, and I believe one of these is enhancing our energy engineers' competencies. Hence, the overall purpose of my research is to develop a meaningful and practical competency model for Hong Kong energy engineering practitioners to meet the future difficulties and potentials brought about by the energy transition in Hong Kong.

To achieve a meaningful and practical competency model for this study, I define the following objectives:

1. To determine the necessary competencies to equip local energy engineers to respond to the challenges and opportunities of the Hong Kong energy sector;
2. To provide meaning to the determined competencies for energy engineers in Hong Kong; and
3. To develop a practical competency model accordingly.

Organization of the Thesis

I have used the word 'competency' many times in the preceding paragraphs, and many scholars and human resources professionals worldwide have focused significant efforts on this subject. However, the notion of 'competency' is not universal, and various people understand it differently. To make sense of my research, I believe it is critical to clarify this concept, which is discussed in the next chapter.

In Chapter 2, the knowledge landscape relevant to the study is also reviewed. In particular, I present a historical synopsis of competency concepts, theories and models, the roles and responsibilities of engineers, and the various competency models for engineers. The chapter also discusses academic sources, contemporary professional journals in engineering and competency modelling, global and regional situations in the energy industry, government regulations and policies, and future challenges and opportunities. The rest of the thesis is organized as follows.

The research methods and design employed in my study are explained in Chapter 3. This chapter investigates my positionality and the justifications for my chosen design and concludes with the ethical considerations of my preferred research methods. The study's aim and objectives are defined, and the research questions are presented. The chapter also includes a thorough literature review of research approaches and philosophical underpinnings.

The study design's structure, components, and flow are the subject of Chapter 4. It also describes the objectives, processes, and activities of the many steps followed in this study, such as the sampling process, the recruitment of participants, the data collection, and the data analysis using quantitative and qualitative research methods. The chapter also discusses the development of a questionnaire and the connection between quantitative and qualitative research.

Since my study adopts an exploratory sequential mixed methods approach, Chapter 5 describes the analyses and findings of all research phases. The first part presents and discusses the results of the quantitative analysis. The second part presents the qualitative results based on the thematic analysis of interviews conducted with 19 volunteer participants. The last part of this chapter explains the purpose of integrating the quantitative and qualitative findings using a mixed methods approach and then investigates the combined findings. It also consolidates the competencies derived from the quantitative and qualitative results.

Chapter 6 discusses the competency model for Hong Kong energy engineers, addresses the challenges and opportunities of the energy transition, comments on the study's theoretical and practical implications, evaluates the study's limitations, and makes recommendations for future research.

Chapter 7 provides an opportunity to reflect on my experience conducting this study. It concludes the thesis by highlighting the lessons I have learned during this research journey. This chapter's purpose is to reflect on what the research means to me personally and professionally.

Chapter 2: The Knowledge Landscape

Overview

Many professions, enterprises, non-profit organizations, and government departments have adopted the competency model, but it is still rare in the energy industry. Before developing a competency model for Hong Kong energy engineers, this chapter reviews a substantial body of literature related to the notion of competency, its relationship to human resources management, and applications of competency modelling. This literary review serves as the foundation for this study. The first section of this chapter discusses the concept of competency, its historical development, the difference between competency and competence, various levels of competencies, and the concept's link to strategic human resources management (SHRM). The second section focuses on the competency modelling (CM) concept, various approaches to developing CM, and applications of CM in organizations. The last section examines different engineering-related competency models, which form the basis of my survey design.

Competency Concept and its Relationship to Strategic Human Resources Management

The Definition of Competency

'Competency' is derived from the Latin word *competentia*, which literally translates as 'is authorized to judge' and 'has the right to speak' (Caupin, 2006). The term 'competency' is defined by the *Oxford Dictionary of English* as 'the ability to do something successfully or efficiently'. This definition is broad and vague and leads to many interpretations. Distinguishing between terms such as 'proficiency', 'capability', 'capacity', and 'competence' is difficult and might lead to misunderstanding and confusion (Byham and Moyer, 2000; Cooper, 2000; Mirabile, 1997). Whoever attempts to examine the concept of competency is immediately struck by the absence of consistent definitions, structures, and approaches (Cooper, 2000; Dalton, 1997).

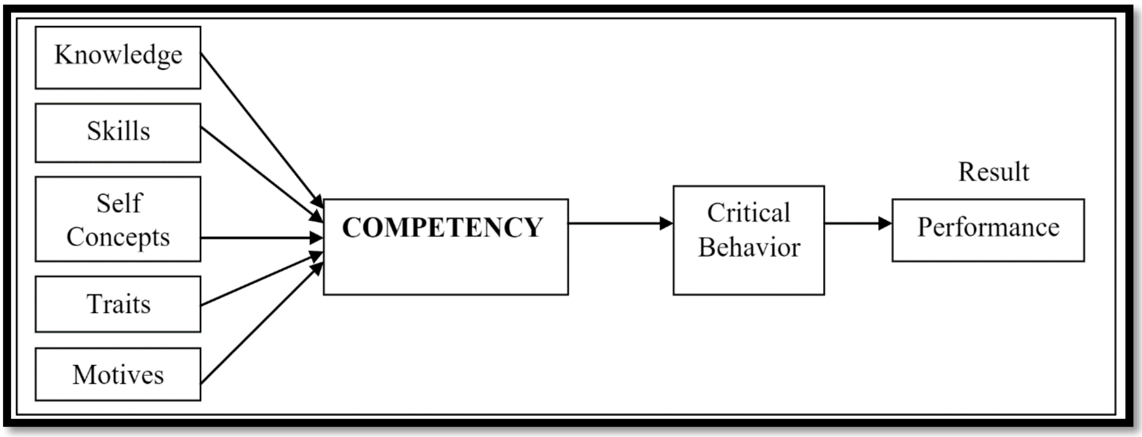
The concept of competency can be traced back to the American psychologists Robert White and David C. McClelland in the 1960s. White (1959) believed that competency is related to the individual characteristics of high job performance and strong motivation. McClelland (1973) considered that tests in intelligence and aptitude could not effectively predict performance and that other underlying factors could explain performance more appropriately. Competency was defined as personal traits or habits that led to more effective or superior job performance. In other words, competency could contribute definite economic value to the efforts that employees are paid. McBer Consulting and the American Management Association followed McClelland's (1973) steps to further define competency by applying behavioural event interviews to distinguish the underlying characteristics that distinguished high-performing and average employees (Rothwell and Lindholm, 1999). The above two psychologists' recognition of the individual attributes of high-performance employees opened the way for subsequent researchers to study the concept of competency.

The American Management Association has defined competency as knowledge, skills, self-concept, traits, and motives (Hayes, 1979). Spencer and Spencer (1993) have emphasized that competencies must be related to performance in the workplace and not what would be desirable to have. They elaborated on the five components of competency as follows:

1. Knowledge refers to an individual’s professional know-hows.
2. Skill relates to an individual's ability to perform tasks, either physically or psychologically.
3. Self-concept means to an individual’s attitude, values, and self-impression.
4. Traits are related to an individual’s physical characteristics and a continuous response to certain situations or messages.
5. Motives are referred to an individual’s continuous desire for a particular idea and how this is put into action.

Chouhan and Srivastava (2014) argued that motives and traits are the significant components motivating individuals to work without supervision, establishing employees' critical behaviours that lead to high work performance. The degree of performance is always influenced by the levels of other components – knowledge, skills, and attitude. The relationship between the competency components and employees' performance is demonstrated in Figure 2.1.

Figure 2.1: The Concept of Competency (adapted from Chouhan and Srivastava, 2014, p. 17)



However, this competency definition is not much different from the knowledge, skills, abilities (KSAs) and other characteristics emphasized by traditional business psychology (Sun, 2006). Rather than directly measuring these potential characteristics, the attributes of competency aimed at high job performance behavioural patterns are revealed by behavioural event interviews. Therefore, behavioural event interviews were regarded as a method of worker-based job analysis which determined the superior and excellent characteristics of 'high job performance' employees (Cheng et al., 2003; Iles, 1993).

The definition of competency has been a popular topic in business research, with little consensus among researchers. Since the competency concept proposed by McClelland in the 1970s, many scholars have furthered studies on competency. Klemp (1980) defined competency as an underlying characteristic of an individual which results in effective or superior performance on the job. Boyatzis (1982, 2007) gave a clear definition of competency, claiming that competency comprised certain essential traits of an individual, which were the key attributes that led to and influenced the individual's ability to perform better, more efficiently, and more effectively in the workplace. He recognized 19 potential generic management competencies that high-performance managers possessed and classified them into five clusters: goal and action management, leadership, human resource management, directing subordinates, and focusing on others. Competency could be described as a set of potential personality traits that could lead to high work performance, and these traits were developable and manageable.

Hornby and Thomas (1989) believed that competency is the ability to perform effectively the functions associated with management in a work situation. Jacobs (1989) considered competency an observable skill or ability to complete a managerial task. Hogg (1989) defined competencies as the characteristics of a manager that lead to the demonstration of skills and abilities, which result in effective performance within an occupational area. Competency also embodies the capacity to transfer skills and abilities from one profession to another. Based on Boyatzis's (1982) definition, Spencer and Spencer (1993) further defined competency as the underlying personal traits of an individual that can be used to measure and predict an individual’s job performance. Cofsky (1993) believed that, even though an individual possessed superficial characteristics such as knowledge and skills, it could not be guaranteed that such an individual could produce high job performance. Superior job performance must rely on higher competency levels, such as personality, traits, motivation, self-concept, and values. High job performance can be expected when these factors are appropriately combined in the proper context.

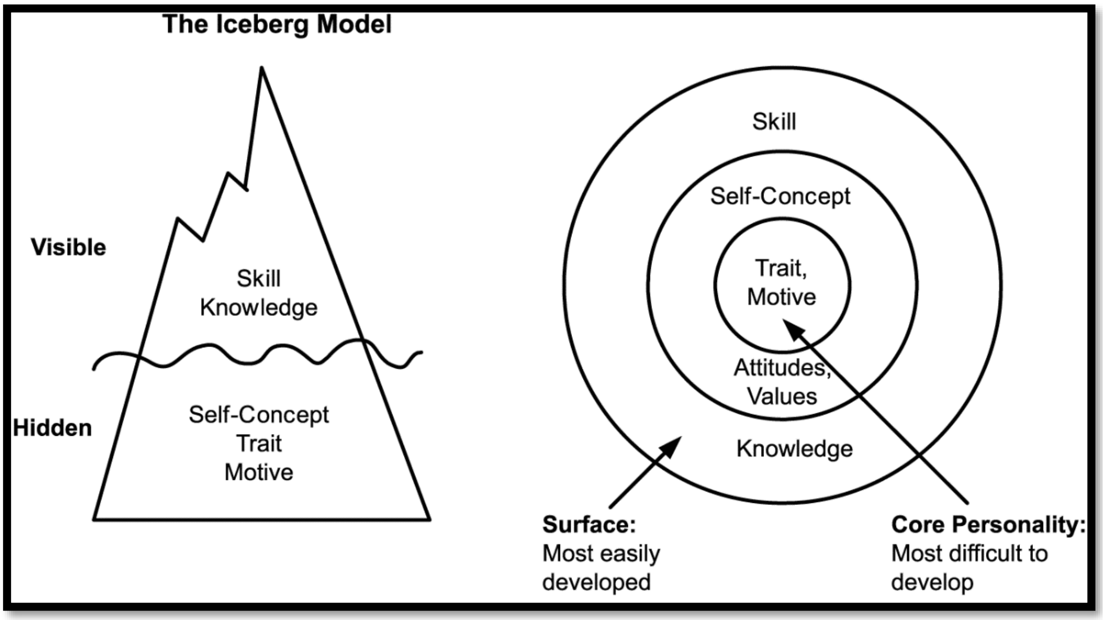
A breakthrough in the definition of competency was the focus shift from the less assessable competencies related to personal characteristics or competencies to directly observable and testable competencies, such as knowledge and skills. After reviewing 337 citations, Page and Wilson (1994) defined competency as ‘the skills, abilities, and personal characteristics required by an effective or good manager’. Gilbert (1996) defined competence as the capacity to consistently provide the excellent results necessary for the most efficient and effective achievement of the larger organizational objectives. Dubois (1998) claimed that competences were those traits – knowledge, skills, attitudes, thinking patterns, etc. – that resulted in effective performance, whether utilized alone or in diverse combinations. Evarts (1998) defined competence as an underlying trait of a manager that is causally associated with higher job performance. Parry (1998) believed that competency was a group of knowledge, attitudes and skills which affected individual job performance. Competency could be measured by an acceptable standard and improved by training and development.

Woodall and Winstanley (1998) argued that competency consists of skills, knowledge and understanding, qualities and attributes, values, beliefs and attitudes that lead to an effective managerial performance in a given context, situation, or role. Sinnott, Madison, and Pataki (2002) pointed out that competencies differed from knowledge, skills and abilities (KSAs). Competency should include KSAs and other personality characteristics. Cernuşca and Dima (2007) explained the linkage between one's performance and career development. They studied various models of competency mapping and appraisal tools for performance management and explained how these helped human resources experts choose the right employees for the right position. Rothwell et al. (2004) stated that competency efforts in the US programmes had evolved from an early focus on distinctions between best-in-class and entirely successful performers to a link between organizational strategy and organizational and individual performance.

As interest in competency-based approaches grew, training and development professionals began to use competency models to clarify organization-specific competencies to improve human performance and unify individual abilities with organizational competencies. Gaspar (2012) observed that competency-based selection was a healthy, structured, and comprehensive method for recruitment. Selected applicants had to demonstrate their competencies after an organization hired them. The competency-based evaluation assessed staff performance, diagnosed future training and development needs, and helped human resources executives assist employees in decisions such as promotions and transfers.

Highlighting the characteristics of competence, in their book *Competence at Work: Model for Superior Performance*, Spencer and Spencer (1993) proposed the iceberg competency model, illustrated in Figure 2.2. In the model, skills and knowledge are visible, while self-concept, traits, and motives based on personality are hidden. Compared with the hidden traits, the visible ones are easier to cultivate through education and training.

Figure 2.2: The Iceberg Competency Model (adapted from Spencer and Spencer, 1993, p. 11)



According to the iceberg competency model, the five competency components are divided into two types: The first type is the explicit competencies, which are prominent and positioned at the upper part of the iceberg. This part constitutes only about 20% of the entire iceberg. This part of competency components, such as knowledge and skills, can be directly observed, evaluated, and quickly improved through education and training. The second type comprises implicit competencies, which refer to the lower part of the iceberg. Competency components such as motives, traits, and self-concept are included in this part, accounting for about 80% of the iceberg. In this part, motives and traits are difficult to evaluate or improve through education and training. The self-concept, however, can be gradually adjusted through training and intensive work experience, even though it is formed by the accumulation of long-term experience (Spencer and Spencer, 1993).

The Definition of Competence

In addition to the term ‘competency’, there is also the term ‘competence’. To date, there are no clear and generally agreed definitions of these two similar terms, which has always generated a great deal of confusion in performance assessment; further clarification is needed.

The development of the term ‘competence’ started in the 1980s. Due to economic depressions in this period, structural and demographic changes in employment, markets influenced by unemployment, and the threats and opportunities of a single European market, the UK faced the challenge of a skills shortage (Barker, 1993; Confederation of British Industry, 1989; Le Deist and Winterton, 2005; Foot and Megginson, 1996). The UK government discovered a matching gap between the education system and existing workforce needs (Holmes, 1995), and the imperfections in the vocational education and training (VET) system, meaning that graduates could not successfully apply their know-how in the workplace. Therefore, to maintain the UK workforce's competitiveness, the British government launched the ‘New Training Initiative’ in 1981 to establish standards-based training for young people entering employment (De Ville, 1986). More importantly, to cope with the changes in the vocational training system, the British government introduced the competence-based approach to creating a national vocational qualifications (NVQ) system (Le Deist and Winterton, 2005).

This competence-based approach was promoted by the Management Charter Initiative (MCI) and the National Council for Vocational Qualification (NCVQ) in the UK. The MCI was a government-appointed industry lead body for management and supervisory occupations whose objective was to increase the quantity, quality, relevance, and accessibility of management education and development to improve the quality of British managers and the overall effectiveness of the country (Tate, 1995). Established in 1986, the NCVQ was an independent organization that promoted NVQ, facilitating the establishment and maintenance of NVQ for various industries in the UK (Jessup, 1991).

The NVQ was a certificate awarded by industrial and professional bodies, providing the awardee with a statement of competence (De Ville, 1986). The statement of competence described the minimum standards of action, behaviour and outcome that the employee should perform in the workplace (Cheng et al., 2003). These minimum standards were derived from a functional analysis of a particular job, including its goals, roles, tasks, and duties (Jessup, 1991). These standards generated elements of competence with corresponding performance criteria for subsequent evaluation (Iles, 1993).

Many scholars believe that functional and traditional work-oriented job analysis are identical, that a job is composed of a series of tasks, and that some performance indicators can measure each task for achievement evaluation. This view follows the task specialization concept of Taylor’s traditional scientific management theory: The settings of these performance indicators represent the optimal or minimal standards of actions, behaviours, and outcomes of the job. Therefore, the term ‘competence’ implies that the workers are expected to meet the ‘optimal or minimal standards’ of performance for each task (Cheng et al., 2003; Iles, 1993).

Iles (1993) further defined competence as the ability to perform occupational activities to meet employment standards. Unlike the behaviour model emphasized by competency, competence referred to KSAs that were functional or task-specific and measurable. When the employees’ KSAs passed the assessment, they were certified as having a particular competence.

Regarding vocational education and training, the competence system provided a preliminary understanding of tasks to be completed by job seekers in the workplace. From a human resource development point of view, the competence system provided the practitioners with the work standards to ensure they could achieve the appropriate organizational goals (Robertson, 1995). This competence-based approach also significantly affected British national education policy (Grollmann, 2008): Its theoretical foundation was built on vocational education training and human resource development (Burgoyne, 1993; Ellström, 1997; Norris, 1991).

Different Schools of Thought

Since American researchers proposed the ‘competency’ concept while British researchers proposed the ‘competence’ concept, the concepts implied different perspectives: The former was individual-oriented while the latter was job-oriented. The distinction between these concepts was commonly known as the American and British schools (Tate, 1995). Compared with the competency concept, which was a theory-oriented study based on the behavioural psychology of individuals, the competence concept mainly focused on the practical approach of the linkage between vocational education and jobs without the theoretical construction of human resource development. Hence, the role of human resource development sought to assist practitioners with the skills required to achieve vocational certification (Ellström, 1997). In other words, the individual orientation of the American school explained that competency was based on an individual’s traits. It emphasized that these traits were derived from the behavioural analysis of high-job-performance workers. Therefore, workers with these traits could achieve excellent and outstanding outcomes. By comparison, the British school's orientation focused on a job's performance requirements as the central axis (Stuart and Lindsay, 1997). Workers who fulfilled a job’s performance requirements were awarded vocational qualifications, which standardized the criteria of recommended standards for the job. These qualifications certified the workers’ performance and proved their employability.

In practice, however, ‘competency’ and ‘competence’ were used interchangeably in Western countries (Brown, 1993, 1994; Cheng et al., 2003; Le Deist and Winterton, 2005). Scholars have summarized the reasons for this as follows. First, these two terms were easily interchanged because both words were used in the workplace and were related to job performance. In addition, based on Taylor’s scientific management theory, job division and task specialization were included in job design. Kristof (1996) emphasized the match between personal abilities and job requirements; that was the individual-job fit perspective. Second, Stuart and Lindsay (1997) pointed out that individual-oriented ‘competency’ focused on input measures while job-oriented 'competence' focused on output measures. These two measures were complementary to one another. The output measures of 'competence' must be performed by individuals with the input measures of 'competency'. In other words, the capabilities of an individual could be determined by whether the individual fulfilled the job requirements. Teodorescu (2006) compared the differences between 'competency' and 'competence', as in Table 2.1.

Rowe (1995) suggested using 'competence' to denote a skill and the standard of performance while using 'competency' to refer to the behaviour by which it is achieved. In other words, 'competence' describes what people can do, and 'competency' focuses on how they do it. In this regard, Chang (2012) shared the similar idea that 'competency' emphasized implicit components (i.e., motives, traits and self-concepts), while 'competence' highlighted explicit parts (i.e., knowledge and skills) based on the concept of fitness at work.

Table 2.1: Comparison Between Competency and Competence (summarized by Teodorescu, 2006)

Competency	**Competence**
Definition	
Competency is a set of characteristics, such as knowledge, skills, mindsets, thought patterns, and the like, that when used, whether singularly or in various combinations, results in successful performance (Dubois, 1988).	- Competence equals worthy performance that leads directly to the most efficient accomplishment of organizational goals. - Competence is a function of worthy performance, which is a function of the ratio of valuable accomplishments to costly behaviour. Competent people are those who can create valuable results without excessively costly behaviour (Gilbert, 1996).
Area of focus of models	
The area of focus of competency models: - Definition of skills, knowledge, attributes, and behaviours that successful people own. - Other people can learn the competencies and become more successful. - Professionals, experts, and trainers can develop competency models by studying successful people. - Less successful people can develop their competencies through hiring, training, assessment, and development programmes.	The area of focus of competence models: - Definition of measurable, specific, and objective milestones for consistently achieving and exceeding the goals for their roles, team, division, and organization. - Competence models aim to eliminate incompetence by offering a clear, concise, and measurable roadmap to success. - Very clear definition of the required skills, knowledge, and key tasks and behaviours to support competence.

Results	
The result of a competency model is a list, graphic, spreadsheet, or interactive programme that lists the skills, knowledge, attributes, and desirable behaviour for the successful performance of a specific job role.	The result of a competence model defines: - The process for achieving the required results. - The key skills and knowledge, vital procedures, tasks, and best practices of top performers for accomplishing and exceeding corporate goals. - The favourable environment for achievement.
Application	
Competency models are used in various ways by organizations to accomplish training, hiring, evaluation, and assessment in the following stages: - Competencies are ranked for order of importance and desired level of attainment. - Individual performers are given the competency model for their role and asked to exhibit the competencies defined in the model. - Self-assessments and/or 360-degree assessments are built based on the competency model to assess whether individuals have acquired all the competencies. Individuals are given a number and/or a graphic indicating their areas of strength and weakness compared to the required competency levels for their current or future role. - Individuals are given lists of training, tools, information, and resources to help them bridge any gaps and attain the desired level of competency.	Competence models can be used to provide guidelines to success, assess measurable gaps, and direct people to tools, resources, and training that are directly aligned with the work results required of the job and with the goals of the organization. Specifically, competence models can be used to: - Set clear, measurable, and specific expectations about how to produce the results the organization needs. - Simplify management and improve performance by laying out a successful and repeatable work process, decreasing variability in performance, increasing consistent top performance, and controlling costs and risk. - Measure, track, coach, and improve performance. - Ensure training meets the performance requirements of individual roles and the goals and metrics of the business. - Define and set measurable performance standards for hiring and selection.

Vazirani (2010) believed that ‘competency’ describes behaviours which were not simply about developing readiness or having the skills, knowledge, and attributes to perform. He also thought that ‘competence’ describes job outputs which involve the willingness and desire to perform. Chen and Chang (2011) presumed that ‘competency’ and ‘competence’ represented ‘two sides of the same coin’ of individual abilities. To interconnect these two similar concepts, Rowe (1995) proposed an interface between ‘competency’ and ‘competence’ where the competent application of a skill was likely to let an individual act competently and vice versa. Figure 2.3 illustrates this interface.

Figure 2.3: The Interface between Competence and Competency (adapted from Rowe, 1995, p. 13)

Competence		Competency
Skilled-based	→	Behaviour-based
Standard attained		Manner of behaviour
What is measured	←	How the standard is achieved

Core Competence

A similar term to ‘competence’, namely ‘core competence’, was initiated in the 1980s and 1990s. During this period, rapid changes in the market environment prompted organizations to face unexpected internal and external pressures and challenges (Drejer, 2002). To respond quickly to customer needs, organizations generally adopted the strategic positioning methodology (Porter, 1980). They believed sustainable competitive advantages came from competitive advantages in an organisation's products, production, and marketing (Clardy, 2008). The strategic business unit (SBU) was one of the effective methods of the strategic positioning methodology and emphasized decentralization and independent management in response to turbulent market changes (Unland and Kleiner, 1996). In the 1990s, however, technological innovation influenced market competition, which created a ‘new competitive landscape’ (Bettis and Hitt, 1995). In many industries, skyrocketing customer expectations of product quality significantly shortened products’ technological life cycles. The traditional market positioning methods, which emphasized analysing opportunities and threats in a competitive market, could not tackle this new challenge (Drejer, 2002). Therefore, scholars gradually shifted their focus from the external environment to an organisation's internal resources.

In the 1980s, US companies in many industries were defeated by Japanese companies such as Sony, Toyota, Hitachi, etc. Prahalad and Hamel (1990) explored the core competence concepts using a case comparison between the Nippon Electric Corporation (NEC) from Japan and the General Telephone & Electronics Corporation (GTE) from the US. In the early 1980s, GTE was a leading information technology company. With better coordination and integration amongst strategic business units, the NEC surpassed the GTE in the late 1980s. Prahalad and Hamel (1990) argued that resource integration and coordination amongst strategic business units were two of the core competences of an organization. They believed that the overall competitive advantage of Japanese companies mainly came from their internal ‘core competences’ rather than their external market positioning. Therefore, strategic management researchers focused on integrating internal resources, especially the core competences of an organization.

Many strategic management scholars, however, considered that Prahalad and Hamel (1990) adopted the resource-based theory perspective to define ‘core competence’ as productive skills and technology. Still, this view did not explain how the resources created competitive advantages and kept them sustainable. Therefore, some scholars subsequently proposed an idea focusing on dynamic capability (Teece, 2007; Teece and Pisano, 1994; Teece et al., 1997) and defined the organizational core competence as the organizational abilities in integration, reconfiguration, gain, and release of internal resources. Organizations with this core competence could create a sustainable competitive advantage (Eisenhardt and Martin, 2000).

On top of skills, technology, and dynamic capabilities, scholars believed that tacit knowledge created by socially complex interactions could integrate and shape resources into unique organizational core competence (Drejer, 2002; Leonard-Barton, 1995). In this perspective, the development of core competence is based on organizational learning (Lei et al., 1996; Murray, 2003; Petts, 1997) and corporate culture (Barney, 1986; Håland and Tjora, 2006; Lawler, 1994). ‘The core competence [comes] from organizational learning’ (Prahalad and Hamel, 1990), which creates a series of problem-defining and problem-solving insights (Lei et al., 1996) and forms bridges amongst various SBUs that help these SBUs to locate common interests, problems, competence, and opportunities (Javidan, 1998). The establishment of core competence is also based on the corporate culture, while the organizational values, beliefs, and norms can guide employees to the appropriate interaction with the external world and guide their behaviours towards organizational goals (Chen and Chang, 2010).

There seem to be two discrepancies between core competence and Teodorescu's (2006) concept of 'competence'. First, core competence is no longer at the individual level, or the organization might be treated as a big 'individual'. More importantly, the skills, technology, dynamic capabilities, and tacit knowledge should be included in 'competency' models, which might not provide measurable, specific, and objective milestones to the big 'individual'.

Lahti (1999) stated that the concept of core competence demonstrated a close connection to strategic thinking: Core competence was rooted in the individual level and was well connected to organizational competitiveness, shifting academic attention on core competence from the micro to the macro perspective.

Subsequently, strategic management integrated core competence with resource-based theory into strategic thinking (Barney and Wright, 1998; Mueller, 1996). De Saa-Perez and Garcia-Falcon (2002) claimed that core competence could generate a competitive advantage by combining resources and capabilities.

Individual-Level and Organizational-Level Competencies

Turner and Crawford (1994) categorized competencies into personal and corporate classifications. Personal competencies represent individual characteristics such as knowledge, skills, abilities, experience, and personality. Corporate competencies refer to the established processes and structures that remain in an organization even after the employees have left. Both classifications were not mutually exclusive: Individual-level competencies might develop an organizational processing style or culture, while organizational-level competencies might evolve an organization-fit individual best practice. In other words, organizational-level competencies were embedded in individual-level competencies.

Based on this classification, Hoffmann (1999) shared a different view on the uses of competencies: He focused on the input and output dimensions of using competencies at the individual and organisational levels. The input-based dimension paid attention to the underlying attributes for competent performance, while the output-based dimension emphasized the specific performances and standards required. Different approaches brought advantages in different circumstances – straightforward jobs might best use an output-based approach, but complex jobs might benefit from an input-based approach. Table 2.2 explains the differences in the meaning and purpose of the two types of approach. The input and output columns refer to the two types of competency usages in individuals and organizations, respectively. The output-based competency approach suits relatively straightforward jobs where standards or performance can be clearly defined and described. However, the input-based competency approach is preferable for more complex and less tangible jobs because outputs are not easy to define simply as performances, while inputs can be clearly described. Accordingly, the purpose column in Table 2.2 highlights that on-the-job training is suitable for simple jobs, and off-the-job training is appropriate for complex jobs.

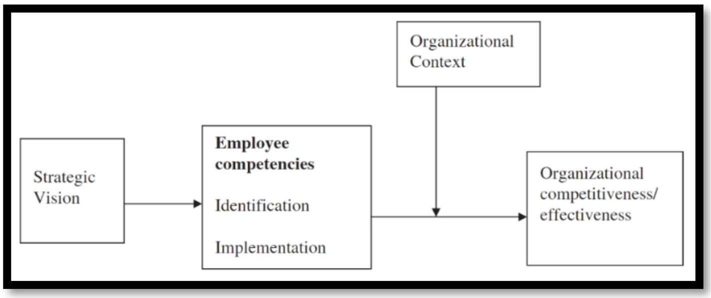
Table 2.2: Typologies of Meaning and Purpose for the Term ‘Competency’ (adapted from Hoffmann, 1999, p. 283)

	Individual	**Corporate**	**Purpose**
Output	Performance Standards	Benchmarks	Performance based objectives (Training)
Inputs	Knowledge, Skills and abilities	Distinctive strengths	Subject matter content (Education)

By comparison, Cardy and Selvarajan (2006) argued that individual competencies could help an organization gain a competitive edge as long as the competencies align with the organization’s strategic direction. Hence, they viewed competencies as the capabilities of individuals from a human resource management (HRM) perspective. At the same time, competencies were viewed as functions, processes, and organizational routines from a strategic management perspective. In other words, the interconnection between strategic management and HRM within an organization was established via competency. The concept of competency was essential to both HRM and strategy approaches, while the lenses through which competencies were perceived and developed diverged between these two perspectives. The strategic approach focused on organizational-level competencies and considered them more abstractly as a unique mix of resources and capabilities. Conversely, the HRM approach treated competencies as personal characteristics associated with successful work performance. It was beneficial to align the concept of competencies across both directions to gain competitive advantages.

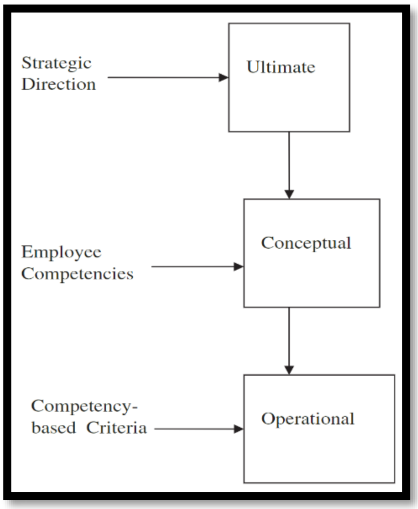
An organisation's strategic intent must be carefully considered beforehand and then translated into appropriate competencies; individual (or employee) competencies must be aligned with and enable the organisation's strategic goal. In addition, individual competencies are contingent upon the organizational context, such as structure and environment, so that organizational competitiveness can be achieved. To visualize how employee competencies contributed to organizational competitiveness, the authors illustrated their relationship, as depicted in Figure 2.4.

Figure 2.4: Employee Competencies as a Means to Competitiveness and Effectiveness (adapted from Cardy and Selvarajan, 2006, p. 238)



Implementing individual competencies was an operational concern in the model: The authors argued that competitive employee competencies must be used as standards during implementation. For those individual competencies that enhanced performance, they explained that an organization had to translate them into criteria and use them as the basis for HRM operations such as staff recruitment, development, assessment, promotion, compensation, and termination. Furthermore, these criteria could help an organization drive toward its strategic direction, value orientation, and future vision. The relationship between individual (employee) competencies and levels of criteria is illustrated in Figure 2.5.

Figure 2.5: Levels of Criteria and Employee Competencies (adapted from Cardy and Selvarajan, 2006, p. 239)



Strategic Link Between Competency Management and Human Resources Management

Except for the above researchers, many scholars introduced the concept of competency management, which interconnected competencies with HRM and business management in terms of a critical process, a method, a system, an approach, or a strategy (Homer, 2001; Rodriguez et al., 2002; Gangani et al., 2006; Draganidis and Mentzas, 2006; Capece and Bazzica, 2013). Today, strategic human resources management (SHRM) is a vital topic in strategic business management due to the importance of a strategic approach to HRM. Listwan (2000, 2010) stated that SHRM covers employee-related decisions and actions that influence long-term personnel operations and organizational success. Its purpose is to offer directions and methods for utilizing employee competencies to accomplish an organisation's strategic goals. In this sense, competency management is perceived as a shared basis for HRM and strategic management; it supports both HRM and strategic management simultaneously. In other words, competency management integrates with HRM sub-functions internally and with business strategy externally. It can be concluded that competency management is a component of SHRM.

Competency Modelling

A model is usually considered a description of an abstract reality that simplifies the complexity to help people better understand the idea or concept. Thus, a competency model is a descriptive tool for identifying the competencies required to perform a specific set of duties within a job, profession, organization, or sector. In other words, a competency model is a behavioural job description specifying each position and occupational function (Fogg, 1999).

Dubois (1998) defined competency models as the ‘glue’ that adheres to the elements of an organizational HRM system. Organizations use competency models to adopt a unified and coordinated approach to developing their HRM system, which includes job designs, recruitment, performance management, staff development, career planning, succession planning, and the salary system.

Sitthisak et al. (2007) stated that adaptive assessment provides efficient and personalized routes to establishing learners' proficiencies. They presented a competency model for assessing learning capacity, considering the achieved competencies to facilitate adaptive assessment for lifelong learning. A competency model is essential for effectively managing adaptive assessment and attaining the objectives of resource sharing, collaboration, and automation to enable lifelong learning and professional development. Using this model, learners can get a multidimensional perspective on their skills while ensuring interoperability across systems as they move.

Incorporated into the SHRM concept, competency models transform an organisation's strategic direction, value orientation, and future vision into specific behaviours that improve organizational performance and competitiveness. According to Vakola et al. (2007), competency modelling should be a forward-looking, dynamic, and proactive approach to business that is connected to strategic business requirements and directed to long-term future performance to achieve long-term success. The authors examined organizational core competencies required for a corporate to compete successfully in the banking sector and the right mix of skills and behaviours individuals would need to possess to produce and support these core competencies.

In summary, a set of individual competencies is structured into a competency model to allow employees in an organization or profession to understand better, discuss, and apply those competencies to improve the overall performance and competitiveness of the organization. Competency models are usually organized into groups of competencies, including descriptions of the activities and behaviours associated with each competency. They are often substantially customized to the needs of an organization and clearly explain the situations and conditions under which employees are expected to perform.

Major Approaches to Developing Competency Models

Identifying and developing individual-level competencies are important in translating an organisation's strategic intent into organizational competitiveness, especially under dynamic, changing, and volatile market conditions. As mentioned earlier, organizational-level competencies are embedded in individual-level competencies. This section discusses various approaches to identifying and developing individual competencies.

Chouhan and Srivastava (2014) summarized three approaches to developing competency models. The first is the single-job approach, the most common way to build competency models. The purpose is to recruit or develop incumbents for a specific job, such as line managers or human resource professionals, by collecting data from a focus group of job holders and their managers via interviews, surveys, and/or observations. Collected data are analysed to establish a competency model with 10 to 20 knowledge indicators, skills, or traits, each with a definition and a list of behaviours that indicate what is required and how to achieve satisfactory performance.

The second approach is the one-size-fits-all approach: This approach is usually adopted by HR professionals who seek a broad, quick, and consistent way of developing competency models for a range of jobs with similar functions, such as all managerial jobs. In practice, identifying the target job is the first step, followed by referencing relevant competency models from books, articles, and other organizations to construct a consolidated competency model.

The third approach is the multiple-job approach: This method is utilized when jobs have few similarities; it creates multiple job-specific and level-specific competency models. Organizations must be ready and clear on using the developed competency models for staff recruitment, development, and performance assessment.

Cardy and Selvarajan (2006) proposed four different approaches for identifying and developing individual-level competencies. Table 2.3 summarizes these four competency identification approaches based on the nature of competencies and the organizational context.

Table 2.3: The Nature of Competencies and Organizational Context as a Function of the Type of Competency Development (adapted from Cardy and Selvarajan, 2006, p. 240)

	Job-based	Future-based	Person-based	Value-based
Nature of competencies	Static – focus on what gets done	Directional change – focus on what needs to be done.	Broad and emergent	Process – focus on how things are done
Organizational context	Fixed – static, hierarchical	Fixed – future-oriented	Innovative – organic and dynamic; empowered	Strong process focused

Job-Based Approach

This approach is probably the most common way of identifying and developing competencies. Using this method, the formulation of competency criteria starts with analysing current job requirements; competencies reflect the most significant or time-consuming tasks and duties. Surveying and interviewing employees are the prevalent methods to explore the competencies while referencing a generic list of competencies is an alternative way. With this approach, the identified competencies reflect the required skill set to perform a job in an organization. Hence, a stable job performance requirement is assumed; therefore, the identified competencies are expected to be steady. The job analysis focuses on the job content in which the competencies could be studied. Job-based competencies best fit in with and support a hierarchical and fixed organizational culture. Furthermore, job expectations are well-defined, and the environment is expected to stay the same.

Future-Based Approach

Competencies, in theory, integrate HRM with the business strategy or align HRM services with organizational strategic goals. Unlike the job-based approach, this approach identifies competencies based on an organization's mission and future strategic direction. The future corporate strategy specifies the core competencies that would be core and central to the organization's interests. As a result, HR operations such as recruitment, assessment, training, and development are also determined. In other words, the competencies link an organization's future strategy with human resources, providing a rational and common foundation for HRM functions.

This approach produces future-oriented competencies that focus on what needs to be done in an organization in the future; it requires a clear vision of an organization's roadmap as well as job duties and tasks. Thus, the organizational culture associated with this approach can be described as future-oriented in general. However, it is still fixed since the competencies focus on particular areas of job performance.

Person-Based Approach

The person-based approach to competency development focuses on identifying the employee attributes that would provide an organization with the best potential in terms of its human resources. It includes broad employee skills and other personal characteristics, creating an environment where these competencies could result in marketable products or services. Competency development with a person-centred orientation might be appropriate for knowledge-based organizations that rely on individuals' creativity and innovativeness for organizational performance.

Unlike job-based or future-based approaches, which might be too mechanical to create competencies that generate creativity, the person-based approach focuses more on individual interests and attributes. The emphasis on the personal interests of knowledge workers encourages employees to participate in more information-seeking activities, resulting in more innovation and knowledge development. These competencies are valuable organizational assets that contribute to creativity, flexibility, and opportunity. The culture associated with the person-based approach is innovative and bottom-up. The workplace is dynamic, and employees have enough opportunities to develop their ideas.

Value-Based Approach

For the value-based approach, organizations are likely to identify their core values and promote and emphasize these to develop their value-based competencies. Focusing on core values offers a stable anchor for organizations operating in volatile circumstances since an organization’s core values might be steadier than its strategies which are vulnerable to market fluctuations. Competencies established based on this approach mainly concentrate on the work process of an organization that determines how things should be done rather than what tasks should be done.

This approach also helps organizations develop a strong culture of how work should be carried out; it can be effective in developing ethical competencies because ethical conduct can only be ensured if employees share the values that govern such conduct. Following recent incidents involving unscrupulous corporate executives, moral values have returned to the centre of business management. Developing ethical competencies is crucial for organizations to be able to engage with their customers, shareholders, employees, and other stakeholders in an ethical manner. According to Spurgin (2004), the ethical competencies of employees include knowledge of moral philosophy, awareness of business ethics issues, and the ability to evaluate arguments on business ethics issues critically. Organizations that value ethics are more likely to acquire and preserve ethical competencies than organizations that adopt a moral orientation for short-term strategic reasons. In other words, the value-based approach offers better effectiveness than other approaches for developing ethical competencies.

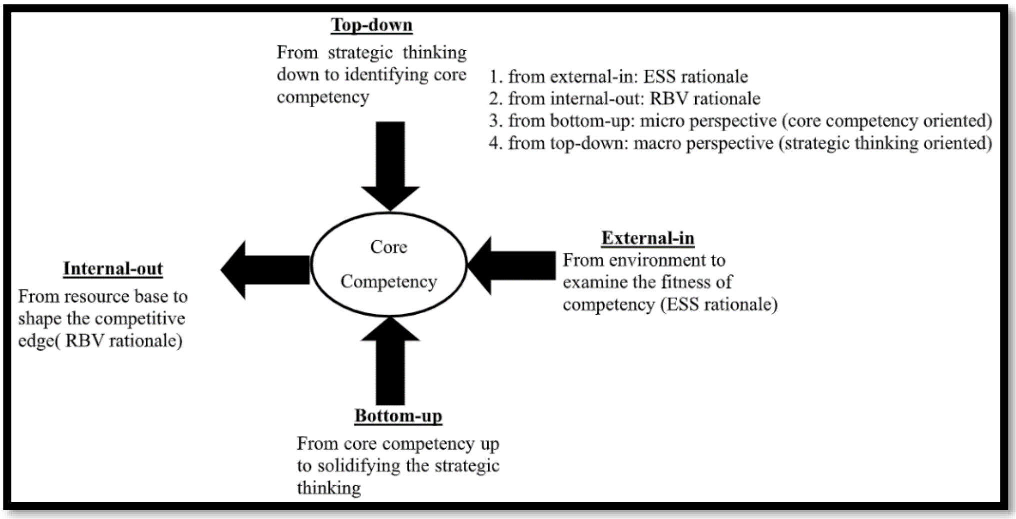
As many successful organizations have developed branches over the rest of the world, international communications have become a significant concern for organizations. As the multinational working environment is highly dynamic, it is challenging for an organization to develop employees to perform effectively in an international environment. On the one hand, organizations that respect and value global diversity and the multicultural nature of the working environment find it easier to develop multicultural competencies. The value-based approach performs better than other approaches in developing employee cross-cultural competencies.

Process-Oriented Core Competency Identifying Model

In addition to the perspectives on the nature and organizational context for identifying competencies, Yang et al. (2006) proposed a model focusing on value activity and process analysis to identify organizational-level competencies, which they named the process-oriented core competency identifying (POCCI) model. This model can identify competencies linking organizational strategies and HRM. The core of this model is value activity analysis. The process analysis method is used to determine organizational-level competencies by analysing the value activities of an organization. Moreover, the missing competencies critical for competitiveness can be explored through stepwise identification processes.

The POCCI model utilizes top-down and bottom-up approaches in developing organizational-level competencies. The top-down approach is strategic thinking oriented and employs strategic goals and directives to determine necessary competencies. It is motivated by the environmental strategy structure (ESS) principle, which states that by studying the external factors, an organization’s strategic focus and competencies are determined to address the challenges of the external environment. On the other hand, the bottom-up approach begins from the micro perspective and utilizes existing competencies to explore the winning position for an organization; it is supported by the resource-based view (RBV), which regards current competencies as corporate resources for strategy formulation. By integrating external and internal factors with the concerns from top-down and bottom-up approaches, organizational competencies are not only developed by their competitive edge as the essential internal resource base but also evaluated by external factors to ensure their adaptation to the environment. In other words, organizational competencies are required to satisfy the strategic thinking requirements from the top and to connect to the individual-level competencies from the bottom. The structure and the rationale of the POCCI model are illustrated in Figure 2.6.

Figure 2.6 The Structure and Rationale of the POCCI Model (adapted from Yang et al., 2006, p. 65)



Application of Competency Models in Organizations

After determining the competencies required for the high performance of jobs, a set of competency models are developed for a particular organization. This section discusses where and how competency models can be applied to support business objectives and accomplish an organisation's strategic goals.

Briscoe (1996) observed that competency models play an essential role in every process of HRM systems, while McLagan (1997) also recognized that competency models were increasingly being employed as the cornerstone of many organizations' HRM functions. Many scholars have proposed that competency models can be applied to various HRM functions, such as recruitment, training and development, performance assessment, and succession planning. Hence, an organisation's quality incumbents can be continuously recruited and retained. Even though competency models might offer such advantages to organizations, some managements prefer to adopt them gradually since it is not easy to locate the starting point to use competency models for HRM functions. Some organizations selected to first apply their competency models to recruitment or training and development functions because it was easier to receive management approval for this than to start with performance assessment and succession planning. However, the culture and the commitment of key decision-makers of organizations also determine the final decision.

Understanding the significance of competency models to different HRM functions helps management to determine how to effectively implement these models in organizations and also supports them in judging the implementation scope and the support from key stakeholders. Many researchers, such as Lucia and Lepsinger (1999), and Dubois and Rothwell (2004), have studied the scope of HRM functions to which competency models could effectively be applied. Their findings are summarized in Table 2.4.

Table 2.4: The Scope of HRM Functions to which Competency Models Can Be Applied (extracted from Lucia and Lepsinger, 1999; Dubois and Rothwell, 2004)

HRM function	Advantages
Planning	- Emphasizing the talents and values generated by HR. - Offering data-driven HR planning. - Planning with quality methods.
Recruitment & selection	- Providing guidelines to select talented applicants. - Offering competency-based recruitment. - Increasing the chances of hiring successful employees. - Minimizing both time and expense on unqualified applicants.

	- Ensuring a more systematic interview process. - Distinguishing trainable from difficult-to-develop competencies.
Training & development	- Focusing on the skills, knowledge, and attributes that improve effectiveness. - Aligning training and development with organizational values and strategies. - Optimizing training and development time and expense. - Providing ongoing coaching and feedback. - Discovering employees' competencies. - Helping employees to gain new experience.
Appraisal	- Sharing a plan of monitoring and measuring for employees. - Facilitating a feedback system for employees to enhance their performance. - Providing focus for gaining information about a person's behaviour on the job.
Compensation	- Attracting and retaining talented employees contributing to organization.
Succession planning	- Clarifying the skills, knowledge, and traits required for some important jobs. - Assessing a candidate's role-readiness. - Exploring the missing competencies for training and development plans. - Measuring the number of high-potential successors inside an organization.

Engineering and Engineering Competency Models

The Origins of Engineering

The term 'engine' is derived from the Latin *ingenerare*, which literally means 'to create'. The Latin *ingenium*, which means 'the fruits of genius', was first used to describe the invention of the new machine around 2,000 years ago. Thus, the term *ingen* was used to refer to any kind of machine. Spelt 'ingen' in English, people would pronounce the term as 'engine', and individuals who came up with innovative ideas were known as 'engine-ers'. So, people who created and analysed systems that combined energy, materials, motion, and information to meet human needs were referred to as engineers. Hence, many branches in the engineering industry include energy, mechanical, information, etc. (Kosky, 2016).

The Jobs of Engineers

Asimov (1970), a late scientist and science fiction writer, stated, 'Science can amuse and fascinate us all, but it is engineering that changes the world.' Engineers have enhanced almost everything in our environment in some way: They are creative individuals who develop new things and address our problems using mathematics, scientific concepts, material characteristics, and computer machines. Engineers can perform a wide range of tasks, including designing and constructing roads, bridges, automobiles, aircraft, space stations, cell phones, computers, medical equipment, and other structures. Regarding job types, engineers can be divided into the following categories: Administration, construction, consulting, design, development, teaching, planning, production, research, sales, service, and test engineers (Kosky, 2016). Since engineering covers most items, the number of engineering disciplines is large. As a result, numerous engineering societies represent various engineering fields, including the American Institute of Aeronautics and Astronautics (AIAA), the American Institute of Chemical Engineers (AIChE), the American Nuclear Society (ANS), the American Society of Civil Engineers (ASCE), the American Society of Mechanical Engineers (ASME), the American Society for Testing and Materials (ASTM), the Biological Engineering Society (BMES), the Institute of Electrical and Electronic Engineers (IEEE), and many others.

Engineering Technology

The Accreditation Board for Engineering and Technology (ABET) of the US defines engineering technology as a profession in which a knowledge of mathematics and natural sciences gained by higher education, experience, and practice is devoted primarily to implementing and extending existing technology for the benefit of humanity. Many engineering technologists collaborate closely with engineers to coordinate the engineering workforce, materials, and machinery to achieve the specific objectives of a given project; they are often in charge of the design and development of new products. Additionally, engineering technicians operate in quality control, inspecting goods and processes, performing tests, and collecting data. They can be involved in product design, development, or production in the manufacturing industry (Moaveni et al., 2011).

How to Become a ‘Good’ Engineer

Engineering is intrinsically multifaceted and interdisciplinary in nature. ‘Good’ engineers are difficult to define since the knowledge, skills, and attitudes necessary to be an engineer are constantly evolving. The competencies contributing to professional success are no longer the same as they were 20 years ago and never will be. Engineers' mindsets must be multidimensional and interdisciplinary to grasp the technological implications of the concessions. Hence, engineers always have to cope with a variety of conflicting considerations. To solve specific problems, they divide a big issue into many tiny but specific problems. Then they provide answers to those small problems using design variables, units, and numerical values (Moaveni et al., 2011). At the lowest limit, it was generally believed that a 'good' engineer would not use their knowledge and expertise to do something bad to humankind. In other words, engineers are expected to fulfil some ethical standards required by the public.

Professionalism for Engineer

In addition to technical know-how and ethical standards, many scholars define professionalism as the underlying characteristics of individuals who can achieve success at work, maintain good social relationships in the workplace, and concentrate on work-related issues. According to Kalbers and Timothy (1995), professionalism positively impacts work performance. Charnegie and Napier (2010) claimed that professionalism was a dynamic process aimed at education, ethics, and expertise. Baczyrisha et al. (2016) also agreed that individual professionalism requires acquiring and applying competencies, including knowledge, skills, and behaviours. Some researchers defined the dimensions of professionalism. Mat and Zaharul (2010) believed that the domains of professionalism included: 1) dedication to the profession; 2) social obligations; 3) independence; 4) confidence in professional regulations; and 5) relationships with fellow professionals. Furthermore, the seven dimensions of professionalism defined by Brock's (2012) typology were: 1) knowledge; 2) qualifications, training, and professional development; 3) skills; 4) autonomy; 5) values; 6) ethics; 7) rewards. This typology, in conjunction with the iceberg competency model proposed by Spencer and Spencer (1993), provides insights to develop a competency model for this research.

Analysis of Published Engineering Competency Models

To develop a competency model for Hong Kong energy engineers tackling the challenges of the energy transition, I need to study current engineering competency models for reference. There are many engineering competency models worldwide. Various organizations, including governments, professional engineering bodies, talent development associations, engineering-related companies, human resources recruitment firms, and academic institutions, have developed international engineering-related competency models. Except for commercial and theoretical competency models, which I have purposefully excluded from my research, the engineering competency models with practical applications I have investigated are the following:

- The US Department of Labor – Engineering Competency Model (2015);
- The US Department of Energy – Energy Auditor and Quality Control Inspector Competency Model (2018);
- The US Missouri Department of Economic Development – Missouri Energy Industry Competency Model (2008);
- The US Center for Energy Workforce Development – Energy Industry Competency Model (2019);
- The International Engineering Alliance – Graduate Attributes and Professional Competencies Profiles (2013);
- The European Federation of National Engineering Associations – Framework for Assessing Professional Engineering Competence (2018);
- The UK Engineering Council – The UK Standard for Professional Engineering Competence and Commitment (2020);
- The Institution of Engineers Australia – Competency Standard (2013);
- The Hong Kong SAR Government – Qualification Framework (2008);
- The Singapore Ministry of Education – Skills Framework for Energy and Power (2016);
- The Singapore Energy Market Authority – Power Engineering Competency Framework (2018); and
- The China Association for Science and Technology – Standards of Capabilities for Chinese Professional Engineers (2018).

After studying the above engineering competency models, I noticed that different countries adopted various engineering qualification approaches. These approaches can be summarized into three different types in terms of the involvement of governments and professional engineering bodies:

- Government only: Many governments are solely responsible for standard setting and controlling the issue of engineering qualifications. In some European countries, such as France and Germany, engineers' accreditation is in the hands of the central government, while It is in the hands of state governments in the US and Canada.
- Cooperation between government and professional bodies: The British government is a typical example. The government does not participate in engineers' accreditation but authorizes and endorses the Engineering Council of the UK for the specific work of qualification standards development and engineers' certification.
- Professional bodies only: In Australia, for instance, the government is not involved in engineers' qualifications. Engineers Australia, the professional engineering body in Australia, fully undertakes standards development and issues engineers' certification to local engineering practitioners.

I also recognized that the purposes of developing these competency models were heterogeneous. Some of them were set up as a framework for recruitment, appraisal, or talent development, some as a career ladder for their members or clients to follow, and others as a guideline for developing a curriculum or training syllabus.

The Engineering Competency Model (2015) of the US Department of Labor

All four of the first US competency models in the above list share the same framework, developed by the Employment and Training Administration (ETA) of the Department of Labor since ETA applied this framework to develop competency models for more than ten industries in the US, including energy. Even though these four competency models' structures are almost the same, they offer reference values to this study. According to the definition of the ETA framework, each competency model possesses the following elements:

1) Competency names and detailed definitions;
2) Description of activities or behaviours associated with each competency; and
3) A graphical framework.

The ETA framework has a building-blocks structure, each building block defining a competency area of various vital behaviours. The blocking blocks are organized by type and stacked in a pyramid with hierarchical layers. The pyramid is generally separated into three major areas: foundational, industry-related, and occupation-related (see Figure 2.7).

Figure 2.7: Major Areas of the ETA Framework of the US Department of Labor

(Source: https://www.careeronestop.org/CompetencyModel/pyramid_definition.aspx)

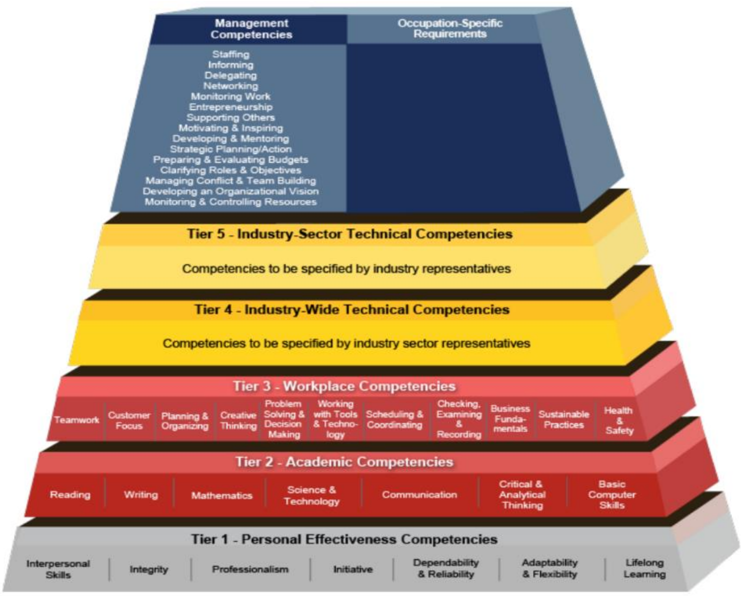
Each area is composed of tiers, each of which has a set of competencies indicating the skills, knowledge, and abilities required to succeed in an industry occupation. In the ETA framework, the tiers include competencies shared by various fields and sectors. The competencies become more industrial and occupation-specific as individuals progress up the pyramid. However, this does not imply that one has to earn or develop all of the lower-level competencies before acquiring or developing the upper-level competencies.

Specifically, the foundational competency area, the lowest part of the pyramid, can be further divided into three tiers, which are personal, academic, and workplace effectiveness. Tiers 1 to 3 represent those competencies that provide the foundation for success in the workplace. These foundational competencies are essential to many occupations and industries and are often used as the starting point for developing other competency models.

The industry-related competency area, located in the pyramid's centre, has two tiers, tiers 4 and tier 5, and represents cross-cutting, industry-wide, and sector-wide skills, knowledge, and abilities. Applying these competencies allows workers to move across industries with comparable competency requirements. Rather than workers being confined to a single occupational career ladder, this model supports the development of an adaptable workforce.

The occupation-related competency area refers to the competencies of tiers 6 to 9, positioned in the upper part of the pyramid. This competency area determines workplace performance, designs competency-based curricula, specifies occupational licences or certification criteria, and describes management competencies within an industry. The structure of the building-blocks competency model is illustrated in Figure 2.8.

Figure 2.8: Sample Structure of the ETA Framework of the US Department of Labor



(Source: https://www.careeronestop.org/CompetencyModel/pyramid_definition.aspx)

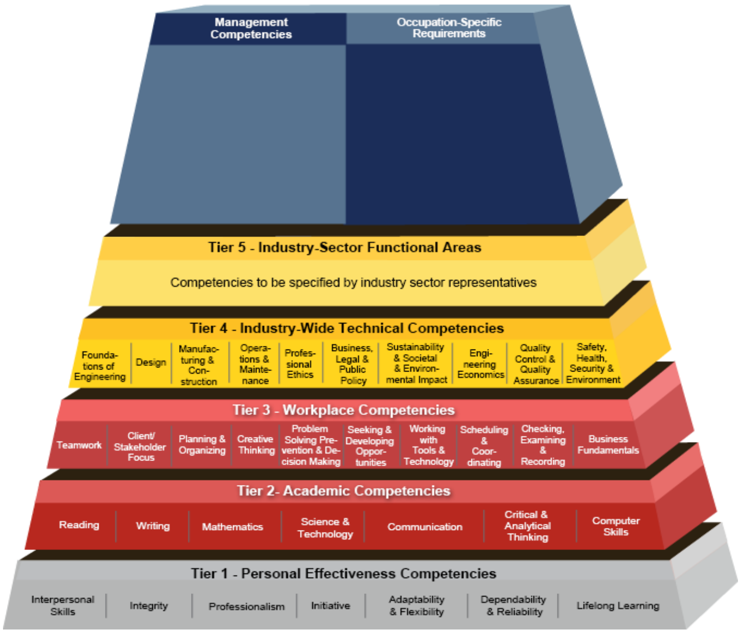
Personal effectiveness competencies (tier 1) address ‘soft skills’ typically learned at home and in the community and reinforced and developed at school and in the workplace. They reflect personal attributes that can be difficult to teach or measure. Tier 1 includes seven competencies: adaptability and flexibility, dependability and reliability, initiative, integrity, interpersonal skills, lifelong learning, and professionalism. Academic competencies (tier 2) include critical competencies developed primarily at school, cognitive skills, and thinking styles. These competencies most likely apply to all organizations and form the basis for industrial and occupational competency areas. Basic computer skills, communication, critical and analytic thinking, mathematics, reading, science and technology, and writing are among the competencies covered in this tier. Workplace competencies (tier 3) are the skills and abilities that enable people to perform in an organizational context. These skills and abilities, together with academic abilities, are typically transferable to a wide range of jobs and industries. The competencies in this tier include business fundamentals, checking, examining and recording, creative thinking, customer focus, health and safety, planning and organizing, problem-solving and decision-making, scheduling and coordinating, sustainable practices, teamwork, and working with tools and technology.

The knowledge, skills, and abilities required by all jobs within an industry are represented by industry-wide technical competencies (tier 4). Because these competencies have to be specified for each sector or profession, it is impossible to accurately define the building-blocks model, which industrial professionals in a competency model development process should establish. The industry-sector technical competencies are located at tier 5 of the pyramid and include the knowledge, skills, abilities, and other traits required by all occupations within an industrial sector. Similar to tier 4, these competencies are not specified in the building-blocks model and have to be identified during the competency model development.

Occupation-specific knowledge competencies are found at tier 6 of the model. This tier contains the specific knowledge areas required for a targeted occupation. Each knowledge area covers an area of expertise that the respective profession requires. Detailed information about the necessary knowledge in various occupations can be obtained from the Department of Labor's Occupational Information Network (O*NET). Tier 7 represents occupational-specific technical competencies, which means technical competencies that are specific to a targeted occupation. Occupation-specific requirements (tier 8) include occupation-specific job credentials, such as educational degrees, certifications, and licences specific to a particular field within an industry. The Department of Education provides a taxonomic scheme of programmes of study and descriptions for reference.

The Engineering Competency Model is one of the competency models developed by the ETA of the US Department of Labor, and it functions as a guide for the development of professionals in the engineering sector. This model establishes a career ladder for engineering, supporting practitioners' understanding of the required skills and abilities to train and nurture a globally competitive engineering workforce. It also serves as a resource for industry leaders, educators, economic developers, and public workforce investment professionals. This model can be used to identify specific employers' skill needs, create competency-based curricula and training tools, and develop industry-specific certifications, skill standards, and performance requirements. The architecture of the Engineering Competency Model is depicted in Figure 2.9.

Figure 2.9: The Engineering Competency Model of the US Department of Labor



(Source: https://www.careeronestop.org/CompetencyModel/Competency-Models/engineering.aspx)

In addition, a list of competency names is defined, and the activities or behaviours associated with each competency are described in detail. All information can be found on the website at: https://www.careeronestop.org/CompetencyModel/competency-models/pyramid-download.aspx?industry=engineering. Samples of competency definitions and behavioural descriptions are presented in Table 2.5.

Table 2.5: Sample Definitions and Behavioural Descriptions of the US Department of Labor

Tier 3: Workplace Competencies

3.1 Teamwork: Working cooperatively with others to complete work assignments.

3.1.1 Identifying team membership and role

- 3.1.1.1 Serve as a leader or a follower, depending on what is needed to achieve the team's goals and objectives.
- 3.1.1.2 Identify and draw upon team members' strengths and weaknesses to achieve results.
- 3.1.1.3 Instruct others in learning new knowledge and acquiring new skills and learn from other team members.
- 3.1.1.4 Assist others who have less experience or have heavy workloads.
- 3.1.1.5 Encourage others to express their ideas and opinions.

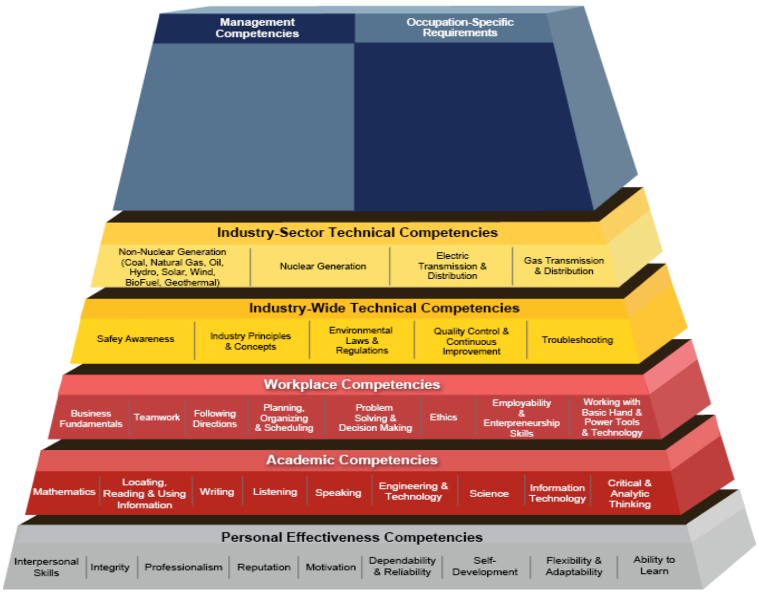
3.1.2 Establishing productive relationships

- 3.1.2.1 Develop constructive and cooperative working relationships with others.
- 3.1.2.2 Exhibit tact and diplomacy and strive to build consensus.
- 3.1.2.3 Deliver feedback and constructive criticism and voice objections to others' ideas and opinions in a supportive, non-accusatory manner.
- 3.1.2.4 Respond appropriately to positive and negative feedback.

The Energy Industry Competency Model (2019) of the US Center for Energy Workforce Development (CEWD)

The CEWD in the US is a non-profit consortium of energy corporations, contractors, associations, unions, educators, and business partners committed to ensuring a skilled, diversified workforce pipeline to meet future industry demands. The consortium links more than 120 energy organizations from electricity, natural gas, and nuclear backgrounds. The purpose of the CEWD is to represent workers' demands, communicate between current and potential workers regarding skills and knowledge, and collaborate with institutions to provide scalable career paths for US energy occupations. Recently, the CEWD also focused on eliminating skill gaps in mission-critical jobs, such as the energy industry adapting to technological development in clean energy. Hence, based on the ETA framework mentioned above, in 2019, the CEWD developed the Energy Industry Competency Model, whose structure and competency descriptions are presented in Figure 2.10 and Table 2.6, respectively. The full document can be found on the website at: https://cewd.org/documents/EnergyModel-rev2019.pdf.

Figure 2.10: The Energy Industry Competency Model of the US Center for Energy Workforce Development



(Source: https://www.careeronestop.org/competencymodel/competency-models/energy.aspx)

Table 2.6: Sample Definitions and Behavioural Descriptions of the US Center for Energy Workforce Development

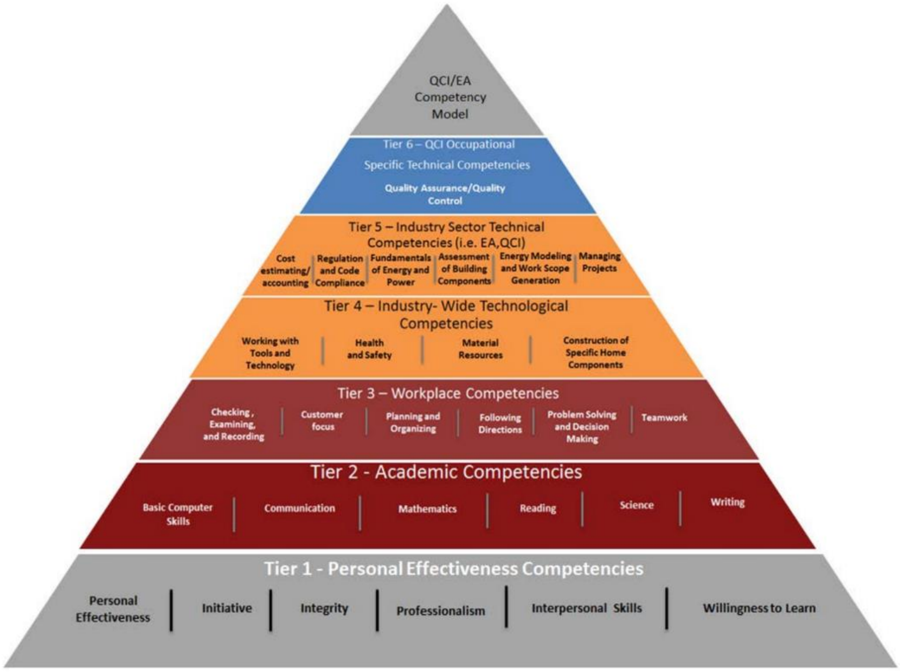
Tier 3: Workplace Competencies

WORKPLACE COMPETENCIES
1. *Business Fundamentals*: Understanding the relationship between an individual's own job and the goals and operations of company and industry
• Is able to articulate the organization's mission and functions and its position in the marketplace • Recognizes one's role in the functioning of the company • Complies with applicable laws and rules governing work and reports loss, waste or theft of company property to appropriate personnel • Acts in the best interest of the company, community and environment
2. *Teamwork*: Developing capacities used to work with others
• Accepts membership in the team • Identifies with the goals, norms, values and customers of the team • Uses a group approach to identify problems and develop solutions based on group consensus • Effectively communicates with all members of the team to achieve goals • Develops constructive and cooperative working relationships with others • Shows sensitivity to the thoughts and opinions of others • Responds appropriately to positive and constructive feedback

The Energy Auditor and Quality Control Inspector Competency Model (2018) of the US Department of Energy

The US Department of Energy was established in 1977. It manages most US energy activities and is in charge of long-term, high-risk energy technology research and development, power marketing, energy conservation, energy development and regulation, and transformation to clean energy technologies. In 2018, the Department of Energy completed a project to improve the quality of residential retrofits and increase energy savings in the residential market through quality control inspector (QCI) and energy auditor (EA) training and certification. Adopting the ETA framework, the Department of Energy developed a competency model for QCIs and EAs in which the soft skills, foundational competencies, and definitions of skills, knowledge, and abilities are identified. Subsequently, this competency model was approved as representing the competencies of the Home Performance Industry's QCI and EA job categories. The architecture of the competency model for QCIs and EAs is illustrated in Figure 2.11.

Figure 2.11: The Competency Model for QCIs and EAs of the US Department of Energy



Together with the definitions and descriptions of these competencies, all information can be found on the website at: https://www.nrel.gov/docs/fy18osti/71001.pdf. A sample of some competencies' definitions and descriptions is presented in Table 2.7.

Table 2.7: Sample Definitions and Behavioural Descriptions of the US Department of Energy

Tier Four–Industry-Wide Technical Competencies–Residential Home Performance

Working with Tools and Technology:

Select, use, and maintain tools and technology to facilitate work activity.

Select and Use the Appropriate Tools and Technology

- Identify the hand and power tools appropriate to the work site and to the trade
- Select tools, technology, machinery, and equipment appropriate for a given job
- Demonstrate appropriate use of tools to complete work functions
- Identify potential hazards related to the use of tools
- Operate hand or power tools and equipment in accordance with established operating procedures and safety standards

Keep Current

- Demonstrate an interest in learning about new and emerging tools and technologies
- Identify sources of information concerning state-of-the-art tools, equipment, materials, and technologies

The Missouri Energy Industry Competency Model (2008) of the US Missouri Department of Economic Development

This competency model was developed by the Missouri Economic Research and Information Center (MERIC), the research arm of the Department of Economic Development of Missouri state in the US; it is one of a series of competency models for eight different industries. This competency model aims to evaluate the adequacy of talented workers in Missouri to support the migration and expansion of businesses. The objective of developing this competency model was to provide a dynamic, industry-driven framework for employees that will assist them in meeting the demands of a globally competitive economy. The study aimed to provide an accurate understanding of present and future skill requirements, allowing for timely resource allocation, creating and updating industry-relevant curricula, and efficient provision of career information and job profiles. Similar to previous models, the architecture and competency definitions can be found on the website at: https://meric.mo.gov/sites/meric/files/library/energy_ competency_model_full_report.pdf.

The Graduate Attributes and Professional Competencies Profiles (2013) of the International Engineering Alliance

The International Engineering Alliance (IEA) is a global non-profit organization with members from 41 jurisdictions in 29 countries across seven international agreements. International Engineering Alliance members set and enforce globally benchmarked standards for engineering education and expected competence for engineering practice via the Educational Accords and Competence Agreements. These international agreements control the acceptance of engineering educational credentials and professional qualifications.

Supported by the World Federation of Engineering Organizations (WFEO) and the United Nations Educational, Scientific and Cultural Organization (UNESCO), the IEA developed an international benchmark, Graduate Attributes and Professional Competencies (GAPC) profiles. These profiles represent the requirements for new technologies and engineering disciplines, new pedagogies, and values such as sustainability, diversity, inclusion and ethics. The profiles were developed for three professional tracks: engineers, engineering technologists, and engineering technicians. The components of the profiles are essential for the potential engineering workforce to prepare for their career paths.

The GAPC profiles comprise two parts, namely graduate attributes profiles and professional competencies profiles. Graduate attributes profiles centre on engineering education to develop a knowledge foundation and attributes that allow graduates to continue learning and progress to formative development, to establish the competencies necessary for independent practice. During the formative development period, graduates work with engineering practitioners and evolve from an assistant position to accepting more individual and team responsibilities until their professional registration. The professional competencies profiles, by comparison, summarize the essential elements of engineering competencies for high performance, which registered engineers must obtain, maintain, and enhance throughout their working lives.

Another significant milestone for engineers and engineering technologists is a qualification for the international register held by the various jurisdictions. In addition, several international accords offer mutual recognition of graduates from some accredited engineering programmes. For example, the Washington Accord (WA) recognizes engineering graduates from accredited programmes, the Sydney Accord (SA) recognizes accredited qualifications for engineering technologists, and the Dublin Accord (DA) recognizes accredited qualifications for engineering technicians.

Graduate attributes form a collection of individual demonstratable outcomes that indicate graduates' potential to develop competencies at a certain level; these attributes are clearly defined with concise assertions of expected competencies to differentiate the distinctive behaviours. Unlike the graduate attributes, the professional competencies profile is more than a set of graduate attributes and can be assessed holistically. For instance, taking responsibility in a real-life situation is essential. Samples of some graduate attributes and professional competencies are presented in Table 2.8. The complete document can be found on the website at: https://www.ieagreements.org/assets/Uploads/Documents/Policy/Graduate-Attributes-and-Professional-Competencies.pdf.

Table 2.8: Samples of Graduate Attributes and Professional Competencies of the International Engineering Alliance

4 Common Range and Contextual Definitions

4.1 Range of Problem Solving

References to the Knowledge Profile are shown thus: (WK3, WK4 ...)

In the context of both Graduate Attributes and Professional Competencies:			
Attribute	***Complex Engineering Problems*** have characteristic WP1 and some or all of WP2 to WP7:	***Broadly-defined Engineering Problems*** **have characteristic SP1 and some or all of SP2 to SP7:**	***Well-defined Engineering Problems*** have characteristic DP1 and some or all of DP2 to DP7:
Depth of Knowledge Required	**WP1:** Cannot be resolved without in-depth engineering knowledge at the level of one or more of WK3, WK4, WK5, WK6 or WK8 which allows a fundamentals-based, first principles analytical approach	**SP1:** Cannot be resolved without engineering knowledge at the level of one or more of SK 4, SK5, and SK6 supported by SK3 with a strong emphasis on the application of developed technology	**DP1:** Cannot be resolved without extensive practical knowledge as reflected in DK5 and DK6 supported by theoretical knowledge defined in DK3 and DK4
Range of conflicting requirements	**WP2:** Involve wide-ranging or conflicting technical, engineering and other issues	**SP2:** Involve a variety of factors which may impose conflicting constraints	**DP2:** Involve several issues, but with few of these exerting conflicting constraints
Depth of analysis required	**WP3:** Have no obvious solution and require abstract thinking, originality in analysis to formulate suitable models	**SP3:** Can be solved by application of well-proven analysis techniques	**DP3:** Can be solved in standardised ways
Familiarity of issues	**WP4:** Involve infrequently encountered issues	**SP4:** Belong to families of familiar problems which are solved in well-accepted ways	**DP4:** Are frequently encountered and thus familiar to most practitioners in the practice area

The Framework for Assessing Professional Engineering Competence (2018) of the European Federation of National Engineering Associations

The European Federation of National Engineering Associations, or the *Fédération Européenne d'Associations Nationales d'Ingénieurs* (FEANI), is a professional engineering federation that unites 350 national engineering associations from 33 European countries, representing the interests of approximately six million European engineers. It was founded in 1951 to develop Europe's engineering professions' recognition, status, and interests. It maintains a database of recognized engineering credentials and a register of professionally qualified engineers from member countries. The FEANI is also a founding member of the World Federation of Engineering Organizations (WFEO) and has worked with other organizations concerned with engineering and technology issues and engineering education.

In 2018, the FEANI invited the UK Engineering Council to participate in a project developing an internationally applicable Publicly Available Specification (PAS 525) to assess the competence and commitment of European engineering professionals. The purpose of this project was to establish a national register for professional engineers for their member countries to achieve the following four objectives: 1) facilitate their engineers' mobility and employment, 2) address new societal challenges, 3) contribute to the Sustainable Development

Goals (SDGs) advocated by the United Nations, and 4) uphold standards of safety, sustainability, ethical conduct, and risk management. As the UK Engineering Council is a member of the FEANI and the organization maintaining the UK standards for professional engineering competence (UK-SPEC), they worked with the British Standards Institution on this project. Based on the principles of UK-SPEC, the framework defines standards for knowledge, skills, and behaviours that are required to build and maintain competence within a rapidly changing profession. The framework has five components: knowledge and understanding, engineering problem-solving, responsibilities and management, interpersonal skills, and commitment. The framework can also be used by government agencies, employers, and insurers to support specifications for engineering projects, products, and processes and to guide the training of engineers. Further information can be found on the website at: https://knowledge.bsigroup.com/products/ framework-for-assessing-professional-engineering-competence-specification/ standard.

The UK Standard for Professional Engineering Competence and Commitment (2020) of the UK Engineering Council

The Engineering Council is a regulatory authority in the UK; the UK government recognizes it as the national representative body for UK engineering professionals working in partnership with other engineering institutions. As the title 'engineer' is not protected by law in the UK, the Engineering Council developed and maintained an internationally recognized standard for professional competence and commitment to regulate the UK engineering professions. Registration as a chartered engineer (CEng), incorporated engineer (IEng), or engineering technician (EngTech) is voluntary. The titles ensure that employers, governments, and societies in the UK and overseas can be confident about engineers' and technicians' knowledge, experience, and commitment on the register. Still, candidates must demonstrate a high professional competence acquired through education, training, and responsible experience to register.

Under a Royal Charter, the Engineering Council developed the UK-SPEC for potential registrants to demonstrate their competence and commitment. The UK-SPEC defines five broad areas of competence, which are:

A. Knowledge and understanding;
B. Design, development and solving engineering problems;
C. Responsibility, management, and leadership;
D. Communication and interpersonal skills; and
E. Professional commitment.

For each area, the competence is clearly defined, and the details of the competence are concisely described with examples of evidence potential registrants will find easy to demonstrate. Unlike the US competency frameworks, however, the UK-SPEC offers no architecture. Table 2.9 presents some samples of the UK-SPEC; the full document can be found on the website at: https://www.engc.org.uk/media/3877/uk-spec-v12-web.pdf.

Table 2.9 Samples of the CEng Standard in the UK-SPEC

Competence		Examples of evidence
A. Knowledge and understanding **Chartered Engineers shall use a combination of general and specialist engineering knowledge and understanding to optimise the application of advanced and complex systems.** This competence is about the ability to understand underpinning technical principles relevant to the applicant's area of practice and applying them to develop technical solutions. This could involve technical solutions for novel problems or dealing with significant technical complexity. This may involve the integration of a range of technologies and consideration of other factors. This competence requires that an applicant is maintaining and developing their knowledge in their field of practice and not just that required for specific tasks.	The applicant shall demonstrate that they: 1. Have maintained and extended a sound theoretical approach to enable them to develop their particular role	• Formal training related to your role • Learning and developing new engineering knowledge in a different industry or role • Understanding the current and emerging technology and technical best practice in your area of expertise • Developing a broader and deeper knowledge base through research and experimentation • Learning and developing new engineering theories and techniques in the workplace
	2. Are developing technological solutions to unusual or challenging problems, using their knowledge and understanding and/or dealing with complex technical issues or situations with significant levels of risk.	• Carrying out technical research and development • Developing new designs, processes or systems based on new or evolving technology • Carrying out complex and/or non-standard technical analyses • Developing solutions involving complex or multi-disciplinary technology • Developing and evaluating continuous improvement systems • Developing solutions in safety-critical industries or applications

The Competency Standard (2013) of the Institution of Engineers Australia

The Institution of Engineers Australia, or Engineers Australia (EA), is a professional body, non-profit organization and the national forum for the advancement of the engineering field in Australia; it is also the designated assessing authority for engineering occupations. The EA has three occupational categories for membership: chartered engineer, engineering technologist, and engineering associate. Similar to the UK, there is no formal regulatory system for engineers in Australia. Engineering services are regulated under various Acts in ad hoc areas such as the building and construction industry. Hence, the EA also developed the Competency Standard, which offers the ‘chartered’ title to qualified members of the three occupational categories. Consequently, the EA established a register for skilled engineers, namely the National Engineering Register (NER), to present registered engineers and their high-standard services to the public. Qualified engineers are required to broadly accept responsibility for engineering projects and programmes, including engineering knowledge and skill; social, environmental, and economic concerns; stakeholder management; etc.

The Competency Standard for professional engineers consists of two stages. Stage 1 describes the fundamental characteristics of mature experienced engineers. It consists of three competency categories covering 16 mandatory elements of competency, representing the profession’s expression of the knowledge and skill base, engineering application abilities, and professional skills, values, and attributes. In the Competency Standard, all elements of competency are well described, with suggested indicators of attainment that cover the breadth and depth of competence of the stage 1 standard. Samples of the stage 1 standard are presented in Table 2.10.

Stage 2 of the Competency Standard focuses on four aspects of leadership and management competencies: personal commitment, obligation to community, value in the workplace, and technical proficiency. Stage 2 assesses chartered membership of the EA (CPEng), a professional credential recognized by the government, businesses, and the general public worldwide. Akin to Stage 1 of the Competency Standard, each aspect defines elements of competency and their corresponding indicators of attainment. This information serves as a guideline for demonstrating the attainment of these competencies. Samples of the stage 2 standard are presented in Table 2.11, while the full documents can be found on the websites at: https://www.engineersaustralia.org.au/sites/default/files/2019-11/Stage1_Competency_Standards.pdf. and https://www.engineersaustralia.org.au/sites/default/files/content-files/2016-12/competency_standards_june.pdf.

Table 2.10 Samples of the Stage 1 Competency Standard of the EA

Table 2 Engineering Application Ability: Elements and Indicators

ELEMENT OF COMPETENCY	INDICATORS OF ATTAINMENT
2.1 **Application** of established engineering methods to *complex* engineering problem solving.	a) **Identifies, discerns and characterises** salient issues, **determines and analyses** causes and effects, **justifies and applies** appropriate simplifying assumptions, **predicts** performance and behaviour, **synthesises** solution strategies and **develops** substantiated conclusions. b) **Ensures** that all aspects of an engineering activity are soundly based on fundamental principles - by diagnosing, and taking appropriate action with data, calculations, results, proposals, processes, practices, and documented information that may be ill-founded, illogical, erroneous, unreliable or unrealistic. c) **Competently addresses** complex engineering problems which involve uncertainty, ambiguity, imprecise information and wide-ranging and sometimes conflicting technical and non-technical factors. d) **Investigates** complex problems using research-based knowledge and research methods. e) **Partitions** problems, processes or systems into manageable elements for the purposes of analysis, modelling or design and then **re-combines** to form a whole, with the integrity and performance of the overall system as the paramount consideration. f) **Conceptualises** alternative engineering approaches and **evaluates** potential outcomes against appropriate criteria to justify an optimal solution choice. g) **Critically reviews and applies** relevant standards and codes of practice underpinning the engineering discipline and nominated specialisations. h) **Identifies, quantifies, mitigates and manages** technical, health, environmental, safety and other contextual risks associated with engineering application in the designated engineering discipline. i) **Interprets and ensures** compliance with relevant legislative and statutory requirements applicable to the engineering discipline.
2.2 **Fluent application** of engineering techniques, tools and resources.	a) **Proficiently identifies, selects and applies** the materials, components, devices, systems, processes, resources, plant and equipment relevant to the engineering discipline. b) **Constructs or selects and applies** from a qualitative description of a phenomenon, process, system, component or device a mathematical, physical or computational model based on fundamental scientific principles and justifiable simplifying assumptions. c) **Determines** properties, performance, safe working limits, failure modes, and other inherent parameters of materials, components and systems relevant to the engineering discipline. d) **Applies** a wide range of engineering tools for analysis, simulation, visualisation, synthesis and design, including assessing the accuracy and limitations of such tools, and validation of their results.

Table 2.11 Samples of the Stage 2 Competency Standard of the EA

ENGINEERS AUSTRALIA

AUSTRALIAN ENGINEERING COMPETENCY STANDARDS STAGE 2 – PROFESSIONAL ENGINEER IN LEADERSHIP AND MANAGEMENT ROLE

Elements of Competence – PERSONAL COMMITMENT

This unit of competence requires you to demonstrate:

- how you deal with ethical issues when they arise
- how you develop and define your areas of competence
- how you display a personal sense of responsibility for your work

ELEMENT OF COMPETENCE – PROFESSIONAL ENGINEER	**What this competence means in practice**	**Indicators of Attainment** Refer to only as many Indicators of Attainment as you need to demonstrate the Element of Competence
1. **Deal with ethical issues**	*means* you anticipate the consequences of your intended action or inaction and understand how the consequences are managed collectively by your organisation, project or team; and *means* you demonstrate an ability to identify ethical issues when they arise and to act appropriately	• appraise and respond appropriately to ethical dilemmas in your practice area • recognise an unethical situation; take appropriate action • engage in ethical reflective practice Ref: Engineers Australia Code of Ethics
2. **Practise competently**	*means you* assess, acquire and apply the competencies and resources appropriate to *leadership and management activities*	• regularly assess your own competence (in the absence of assessment by more experienced leader or manager) and continually acquire new knowledge and skills. • maintain a concise description of your areas of competence and operate within their boundaries. • maintain records of Continuing Professional Development activities.

The Qualification Framework (2018) of the Hong Kong SAR Government

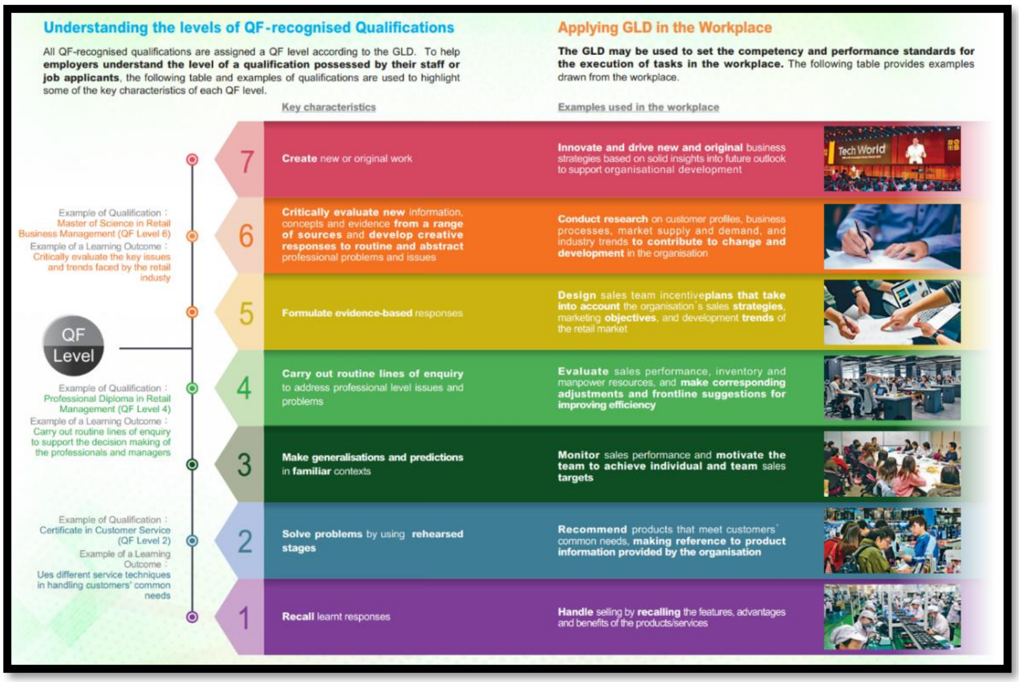
The Qualification Framework (QF) was developed by the government of Hong Kong SAR in 2008 to strengthen the competencies and competitiveness of our workforce, to face the challenges of globalization, rapid technological breakthroughs, and Hong Kong's further challenges in transitioning to a knowledge-based economy. The QF is not an industry-specific framework; instead, it covers 22 different industries and serves employers, education and training providers, practitioners, and the potential workforces of these industries in Hong Kong. Through this framework, practitioners and potential workers can have a clear picture to determine, plan, and develop their career paths. Employers can recruit capable workers to grow their businesses; education and training providers can develop appropriate curricula for the necessary competencies to supply competent workforces for Hong Kong. To achieve the above objectives, the QF in Hong Kong (HKQF) is a complicated framework with a seven-level structure covering academic, vocational, professional, and continuing education qualifications to promote and support lifelong learning and improve the quality, professionalism, and competitiveness of our workforce. Further information can be found on the website at: https://www.hkqf.gov.hk/en/home/index.html.

In the HKQF, each QF-recognized qualification is assigned a specific QF level, ranging from 1 to 7, reflecting the competency level; a higher QF level indicates a greater degree of proficiency. The QF level of each QF-recognized qualification is determined by a set of generic level descriptors (GLDs), which reflect the corresponding performance requirements at that particular QF level. The GLDs cover four major domains, which are:

1) Knowledge and intellectual skills;
2) Processes;
3) Autonomy and accountability; and
4) Communication, ICT, and numeracy.

The relationships amongst QF-recognized qualifications, QF levels and GLD are explained in Figure 2.12, and the details of the GLDs can be found on the website at: https://www.hkqf.gov.hk/filemanager/en/content_13/The%20revised%20GLD%20and%20the%20Explanatory%20Notes_Eng_April_2018.pdf

Figure 2.12 Relationships Amongst the QF-Recognized Qualifications, the QF Levels and the GLDs of the HKQF



Mapping the QF-recognized qualifications to traditional academic qualifications was another objective of the HKQF. The Award Titles Scheme (ATS) reflected the equivalent academic qualifications for employers' reference. Details of the ATS are presented in Figure 2.13.

Figure 2.13 The Award Titles Scheme of the HKQF

The Competency Standard is the core of the HKQF; it outlines practitioners' skills, knowledge, and performance requirements to execute job duties effectively. The HKQF divides competencies into generic and industry-specific categories, covered by the Specification of Generic Competencies (SGC) and the Specification of Competency Standards (SCS), respectively. The SGC describes four strands of foundational abilities: English, Chinese (including Cantonese and Mandarin), numeracy, and information technology. By comparison, the SCS refers to industry-specific abilities for successful job function performance by practitioners at work. The HKQF covers 22 different industries; thus, 22 sets of SCS, combined with a shared set of SGC, provide full pictures of essential competencies for these 22 industries. Employers and human resources managers can apply these to develop in-house training programmes, competency-based job descriptions, and recruitment criteria. Practitioners can use them to evaluate and recognize their abilities and expertise, while learners can establish their career goals. Education and training providers can also refer to these competencies as valuable benchmarks for curricula design.

Table 2.12 Samples of Electrical Engineering UoCs of the HKQF

1. Title	Draw schematic single-line diagrams for the power supply of simple high voltage distribution or generation systems		
2. Code	EMELDE311A		
3. Range	Applicable to the works of high voltage distribution or generation systems (not including Power Generation Stations). Know about the basic arrangement of high voltage distribution or generation systems and common electrical graphic symbols, and draw schematic single-line diagrams of simple power supply systems for high voltage distribution or generation.		
4. Level	3		
5. Credit	4		
6. Competency			Performance Requirements
	6.1 Understand the basic arrangement of high voltage distribution or generation systems and common electrical graphic symbols	◆	Understand the basic arrangement of high voltage distribution system, such as distribution equipment, distribution equipment, protection system, etc.
		◆	Understand the basic arrangement of generation system, such as generation equipment, distribution equipment, earthing arrangements, distribution equipment, protection system, etc.
		◆	Understand the names and symbols of various kinds of high voltage distribution or generation equipment such as high voltage main switchboard, cables, transformers, electric motors, protection device, etc.
	6.2 Draw single-line planning diagrams of simple power supply systems for high voltage distribution or generation	◆	Master common techniques of drawing power systems, and draw schematic single-line diagrams of simple high voltage distribution or generation systems according to basic requirements for electrical drawings

One objective of the HKQF was to guide education and training providers in designing materials for training purposes. Hence, the competencies were divided into small operational pieces, units of competency (UoCs), and associated with an appropriate QF level to develop detailed and refined procedures for learners' training. Taking electrical engineering as an example, its SCS covers nine functional areas, which comprise 304 UoCs ranging from level 1 to 7. Each UoC only focuses on a small part of a job. Samples of electrical engineering UoCs are presented in Table 2.12.

The Skills Framework for Energy and Power (2016) of the Singapore Ministry of Education

The Skills Framework for Energy and Power (SFwEP) is one of the skills frameworks under the national campaign called SkillsFuture Singapore (SSG). Founded in 2016, SSG is a new statutory body managed by the Ministry of Education in Singapore. Its primary duty is to promote and oversee the implementation of SkillsFuture, a project helping Singaporeans develop their full potential for growth toward an advanced and inclusive society. The idea of

SkillsFuture was launched in 2015 to promote Singapore's next stage of economic growth by providing Singaporeans with opportunities for lifelong learning and skill development. The campaign aims to achieve the following four objectives:

- Supporting people in making well-informed decisions about education, training, and careers;
- Establishing an integrated, high-quality education and training system to respond to continuously changing industrial demands;
- Promoting competency-based career development to employers; and
- Fostering a culture for lifelong learning encouragement.

SkillsFuture is a national campaign involving a vast array of policy instruments, targeting a wide range of beneficiaries from the schooling years to the silver years, offering a variety of available resources to help people attain competencies. Its stakeholders include students, adult learners, employers, and training providers. Many significant initiatives are included in the campaign, including SkillsFuture Credit, SkillsFuture Earn and Learn, SkillsFuture Credit for learners, and Skills Frameworks (SFw) for employers.

The SFw, co-created by various employers, industry associations, education institutions, unions, and the government, aims to provide a unified skills language for all the above stakeholders. It also aims to cultivate individuals' skills, improve business competitiveness, and promote employability by providing up-to-date information on sectors, career pathways, occupations, job roles, and existing and emerging skills, as well as relevant education and training programmes. Over 30 sectors' information has been published since the campaign's launch in 2016. Detailed information can be found on the website at: https://www.skillsfuture.gov.sg/.

The SFwEP was established collaboratively by the SSG, Workforce Singapore, and the Energy Market Authority, together with industry associations, training providers, organizations, and unions. The SFwEP offers essential information for all stakeholders in this sector, including data on trends, workforce profiles, career pathways, skills maps, definitions of technical competencies, and available training programmes. Regarding career pathways, it demonstrates 11 possible tracks with 122 job positions for vertical and lateral promotion and growth in the energy and power industry, such as power generation, electricity transmission and distribution, town gas production and plant maintenance, energy trading and portfolio, etc. Furthermore, the critical work functions, essential tasks, and competencies of the 122 job positions are covered in skills maps; a sample of a skills map for an engineering and maintenance engineer is presented in Table 2.13. Details of the career pathways can be found on their website at: https://www.skillsfuture.gov.sg/skills-framework/ energyandpower.

Regarding the skills and competencies required in the 122 job positions, the SFwEP classifies these into two main categories: critical core skills (CCSs) and technical skills and competencies (TSCs). The CCSs refer to transferable interdisciplinary abilities that facilitate the acquisition of technical skills and job mobility; they include 16 competencies grouped into three clusters: thinking critically, interacting with others, and staying relevant. Details of the CCSs are presented in Figure 2.14.

Table 2.13 Sample Skills Map for Engineering and Maintenance Engineer of the SFwEP

SKILLSfuture SG

SKILLS FRAMEWORK FOR ENERGY AND POWER
SKILLS MAP - ENGINEERING AND MAINTENANCE ENGINEER

Sector	Energy and Power
Sub-sector	Electricity
Track	Power Generation
Sub-track	Engineering and Maintenance
Occupation	Engineer
Job Role	**Engineering and Maintenance Engineer**
Job Role Description	The Engineering and Maintenance Engineer supervises the asset management team in carrying out preventive and corrective maintenance of the plant equipment. He/She performs predictive maintenance and reliability-centred maintenance works, implements plant improvement projects and reviews plant incidents and responses. In a bid to protect the plant against cyberthreats, he carries out cybersecurity operations in monitoring, preparing and responding to incidents. He develops staff capabilities using appropriate capability development interventions and through on-the-job training. He monitors the execution of Permits-to-Work procedures, and implements Safe System of Work (SSoW) frameworks and practices to his area of work. In times of emergency, he analyses the impact of emergency responses and relevant safety procedures on business operations. He also facilitates the Emergency Response Team's activities on site incident management. He works in the administration office of the power plant, which is typically situated in the industrial areas of Singapore. He also deals with the equipment in the power plant station equipment, such as generators, motors, turbines, high pressure vessels, boiler, condensers and compressors. He is detail-oriented and systematic in conducting maintenance procedures and has good communication skills to collaborate with his team. In addition, he is agile and quick-witted in responding effectively to faults and outages. Furthermore, he is intellectually curious in identifying ways to improve the plants' preparedness against cyberthreats.

	Critical Work Functions	Key Tasks	Performance Expectations (For legislated / regulated occupations)
Critical Work Functions and Key Tasks / Performance Expectations	Administer safe work practices	Implement Safe System of Work (SSoW) frameworks and safety regulations to area of work	In accordance with: • Work at Height Certification • Confined Space Assessor
		Monitor contractors on safe work practices	
		Monitor the execution of Permits-To-Work procedures	
		Lead safety checks in the workplace	
	Manage responses to emergencies and crises	Analyse the impact of emergency responses and relevant safety procedures on business operations	
		Facilitate the Emergency Response Team activities on site incident management	
	Perform power generation asset maintenance works	Supervise preventive and corrective maintenance works of the assigned equipment	
		Perform predictive maintenance works of the assigned equipment	
		Perform overhauls of equipment for inspections	
		Review plant incidents and response measures taken	
		Supervise contractors on maintenance works in accordance with project requirements	
		Procure spares and equipment needed for the department	
		Perform Risk Based Inspection (RBI) or reliability-centred maintenance on plant equipment	
		Implement maintenance or plant improvement projects	

By comparison, the TSCs comprise occupational or job-specific knowledge, skills, and abilities required to complete the various tasks in the 122 job positions. They encompass 136 competencies organized into 17 distinct job function areas: business development, planning and design, energy management operations, and health, safety and environment management. In addition, the SFwEP also covers the definitions of TSCs. A sample of the TSC for health, safety and environment management is presented in Table 2.14.

Figure 2.14 Critical Core Skills of the SFwEP

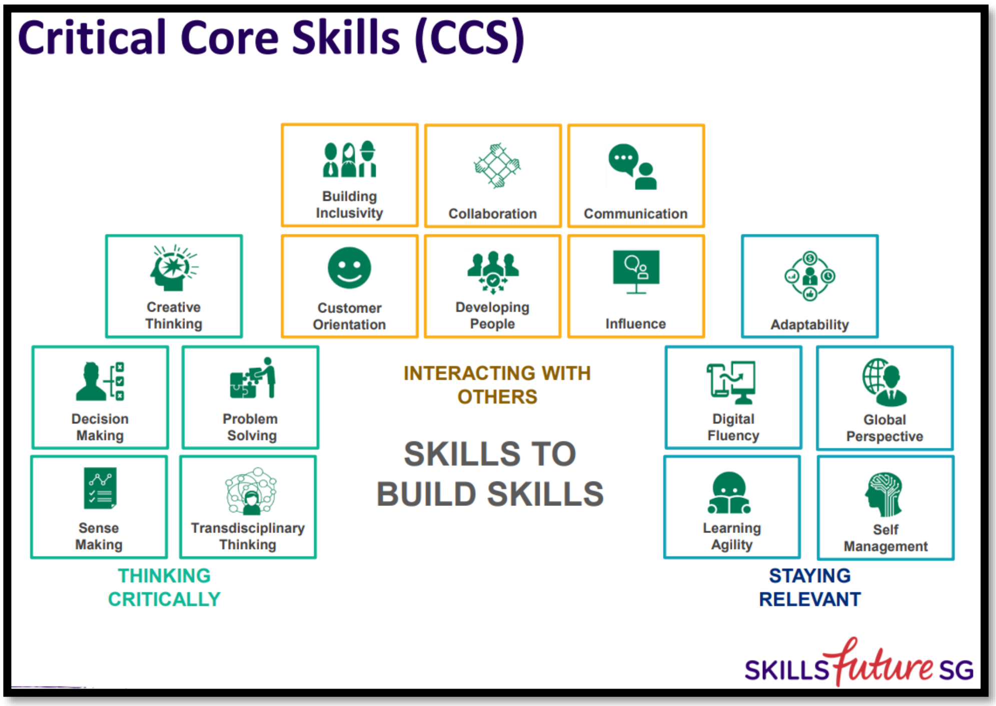
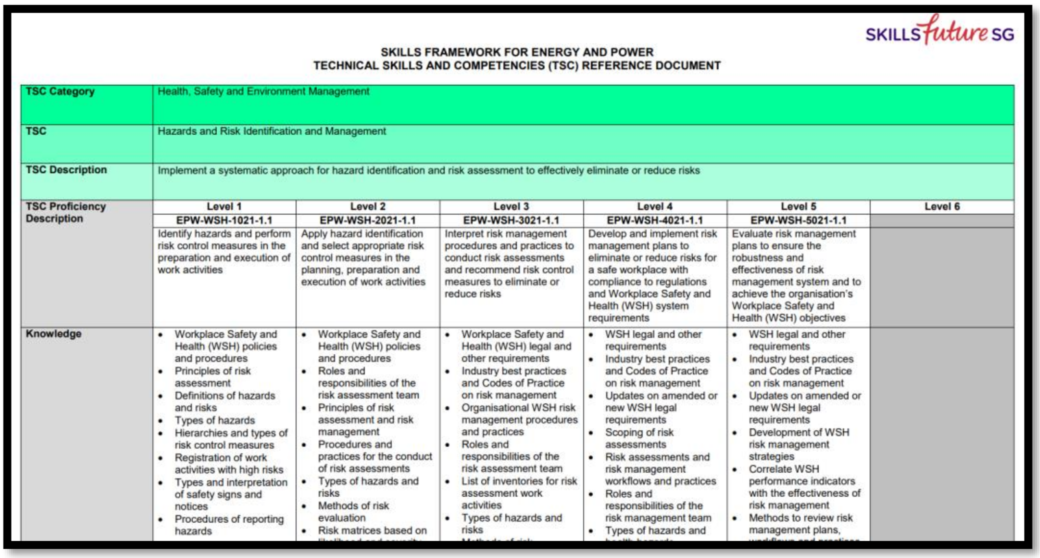


Table 2.14 Sample of TSC for Health, Safety and Environment Management of the SFwEP



SKILLSfuture SG

SKILLS FRAMEWORK FOR ENERGY AND POWER
TECHNICAL SKILLS AND COMPETENCIES (TSC) REFERENCE DOCUMENT

TSC Category	Health, Safety and Environment Management					
TSC	Hazards and Risk Identification and Management					
TSC Description	Implement a systematic approach for hazard identification and risk assessment to effectively eliminate or reduce risks					
TSC Proficiency Description	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6
	EPW-WSH-1021-1.1	EPW-WSH-2021-1.1	EPW-WSH-3021-1.1	EPW-WSH-4021-1.1	EPW-WSH-5021-1.1	
	Identify hazards and perform risk control measures in the preparation and execution of work activities	Apply hazard identification and select appropriate risk control measures in the planning, preparation and execution of work activities	Interpret risk management procedures and practices to conduct risk assessments and recommend risk control measures to eliminate or reduce risks	Develop and implement risk management plans to eliminate or reduce risks for a safe workplace with compliance to regulations and Workplace Safety and Health (WSH) system requirements	Evaluate risk management plans to ensure the robustness and effectiveness of risk management system and to achieve the organisation's Workplace Safety and Health (WSH) objectives	
Knowledge	• Workplace Safety and Health (WSH) policies and procedures • Principles of risk assessment • Definitions of hazards and risks • Types of hazards • Hierarchies and types of risk control measures • Registration of work activities with high risks • Types and interpretation of safety signs and notices • Procedures of reporting hazards	• Workplace Safety and Health (WSH) policies and procedures • Roles and responsibilities of the risk assessment team • Principles of risk assessment and risk management • Procedures and practices for the conduct of risk assessments • Types of hazards and risks • Methods of risk evaluation • Risk matrices based on	• Workplace Safety and Health (WSH) legal and other requirements • Industry best practices and Codes of Practice on risk management • Organisational WSH risk management procedures and practices • Roles and responsibilities of the risk assessment team • List of inventories for risk assessment work activities • Types of hazards and risks	• WSH legal and other requirements • Industry best practices and Codes of Practice on risk management • Updates on amended or new WSH legal requirements • Scoping of risk assessments • Risk assessments and risk management workflows and practices • Roles and responsibilities of the risk management team • Types of hazards and	• WSH legal and other requirements • Industry best practices and Codes of Practice on risk management • Updates on amended or new WSH legal requirements • Development of WSH risk management strategies • Correlate WSH performance indicators with the effectiveness of risk management • Methods to review risk management plans,	

The Power Engineering Competency Framework (2018) of the Singapore Energy Market Authority

The Power Engineering Competency Framework (PECF) is another competency model for power engineering practitioners in Singapore. This framework was developed in 2018 by the Energy Market Authority (EMA) and eight public agencies in Singapore. The EMA is a statutory board under the

Singapore government's Ministry of Trade and Industry. The authority was established in 2001 and performed three critical roles in the Singapore energy market:

1) As a power systems operator, it runs the critical delivery infrastructure used in electricity supply to Singaporeans;
2) As an industry regulator, it manages the energy sectors to promote fair competition and protect consumers' interests; and
3) As an industry developer, it takes a proactive position in advancing workforce capabilities, catalysing innovations, and providing thought leadership to the energy industry.

This framework aims to define the necessary competency requirements to guide the development of energy engineering practitioners for the forthcoming energy transition. As the Singapore government is committed to combating climate change and achieving a sustainable energy future, the PECF mainly focuses on career pathways, occupations, job roles, skills, and competencies for power engineers in the clean energy sector. The career map of the PECF mentions nothing about career pathways regarding fossil fuels but clean energy. It sketches career pathways regarding decarbonization, decentralization, and digitalization. Detailed information is provided on their website at: https://www.poweringlives.gov.sg/ careers/public-service/pecf.

The Standards of Capabilities for Chinese Professional Engineers (2018) of the China Association for Science and Technology

In China, the Standards of Capabilities for Chinese Professional Engineers is a framework regarding the competencies of generic professional engineers. This framework was developed in 2018 by the Centre for Professional Training and Services (CPTS) of the China Association for Science and Technology (CAST). As China is still a developing country, many large-scale and complicated engineering projects are being undertaken or being completed. For example, the Hong Kong-Zhuhai-Macau Bridge, a 55-kilometre bridge connecting Hong Kong, Zhuhai and Macau across the sea, and the Three Gorges Dam, the largest hydroelectric gravity dam in the world, with a capacity of 22,500 MW power generation. To handle these projects, the CPTS, the training centre of the CAST, was one of the units responsible for supplying sufficient high-quality engineers with the ability to embrace challenges such as energy transition, globalization, sustainable development, and industry 4.0.

By establishing this framework, the CPTS aimed to upgrade their engineers' capabilities to an international level and encourage them to pursue continuous professional development. The framework covers five competence areas with 18 competency elements, including:

A. Engineering knowledge and professional competence;
B. Engineering and professional ethics;
C. Teamwork and communicative competence;
D. Sustainable development and lifelong learning; and
E. Organizational leadership and project management capability.

This structure strongly aligns with the competence models of the IEA and the UK Engineering Council. Figure 2.15 demonstrates a comparison of these three competency models.

The Standards of Capabilities for Chinese Professional Engineers is also used as a guideline to assess the technical capabilities of potential engineers, that is, qualified applicants eligible to use the title of a professional engineer. Practitioners from many engineering disciplines are entitled to apply for assessment, including civil engineering, mechanical engineering, electrical engineering, etc. The applicants are asked to submit written evidence with supporting documents during application; they must pass a written examination and a face-to-face interview. Further information can be found on the website at: https://www.wfeo.org/wp-content/uploads/ stc-technology/IFEC-CAST/01-Standards%20of%20Capability%20of%20Evaluation%20for%20 Chinese%20Professional%20Engineers.pdf.

Figure 2.15 Comparison of the Competency Models from CAST, IEA and UK Engineering Council

Comparison of the Competency Models from CAST, IEA and UK Engineering Council

CAST		IEA	UK-SPEC
A	A1	1	A1
	A2	2	A1
	A3	3	B2
	A4	4	B3
B	B1	6	E1, E4
	B2	7	E1, E2, E3, E4
	B3	8	E2, E3, E5
C	C1	10	D1, D2
	C2		D3
	C3		D3
	C4		D3
D	D1	11	E4
	D2		A2, B1
E	E1	5	B1
	E2	9	C1, C3
	E3	12	C2
	E4		B2, B3
	E5	13	D1, D2

The comparison shows good alignment between the competence requirements of the General Specification and the requirements for competence and commitment of IEA and UK-SPEC.

CAST、IEA、UK-SPEC关于工程师能力素质要求具有高度一致之处。

Summary and Discussion

Historically, American scholars have adopted the concept of competency, which is individual-oriented, while British researchers have preferred the idea of competence, which implies a job-oriented perspective. Although these concepts represent ‘two sides of the same coin’ of individual capabilities, they are often used interchangeably, which causes inevitable confusion in business and education disciplines. This literature review on competency and competence led to the conclusion that competency refers to an individual’s knowledge, skills, abilities, traits, and qualities and the values and beliefs required to successfully execute a job role in an organization. Competence relates to the knowledge, skills, and abilities, which are task-specific, measurable, and assessable, to perform occupational activities to meet employment standards in the workplace.

Since both competency and competence focus on the capabilities of individuals, it is evident that they are classified under HRM, which is considered a range of processes involving personnel directed at achieving organizational goals and meeting employees’ requirements. In addition, based on resource-based and capital-based perspectives within HRM, the integration of various individual-level competencies and the established processes and structures within an organization generate organizational-level competencies (or organizational core competence) that bring sustainable competitive advantages to an organization. As the literature increasingly discussed competencies concerning business management, competency management was initiated as a part of HRM and defined as a set of organizational operations focused on identifying, obtaining, developing, and maintaining individuals' competencies that enable an organization to attain its strategic objectives. Along with developing strategic management and HRM, competency management is regarded as a common ground to link strategic management and HRM, becoming SHRM. The purpose of SHRM is to offer guidance and methods for leveraging human resources associated with their competencies to achieve organizational strategic goals.

The literature review also supports the conclusion that competency models constitute a collection of all the competencies required from individuals in an organization, made up of specific categories of competencies known as competency domains. These competency domains contain the competencies needed to perform well in certain organizational job positions, properly carry out the tasks anchored in a particular style of management, contribute effectively to the accomplishment of strategic goals, and successfully fulfil the general and specific expectations of job performance. As the internal and external circumstances and requirements are not identical, organizations utilize various effective approaches and methods to develop their competency models. Hence, competency models are often organization-specific, except for industry competency models, typically established by governments or professional bodies of relevant industries in certain countries. The purpose of industry-specific competency models is to provide guidelines or standards for industrial development and a reference for stakeholders.

Another conclusion is that, in addition to the job-oriented and individual-oriented nature of the competency concept, individual-level competencies can also be identified in terms of job-based, future-based, person-based, and value-based approaches.

First, the job-based approach is the most typical competency identification approach. Through in-depth analysis of the existing job requirements, job-based competencies represent the essential skills and knowledge to perform a job well in an organization; this approach is suitable for organizations with well-defined job expectations and a stable environment.

Second, instead of concentrating on present job competencies, the future-based approach shifts the emphasis to the future strategic direction of an organization. The competencies identified by this approach reflect the collection of knowledge, skills, and abilities needed to achieve organizational strategic objectives. Although an incumbent might not have these competencies, the organization's management must acquire them by developing staff members or hiring new personnel. This approach is appropriate for organizations adopting strategic human resources management.

Third, the person-based approach is suitable for knowledge-based organizations that rely on individuals' broad capabilities for performance. This approach encourages employees to participate in more information-seeking activities, resulting in more innovation and knowledge development. These individuals' competencies are valuable organizational assets. A dynamic and fair job opportunity corporate culture would contribute creativity, flexibility, and performance to an organization.

Lastly, the value-based approach emphasizes establishing organizational core values which focus on how jobs should be done rather than what jobs should be done. This approach helps organizations develop a solid outcome-oriented corporate culture. The value-based competencies always offer a stable anchor in chaotic market situations since organizational core values are more durable than strategies. This approach would also lead organizations to develop their ethical competencies, which are very important to engage their key stakeholders.

Regarding the application of competency models, the literature review concludes that many organizations use competency models for various aspects of their HRM systems. Still, the pace of adoption depends on the organizational culture and commitment. The HRM functions to which a competency model can be applied are planning, recruitment, training and development, assessment, compensation, and succession planning.

This study aims to identify the competencies necessary for Hong Kong energy engineering practitioners to address the challenges of the energy transition. Hence, it is essential first to investigate the globally published engineering competency models for reference. In this context, I reviewed 12 relevant competency models. I observed that most of these models were developed by governments and engineering-related professional bodies in Western nations, with the rest being from Asian countries. Four models are from the United States, three are from Europe, one is from Australia, and four are from Asia. To analyze these 12 published models, I investigated the following aspects:

- The orientation of the models;
- The purpose of the models;
- The stakeholders of the models;
- The architecture of the models;
- Assessment criteria included in the models; and
- Proficiency levels mentioned in the models.

I shall summarize my observations regarding the models in the following paragraphs.

The purposes, structures, and development approaches are comparable to the four competency models from US government departments or professional associations. The US Department of Labor's Engineering Competency Model was a template for establishing these models. In the American-styled competency models, the competencies refer to an individual's capabilities to apply a collection of interrelated knowledge, skills, and abilities to execute a task, function, or work role effectively. Even though the context and stakeholders of these four US competency models are not identical, the purposes and model structures are similar. These models aim to determine the necessary competencies so that the jobs can be done successfully and the strategic objectives can subsequently be achieved. In other words, these competency models utilize a top-down approach to development. In addition, they share a structure of three functional areas and seven tiers. This typical structure, together with the common purpose of the four models, provides a guide to stakeholders regarding the competencies necessary to complete the relevant jobs. These four models only include competencies' definitions and behavioural descriptions but do not provide assessment criteria or proficiency levels for each competency. These characteristics match the individual-oriented perspective of competency.

Conversely, the three European models and the Australian model are British-styled competence models or standards, namely the UK-SPEC (2020) of the UK Engineering Council, the Framework for Assessing Professional Engineering Competence (2018) of the FEANI, the Competency Standard (2013) of Engineers Australia, and the Graduate Attributes and Professional Competencies Profiles (2013) of the IEA. These models have a different developmental approach to their American counterparts; they have a bottom-up approach, and the capabilities are clearly stated, with indicators of attainment or examples of evidence, which could be used as assessment criteria. These models pay close attention to each competency's assessment criteria and proficiency levels. Except for the Australian Competency Standard, all the models or standards clearly define the proficiency level of each competence. Moreover, these four competence models or standards also offer assessment criteria provided by the associated educational or training institutions. Regarding the structure of these competence models or standards, the UK-SPEC and FEANI's frameworks are similar: Both include five broad competence areas. By comparison, the Australian Competency Standard and the IEA's Competencies Profiles include two stages, one for engineering graduates and another for professional engineers.

About the Asian countries, I reviewed three sets of engineering-related competency or competence models, one from Singapore, one from China and one from Hong Kong. The philosophies behind and structures of these three frameworks are different from each other. Amongst these three frameworks, in terms of structural complexity, the simplest one is the Standards of Capabilities Evaluation for Chinese Professional Engineers, developed by CAST in 2018.

Competence definitions and behavioural descriptions are well documented in the framework, and its purpose is to supply sufficient high-quality engineers to implement many engineering projects. Hence, this standard was used as a guideline to assess the technical capabilities of potential engineers and to determine qualified applicants who are eligible to use the title of ‘professional engineer’. The standard comprises five broad competence areas with 18 competency elements, which were derived using the top-down approach. No assessment criteria are included in the standard to evaluate applicants’ abilities.

Regarding the competence assessment, CAST requests applicants to submit written evidence and supporting documents to prove their experience. They have to submit to a written examination and a face-to-face interview. In other words, the assessment criteria of this framework are embedded in another separate evaluation process.

The Hong Kong SAR government developed the Hong Kong Qualification Framework (HKQF) in 2008. Its purpose is to strengthen the competencies and competitiveness of the workforce in Hong Kong, which will have to deal with shortage challenges. The HKQF covers 22 different industries, and the users of the HKQF include employers, education and training institutions, practitioners, and potential workers in these industries. Experts and practitioners contributed their expertise and insights to develop the necessary competences for these 22 industries. Hence, the HKQF adopted a bottom-up strategy for development. Each competence in the HKQF is further divided into several smaller units of competence (UoCs), and the definitions and behavioural descriptions are clearly stated. The UoCs are then correlated with different courses; each UoC is associated with a specific curriculum. Thus, each curriculum focuses on the corresponding UoCs, not the complete competence. In addition, the HKQF used a seven-tiered design, which was designed to align with the academic qualification structure in Hong Kong. By studying a series of accredited curricula or courses in a given sector, individuals can obtain an HKQF-recognized qualification equivalent to an academic qualification in Hong Kong. In this regard, the HKQF is similar to the British-styled competence model but not identical.

In Singapore, there are two similar frameworks regarding the competencies of energy and power engineering practitioners. The first framework is the Skills Framework for Energy and Power (SFwEP), which belongs to the SkillsFuture (SFw) project. Like the HKQF, the SFw aims to help Singaporeans develop their full potential for growth toward an advanced and inclusive society. However, the SFw has no intention to link up with the academic qualification framework of Singapore. A large amount of information regarding the energy and power sector can be found in the SFwEP framework, including a career map, skills maps, and definitions of technical skills and competencies. The career map reflects the current picture of all available job positions and possible career pathways in the energy and power industry; the framework also serves as a blueprint for developing the skills maps for each job. Inside the skills map of a specific job position, the job role, work functions, and tasks are sketched in detail; the skills map also includes all skills and competencies required, with the proficiency level. The human resources perspective was used to develop the SFwEP, and thus a bottom-up approach was applied.

Another Singaporean model is the power engineering competency framework (PECF), developed by the Singapore EMA and eight public agencies. Like the SFwEP, the PECF also includes a career map, skills maps, and definitions of technical skills and competencies, but the approach to developing this competency framework was different. The authority is mainly responsible for ensuring a reliable and secure energy supply, promoting effective competition in the energy market, and developing a dynamic energy sector in Singapore. To secure a reliable and sustainable energy supply in Singapore, the EMA must focus on clean and renewable energy, which is a future-based perspective. Only the job positions related to electricity are included in the career map; jobs related to traditional energy sources, such as natural gas and petroleum, are excluded. The career map and technical skills and competencies definitions also reflect this observation.

Moreover, in the list of technical skills and competencies definitions, only novel competencies are included, such as decarbonization, decentralization, and digitalization. No competencies related to fossil fuels are included. All these new competencies are essential to lead Singapore toward its strategic goals. Hence, the top-down approach was adopted to develop the PECF.

A comparison of the 12 published competency models is summarized in Table 2.15.

Table 2.15 Comparison of 12 Published Engineering Competency Models

Orientation	**Purposes and Stakeholders**	**Architecture**	**Assessment Criteria**	**Proficiency Levels**
US Department of Labor – Engineering Competency Model (2015)				
Individual-oriented	- For industry leaders, employers, and HR professionals: providing a guide for US professionals' development. - For current and future engineers, and career counsellors: showing the career ladder in the US engineering field. - For education/training providers: training and nurturing globally competitive engineers in the US.	Three functional areas with seven-tiered structure.	No	No
US Department of Energy – Energy Auditor and Quality Control Inspector Competency Model (2018)				
Individual-oriented and economic development-oriented	- For quality control inspectors and energy auditors: Improving the quality of US residential retrofits. - For residents: Increasing energy savings in the US residential markets.	Three functional areas with six-tiered structure.	No	No
US Missouri Department of Economic Development – Missouri Energy Industry Competency Model (2008)				
Individual-oriented and economic development-oriented	- For employers and available workforces: evaluating the adequacy of the qualified energy engineering workforce in Missouri in the US. - For education/training providers: Improving the competencies of Missouri US energy engineers.	Three functional areas with seven-tiered structure.	No	No
US Center for Energy Workforce Development – Energy Industry Competency Model (2019)				
Individual-oriented and energy sector development-oriented	- For employers, graduates, potential workforces, and education/training providers: Supplying qualified workforces to the energy industry in the US.	Three functional areas with seven-tiered structure.	No	No
International Engineering Alliance – Graduate Attributes and Professional Competencies Profiles (2013)				
Individual-oriented and engineering sector	- For international engineering professionals, graduates, and tertiary institutions: Normalizing the competencies and attributes of the	Two stages with 12 and 13 competency elements, respectively.	Determined by each jurisdiction member of the IEA.	Yes

development-oriented	worldwide recognized and potential engineering professionals.			
UK Engineering Council – The UK Standard for Professional Engineering Competence and Commitment (2020)				
Qualification-oriented	- For qualified engineering professionals: Registering on the UK engineering qualification register. - For engineering graduates and engineering professionals: Explaining the competence and commitment requirements in the UK. - For employers: Assessing the competence and commitment of UK engineering professionals. - For education/training providers: Safeguarding the quality of engineering professionals in the UK.	Five broad competence areas with two, three, three, three, and five elements, respectively.	Determined and assessed by the engineering institutions licensed by the UK Engineering Council.	Refer to examples in competence area.
European Federation of National Engineering Associations – Framework for Assessing Professional Engineering Competence (2018)				
Qualification-oriented	- For qualified engineering professionals: Registering on the European engineering qualification register. - For engineering graduates and engineering professionals: Explaining the competence and commitment requirements in Europe. - For employers: Assessing the competence and commitment of European engineering professionals. - For education/training providers: Safeguarding the quality of engineering professionals in Europe.	Five broad competence areas.	Determined and assessed by the engineering institutions, regulators, and engineering bodies licensed by the FEANI.	Refer to examples in competence area.
The Institution of Engineers Australia – Competency Standard (2013)				
Qualification-oriented	- For qualified Australian engineers: Assessing for chartered membership and registration on the National Engineering Register. - For Australian engineering graduates: Normalizing the competencies and attributes required for registration.	Two stages: 16 competency elements in stages 1 and 2, respectively.	Stage 1: Determined and assessed by the engineering institutions accredited by the EA. Stage 2: Included in the Competency Standard and assessed by the EA.	No
Hong Kong SAR Government – Qualification Framework (2008)				
Qualification-oriented and economic development-oriented	- For Hong Kong employers, current and potential workforces, and education/training providers: Promoting lifelong learning with a view to continuously enhancing the quality, professionalism, and competitiveness by three objectives: o Setting standards for academic, vocational, and professional qualifications.	22 different sectors; for each sector, two functional areas with seven-level structure.	Included in each UoC of the HKQF; assessed by the accredited assessment agencies or the accredited education/	No

	○ Assuring the quality of qualifications and learning programmes. ○ Increasing the relevance of learning to the needs of industries.		training providers.	
Singapore Ministry of Education – Skills Framework for Energy and Power (2016)				
Economic development-oriented	- For Singaporeans who wish to join or be processed in the energy and power sector: Assessing their career interest, identifying relevant programmes to upgrade their skills, and preparing for the desired job roles. - For employers: Recognizing these skills and investing in training their employees for career development and skills upgrading. - For training providers: Gaining insights into sector trends and existing and emerging skills that are in demand; designing programmes to address industry needs.	Skills map: 11 functional tracks covering 122 job positions; Critical core skills: Three clusters with 16 competency elements; technical skills and competencies: 17 competency areas with 136 elements.	Determined and assessed by the accredited education/ training providers.	Listed in skills map.
Singapore Energy Market Authority – Power Engineering Competency Framework (2018)				
Individual-oriented and power engineering sector development-oriented	- For Singaporean power engineering practitioners: Identifying relevant skills and competencies for the desired job roles. - For potential power engineering workforces in Singapore: Showing the career paths in the power engineering field.	Skills map: Six functional tracks covering 30 job positions; technical skills & competencies: 15 competence areas with 76 elements.	No	Listed in skills map.
China Association for Science and Technology – Standards of Capabilities Evaluation for Chinese Professional Engineers (2018)				
Qualification-oriented	- For qualified Chinese engineers: Establishing the international equivalent standards of engineers; improving the professionalism and internationalization of engineers. - For qualified Chinese engineers and Chinese education/training institutions: Promoting continuous professional development for engineers.	Five broad competence areas with four, three, four, two, and five elements, respectively.	Assessed by the CAST.	No

After studying these 12 published competency models, I observed varied developmental orientations. Five of them were qualification oriented, and the purpose of developing these models had been to assess qualified engineers and differentiate them from laypeople. This approach could increase the social positions of qualified engineers and help employers to recruit engineers with accredited qualifications. Six of the models were individual-oriented and had been established for the career development of practitioners and graduates. Three of the models were engineering-related and sector-development-oriented; these models had usually been proposed by various engineering bodies and were aimed at the technological development of that particular sector. Four models were economic development oriented; these models were often established by government departments and aimed at the economic growth of countries or regions. Furthermore, some of these models featured more than one orientation, which raised the complexity of their designed purposes.

However, the orientations above are not aligned with the intention of my study, which is to help the Hong Kong energy sector identify the essential competencies to overcome the challenges of the energy transition. Because the transformation from fossil fuels to renewable energy sources is such a revolutionary process, we have not yet encountered it. In addition, Hong Kong is a special place in the world, a city with a robust Eastern culture but governed by a Western nation for more than 150 years. This distinct history might provide a different perspective for our engineers in interpreting the energy transition. Hence, I believe bringing local energy engineering practitioners together might uncover some Hong Kong-specific competencies.

Chapter 3: Research Methodology and Design

Overview

This chapter outlines my thinking process concerning the research methodology I adopted, the research design I selected, and the ethical considerations I included in this study. This study aims to contribute positively to the energy sector in Hong Kong by exploring the essential competencies to achieve the global energy transition. Hence, in this chapter, I clarify my aim and objectives, explain my positionality in this study, and set the philosophical grounds for my research methodology. I conclude with the research design I selected and its justifications, and explicitly identify my research questions and the ethical issues I considered in this study.

Aim and Objectives of the Study

Based on a detailed review of the literature on competency modelling, this study aimed to develop a meaningful and practical competency model for Hong Kong energy engineering practitioners in dealing with the challenges and opportunities in the energy transition. In pursuit of this aim, this study has three specific objectives. The first objective is to determine the competencies of Hong Kong energy engineering practitioners to overcome the energy transition's difficulties and grasp the potential now and in future. I plan to consolidate a list of essential competencies to deal with the challenges ahead. The second objective is to provide meaning to the determined competencies. I expect to explain why these determined competencies are essential; The third objective is to construct a practical competency model accordingly, which is the aim of my study.

Positionality

I will clarify my positionality, standpoint, bias and viewpoint limits of this study, which are critical components. Savin-Baden and Major (2013) defined positionality in this context as the philosophical worldview and the researcher's position for the research. In most cases, practitioner research is related to the organization of the researchers, and they usually position themselves as insiders to study the existing problems which outsiders could not recognize. Dwyer and Limb (2001) asked researchers to consider their subjectivity and positioning within the research process and to negotiate the boundaries between 'insider' and 'outsider' within the research.

As I mentioned earlier, the idea of this study originated when I was a corporate trainer of CLP around 2012. When I discussed the topic of energy technologies with the energy engineers in classes, I observed that technology development in various renewable energies was growing, and I expected that this might bring challenges to the current operations of the energy sector in Hong Kong and even globally. My initial intention was simple: I treated these challenges as a global problem and tried to find practical solutions. Hence, I shifted my focus to what we can do to overcome these challenges.

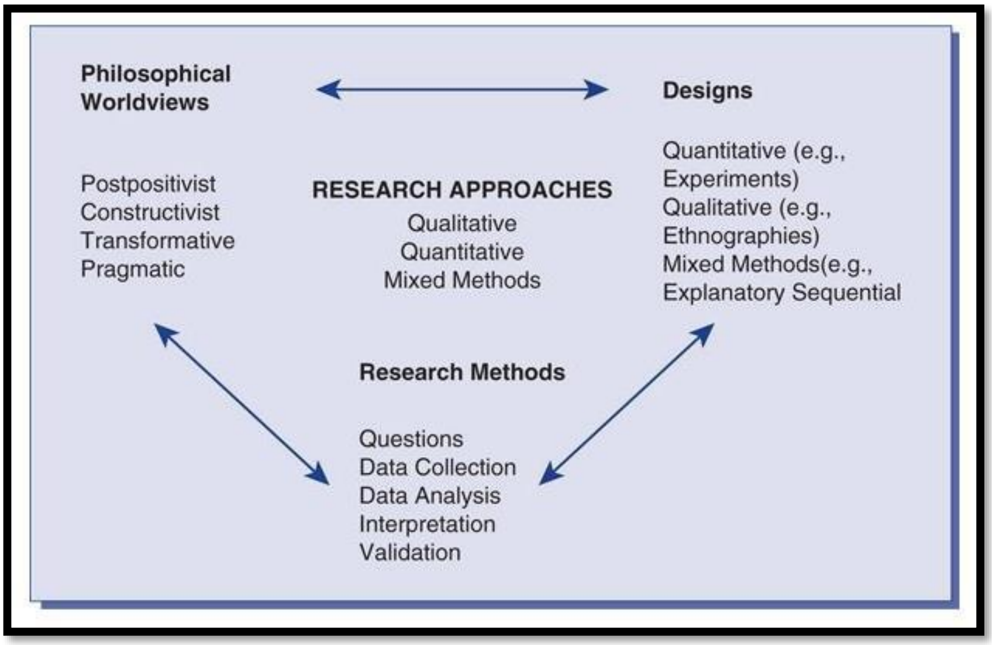
My positionality relates to my personal and academic background, work experience, current job position, and values and beliefs (Grix, 2019; Savin-Baden and Major, 2013; Sikes, 2004). This positionality also impacts the research approaches, outcomes, and findings (Rowe, 2014). In this research, I admit that my personal history, academic science background, IT engineering work experience, and CLP corporate trainer position drove the way I perceived this issue and approached this study. The competency model I aim to construct reflects my perspectives and those I learnt from the CLP engineering practitioners regarding the challenges facing the Hong Kong energy sector and the corresponding capabilities.

In this study, I slide between a 'close to insider' corporate trainer and an 'outsider' academic / researcher. Recognizing this situation was essential; I must recognize my sliding positionality, reflexivity, and viewpoint conflicts. It provided me with closeness to the research and offered me room for objectivity during the research process. Drake and Heath (2010) have argued that doctoral researchers are expected to create new knowledge that should not come from a single research domain but from the unique confluence of the researcher's reflexive work, professional practice, and higher education practice. Practitioner researchers must maintain a fluid and flexible stance to the above three domains, sometimes behaving as a practitioner, sometimes as a researcher, and always as an author who makes sense of the interactions and presents them to an external audience. Sometimes swapping between 'insider' and 'outsider' positions in this study confused me, and I needed extra awareness and conviction to balance the effects of different presumptions and biases. My awareness came from my previous engineering training and practice, while my conviction came from my passion for giving back to the Hong Kong energy sector.

Selection of Research Approach

After the research questions and my positionality were explained, the next step was to find and adopt the most appropriate approach for this study. This choice represents a series of decisions amongst many alternatives at various points in the process. The research approach selection was based on the nature of my research aim and objectives, my positionality and personal experiences, and the targeted readers. Creswell and Creswell (2018) proposed three research approaches, namely quantitative, qualitative, and mixed methods. They further explained that each research approach has three different but inter-related components: 1) philosophical worldviews, which are the philosophical assumptions I bring to the study; 2) research designs, which are the types of inquiry that provide the specific direction for the research procedures; and 3) the research methods, which include specific methods for the collection, analysis, and interpretation of the data (see Figure 3.1).

Figure 3.1: A Framework for Research – The Interconnection of Worldviews, Design, and Research Methods (adapted from Creswell and Creswell, 2018, p. 5)



The overall research approach reflects the final decision on the above three components. The consideration of these three components is explained in the following sections.

Philosophical Worldviews

Social science research studies can adopt various philosophical worldviews or paradigms influenced by the researcher's positionality (Savin-Baden and Major, 2013; Rowe, 2014). Saunders et al. (2019) highlighted five philosophical positions in business and management research: positivism, critical realism, interpretivism, post-modernism, and pragmatism. A comparison of these five philosophical positions is presented in Table 3.1. I noted that pragmatism might be closest to my philosophical stance among these five philosophical worldviews. To determine whether pragmatism was the appropriate philosophical worldview for this study, I reviewed the literature on pragmatism. In the following paragraphs, I explain my ontological, epistemological, and methodological points of view.

Table 3.1: Comparison of Five Philosophical Positions in Business and Management Research (adapted from Saunders et al., 2019, p. 136)

Ontology (nature of reality or being)	**Epistemology** (what constitutes acceptable knowledge)	**Axiology** (role of values)	**Typical methods**
	Positivism		
Real, external, independent One true reality (universalism) Granular (things) Ordered	Scientific method Observable and measurable facts Law-like generalisations Numbers Causal explanation and prediction as contribution	Value-free research Researcher is detached, neutral and independent of what is researched Researcher maintains objective stance	Typically deductive, highly structured, large samples, measurement, typically quantitative methods of analysis, but a range of data can be analysed
	Critical realism		
Stratified/layered (the empirical, the actual and the real) External, independent Intransient Objective structures Causal mechanisms	Epistemological relativism Knowledge historically situated and transient Facts are social constructions Historical causal explanation as contribution	Value-laden research Researcher acknowledges bias by world views, cultural experience and upbringing Researcher tries to minimise bias and errors Researcher is as objective as possible	Retroductive, in-depth historically situated analysis of pre-existing structures and emerging agency Range of methods and data types to fit subject matter
	Interpretivism		
Complex, rich Socially constructed through culture and language Multiple meanings, interpretations, realities Flux of processes, experiences, practices	Theories and concepts too simplistic Focus on narratives, stories, perceptions and interpretations New understandings and worldviews as contribution	Value-bound research Researchers are part of what is researched, subjective Researcher interpretations key to contribution Researcher reflexive	Typically inductive. Small samples, in-depth investigations, qualitative methods of analysis, but a range of data can be interpreted
	Postmodernism		
Nominal Complex, rich Socially constructed through power relations Some meanings, interpretations, realities are dominated and silenced by others Flux of processes, experiences, practices	What counts as 'truth' and 'knowledge' is decided by dominant ideologies Focus on absences, silences and oppressed/repressed meanings, interpretations and voices Exposure of power relations and challenge of dominant views as contribution	Value-constituted research Researcher and research embedded in power relations Some research narratives are repressed and silenced at the expense of others Researcher radically reflexive	Typically deconstructive – reading texts and realities against themselves In-depth investigations of anomalies, silences and absences Range of data types, typically qualitative methods of analysis
	Pragmatism		
Complex, rich, external 'Reality' is the practical consequences of ideas Flux of processes, experiences and practices	Practical meaning of knowledge in specific contexts 'True' theories and knowledge are those that enable successful action Focus on problems, practices and relevance Problem solving and informed future practice as contribution	Value-driven research Research initiated and sustained by researcher's doubts and beliefs Researcher reflexive	Following research problem and research question Range of methods: mixed, multiple, qualitative, quantitative, action research Emphasis on practical solutions and outcomes

Pragmatists' focal point is the consequences of research, the primary importance of the question asked, and the use of multiple data collection methods to inform the problem under study (Patton, 1990). From the ontological point of view, pragmatism is not committed to any system of philosophy or reality; pragmatists tend to take the middle ground, often choosing practical problem-solving research methods (Deway, 1910; James, 1907). As such, pragmatists are receptive to blending worldviews and research methods to solve a problem (Schutz, 2014; Schutz, Chambless and DeCuir, 2004; Schutz, Nichols and Rodgers, 2009). Thus, there was a tendency for pragmatist researchers to approach an inquiry from a universalist perspective, which suggests there might be some fundamental truths; however, these truths and related human processes tend to be influenced by the particular contexts (Berry, Poortinga, Segall and Dasen, 2002; Zusho and Clayton, 2011).

A major underpinning of pragmatist epistemology is that knowledge is always based on experience. Social experiences influence an individual's perceptions of the world. Everyone's knowledge is unique, as unique experiences create it. However, knowledge is socially shared and made from shared experiences. Therefore, all knowledge is social knowledge (Morgan, 2014a). Pragmatist epistemology does not view knowledge as reality (Rorty, 1982). Instead, it is constructed to manage one's existence better and take part in the world (Goldkuhl, 2012).

Pragmatist methodology researchers are 'free' to choose the methods, techniques, and research procedures that best fit their needs and purposes. The choice of methodology can only be evaluated based on the original research questions and the purposes of the research (Morgan, 2014a). Thus, pragmatism enables researchers to adopt different worldviews, assumptions, methods, and data collection and analysis forms. A pragmatist approach is based on what works at the time. It is not based on a duality between reality independent of the mind or within the mind. Thus, researchers use quantitative and qualitative data to provide the best understanding of a research problem. Pragmatist researchers concentrate on the 'what' and 'how' of research based on the intended consequences. They need to establish a purpose for their mixing and a rationale for why quantitative and qualitative data need to be mixed in the first place.

In addition, my research intention, which was mentioned previously, significantly corresponds with the following quotes from Saunders et al. (2019):

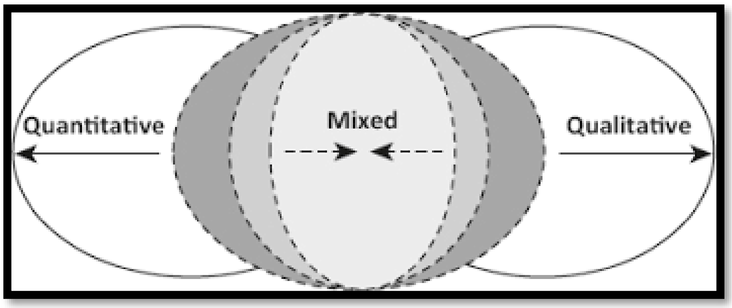
> *For a pragmatist, research starts with a problem, and aims to contribute practical solutions that inform future practice. Researcher values drive the reflexive process of inquiry, which is initiated by doubt and a sense that something is wrong or out of place, and which recreates belief when the problem has been resolved. As pragmatists are more interested in practical outcomes than abstract distinctions, their research may have considerable variation in terms of how 'objectivist' or 'subjectivist' it turns out to be. (p. 143)*
>
> *Pragmatists recognize that there are many different ways of interpreting the world and undertaking research, that no single point of view can ever give the entire picture and that there may be multiple realities. (p. 144)*

Based on the above literature, I believe pragmatism is the appropriate philosophical worldview for this study, with the following justifications. First, this study aims to construct a practical competency model for Hong Kong energy engineers, which is the outcome of this research. In this respect, it matches the characteristic of a pragmatic worldview that focuses on the research outcome. Second, due to the different natures of the first and second objectives, a pragmatic worldview solves the incompatibility generated by adopting a single philosophical worldview. Third, pragmatism is not committed to any system of philosophy or reality; it can use multiple research methods to reach all the research objectives.

Research Designs

In studies that adopt pragmatism as the philosophical worldview, researchers always focus on the research outcomes, which are influenced by the research design. Hence, pragmatist researchers must select an appropriate research design for their studies. Tashakkori and Teddlie (2003) defined that research study designs can be broadly categorized into quantitative, qualitative, and mixed methods. Quantitative and qualitative research are located at opposite ends of the spectrum, while the mixed methods approach is placed in the middle of the continuum, as it integrates both directions. Ivankova (2015) presented a conceptual view of mixed methods research, illustrated in Figure 3.2.

Figure 3.2: Conceptualization of Mixed Methods Research (adapted from Ivankova, 2015, p. 10)



As each design approach involves a systematic empirical investigation of phenomena stemming from a different form of philosophical underpinning, I selected the appropriate research design by considering the nature of the study's research objectives.

Quantitative Design

Aliaga and Gunderson (2006) argued that quantitative design is a deductive reasoning approach. The knowledge derived from quantitative design is believed to be objective and value-neutral (Thompson, 2004). Quantitative research methods are regarded as free of subjective bias. This research design is suitable for achieving the first research objective of this study, namely, to determine the essential competencies for Hong Kong energy engineers to overcome the challenges. Using a quantitative research design, I believe a set of competencies free of subjective bias can be collected. Using some quantitative instruments, the level of importance of these competencies can be quantifiably measured.

Qualitative Design

Creswell and Plano Clark (2007) claimed that the quantitative research design is weak in understanding the context itself; they argued that the quantitative method lacks interactive follow-up and fails to address ‘why’ phenomena in responses to understand respondents’ perspectives within the context. The second objective of this study is to provide meaning to the competencies determined previously. Hence, to achieve the second objective of this study, it is necessary to investigate another research design.

Qualitative design advocates understanding social phenomena based on non-numerical values (Nkwi, Nyamongo and Ryan, 2001) by reconciling information to address underlying reasons for people's attitudes, behaviour, opinions, or motivations. Researchers' values are inherent in all phases of the research process, and social life is only built on subjective and shared meanings. As an inductive research approach, the qualitative research method focuses on exploring sophisticated informants from the social world via dialogue and sharing their lived experiences. Therefore, I believe a qualitative design is the appropriate research design to achieve the second research objective. Some qualitative instruments can reveal the meaning of the competencies perceived by local energy engineering practitioners,

Mixed Methods Design

After analysing the natures of the first and second research objectives, it is clear that these two objectives are associated with two different but appropriate research designs. As a pragmatist researcher, to focus on the solutions to my research problem, I adopted a mixed methods design for my study.

‘Mixed methods design’ is a generic term; there are several ways to ‘mix’ quantitative and qualitative designs. I must identify one of these. Creswell and Plano Clark (2018) developed a typology of three mixed methods designs: convergent design, exploratory sequential design, and explanatory sequential design. Each design type has its unique features, offering complementary strength from the quantitative or qualitative methodologies to make up for its counterpart’s shortcomings.

After carefully considering the mixed methods designs mentioned above, I elected to adopt an explanatory sequential design as the research design of my study. The explanatory sequential design uses a sequential timing approach for data collection and analysis. It begins with the collection and analysis of quantitative data in the first phase. Building on the quantitative findings, the researcher conducts a development phase by designing a qualitative instrument, which is usually given more weight in the study. The qualitative data are collected and analyzed in the next phase using the qualitative instrument. The critical last phase is integrating the findings from both the quantitative and qualitative phases so that the qualitative findings can explain or provide meaning to the quantitative results.

I selected this research design because the flow of the method matches my research logic. First, the essential competencies were collected by using some quantitative instruments from the energy engineering practitioners in Hong Kong. The quantitative data were analysed and revealed a general picture of the essential competencies to tackle the challenges and opportunities faced by the Hong Kong energy sector. Second, a qualitative instrument was developed to collect the justifications for explaining the perceived essential competencies collected from the quantitative phase. Third, a competency model for Hong Kong energy engineers using both perspectives was constructed by mixing both quantitative and qualitative findings. All the competencies in the competency model were extracted from the quantitative results, and the qualitative findings provided meaning to them.

Research Methods

The last major component of the research approach refers to specific research methods, which involve collecting, analysing, and interpreting data. Research methods aim to translate the adopted research design into practice. In the quantitative research phase of my study, I used a survey to compile a list of perceived essential competencies from energy engineering practitioners in Hong Kong. Then, I used descriptive analysis to analyse and interpret the numerical data. In the qualitative research phase of my study, I conducted semi-structured interviews with Hong Kong energy engineers. The participants were asked why their perceived competencies were essential. Then the interview data were processed and analysed using thematic analysis, and the findings were interpreted qualitatively.

Justification for Explanatory Sequential Mixed Methods Design

After carefully considering the nature of my research aim and objectives, my positionality and worldview, and the three mixed methods research designs, the explanatory sequential mixed methods design was deemed the most appropriate design for this research study. This decision was based on my background, knowledge, experience, and research positionality of this research; these four significant components formed the philosophical underpinning of the research design. The rationale for adopting the explanatory sequential mixed methods design is explained in the following paragraphs.

First, as I mentioned before, this research aims to develop a meaningful and practical competency model for Hong Kong energy engineers to tackle the energy transition's challenges and grasp the opportunities faced by the Hong Kong energy sector. I regard this study as problem-solving research, focusing on the study's outcome, a competency model, which hopefully can be referred to by the Hong Kong energy sector and energy engineers. Hence, my original intention, outcome-oriented focus, and research aim are fused with the pragmatic worldview as the philosophical grounding of this study.

Second, Coghlan and Brannick (2005) have suggested that the researcher's ontological and epistemological approaches provide legitimacy for how the research is conducted. In terms of the ontology and epistemology of this research, based on my background, knowledge, and experience, I believe neither one nor multiple everlasting competency models can help the Hong Kong energy industry. Instead, I believe an evolving competency model, based on the development of the world, can solve the problems faced by the Hong Kong energy sector by overcoming the challenges and grasping the opportunities ahead. The model will be based on what works at the time and not on the dualism between positivists' reality and interpretivists' reality (Weaver, 2018).

Third, based on the above research objectives, the answers cannot be achieved using a single research methodology in isolation from others. A mixed methods approach could answer the purposes holistically by combining the strengths of quantitative research to collect the general perceptions of essential competencies from energy engineering practitioners in Hong Kong and the advantages of qualitative research to provide meaning as to why these competencies are necessary.

Overall, the overarching aim of this study is to construct a competency model for Hong Kong energy engineers that will positively impact their productivity and refurbish the whole energy industry to tackle the challenges ahead. This research has a problem-solving focus; thus, pragmatism was adopted as its philosophical worldview. I believe that reality (i.e. the competency model) exists, but it should be neither a single external reality (proposed by positivists) nor a multiple external reality (suggested by interpretivists). Reality should be actively created as an individual act in the world and thus be ever-changing, based on human experience, and oriented toward practical problem-solving (Weaver, 2018). A mixed methods approach can answer the research questions holistically. Therefore, this research study adopted an explanatory sequential mixed methods design in which quantitative research was conducted first, followed by qualitative research. Based on my investigation, however, no academic research employing mixed methods design has been conducted in Hong Kong about the competencies required to address the challenges in the energy sector.

Research Questions

An explanatory sequential mixed methods design was adopted for this study. To integrate my research objectives and the research design, I refined the research questions as follows:

1. To deal with the energy transition's challenges and opportunities faced by the Hong Kong energy sector, what competencies are perceived to be essential by the energy engineering practitioners in Hong Kong?

2. Which perceived competencies do they [Hong Kong energy engineers] consider to be essential?
3. To what extent do their interpretations help to explain their perceptions of the essential competencies?

The first research question guided the quantitative phase of the study, which identified what Hong Kong energy engineers perceive the essential competencies. Hence, a quantitative survey was conducted to collect the perceived competencies.

The second research question guided the qualitative phase of the study. The qualitative data were used to provide meaning to the quantitative data. In semi-structured interviews, the participants explained why they perceived the competencies mentioned in the survey as essential.

The third research question guided the integration of the findings from both the quantitative and the qualitative research; this integration is the focus of the explanatory sequential mixed methods design.

Ethical Considerations

Ethical issues constitute another vital consideration of research studies, especially research involving human beings. Research ethics involves the application of ethical principles to scientific research. Moral researchers are concerned with 'ensuring that ethical principles and values always govern research involving humans' (Habibis, 2010, p. 94). Habibis has summarized the principles of ethical research as 'informed consent, anonymity, confidentiality and protection from harm' (Habibis, 2010, p. 97).

My position in this study was somewhere between an insider and an outsider with a power company in Hong Kong, and I had a dual role as instructor and researcher in this study. The possibility of ethical dilemmas emerged primarily from potential conflicts of interest caused by an individual playing multiple roles. Based on the Research Ethics Review Framework of Middlesex University, I strictly executed the following precaution plan in this study to prevent any concerns of undue influence and conflict of interest and to ensure informed consent and privacy in respect of the participants:

- I did not include any CLP engineers I taught in the qualitative research samples.
- I did not personally interview any CLP engineers until after they had graduated from the DDP.
- I did not discuss anything about my research during my classes.

Ethical approval for this research was obtained from the Trans-Disciplinary DProf. Research Ethics Committee of Middlesex University before beginning the data collection process (see Appendix A). All participants were informed about the purpose, the procedures, and their involvement in the study. They were also informed of their right to withdraw at any time at their discretion (see Appendixes B and G). I ensured the confidentiality and anonymity of the data by using a coding system for the data collection and keeping all data encrypted, password protected, and stored in Microsoft OneDrive. All data will be destroyed five years after the final submission of the research paper. Throughout the research, only the researcher, members of the supervisory team, and the examination team of this research could access the data on private premises; no public Wi-Fi networks or shareable computers were used.

Summary and Discussion

In this chapter, I explained my research methodology and the research design adopted in this study. As a native of Hong Kong, I have enjoyed the benefits provided by the government, such as public housing, free primary and secondary education, subsidies for university fees, etc. At the same time, I have also observed that the Hong Kong energy sector is facing challenges due to the energy transition. I have had an opportunity to work with energy engineering practitioners. Hence, my research intends to help the Hong Kong energy sector deal with the global energy transition to contribute to Hong Kong society. Specifically, my study aims to develop a meaningful and practical competency model for Hong Kong energy engineers to tackle the challenges and grasp the opportunities generated by the global energy transition. To achieve this, I further deconstructed the aim into three objectives: 1) to determine the competencies for Hong Kong energy practitioners to deal with the challenges and opportunities ahead; 2) to provide meaning to the determined competencies; 3) to develop a practical competency model accordingly.

Positionality is a crucial consideration in research, as it reflects the philosophical worldview of the researcher and thus determines the design and methods to be adopted in a study. In this study, my positionality is influenced by my background and position, the research topic and context, and my relationships with potential research participants. When this research idea arose around 2012, I was a lecturer at HKU SPACE, seconded to CLP as a corporate trainer. Through class discussions with the energy engineers, I observed that the development of renewable energies might pose challenges to the traditional operations of the energy sector in Hong Kong and the rest of the world. As a researcher with scientific and engineering background, I wanted to find a meaningful and practical solution to deal with these challenges. In addition, my position at that time was distinct in that I knew a great deal of insider information, but I was not part of the staff of CLP. My unique position – as an inside outsider or an outside insider – led to a special relationship with CLP’s energy engineers. This background influenced my positionality in this study.

In terms of my philosophical worldview, I believe that pragmatism is the appropriate philosophical approach to this study because my study aims to construct a meaningful and practical competency model for Hong Kong energy engineers. It matches the practicality characteristic of the pragmatic worldview, which focuses on the outcome of a research study. In terms of the research design, an explanatory sequential design was the most appropriate research design for this study because the study seeks to develop a meaningful and practical competency model for energy engineering practitioners in Hong Kong. The explanatory sequential research design is a particular type of mixed methods research design; quantitative research was conducted first, followed by qualitative research. The quantitative phase aimed to reveal a general picture of essential competencies perceived by Hong Kong energy engineering practitioners. The qualitative phase sought to explain or provide meaning for the quantitative findings. Hence, I selected a survey and in-depth interviewing as the quantitative and qualitative research instruments for my study.

Chapter 4: Project Activity

Overview

The research methodology and design of this study are introduced in Chapter 3, and this chapter elaborates on the structure, components, and steps of my research design. The objectives, procedures, and detailed description of the activities of the various phases of this study, including the sampling process, participant recruitment, data collection and analysis of quantitative and qualitative data, are explained. I also discuss the development of the questionnaire and the interconnections between quantitative and qualitative research.

The Structure of the Research Design

As a pragmatic philosophical worldview was adopted in this study, I decided to employ a mixed methods research methodology to conduct the study. Among the various types of mixed methods research designs, I selected the explanatory sequential mixed methods research design, which includes two distinct interactive research phases: a quantitative phase followed by a qualitative phase. This design aimed to develop a meaningful and practical competency model for Hong Kong energy engineers. I employed quantitative research to evaluate and determine the essential competencies perceived by Hong Kong energy engineering practitioners in the current context. I also applied qualitative research to interpret participants' perceptions to provide meaning to the determined competencies.

This sequential mixed methods design utilizes the quantitative findings for developing qualitative research and is especially useful for developing and testing a new instrument used to explore an unknown phenomenon (Creswell and Plano Clark, 2011). I expected an outline of a competency model could be developed through data collection and analysis in the quantitative phase. I anticipated that arguments supporting the determined competencies could be collected and analysed in the qualitative phase. These arguments could provide meaning to the determined competencies (Baran and Jones, 2016). The steps of the explanatory sequential mixed methods research design are illustrated in Figure 4.1.

Before I continue discussing the activities of this research study, it is necessary to explain the design structure of my study. The research design can be divided into four phases, as follows:

1. The quantitative research phase;
2. Connecting the quantitative research phase with the qualitative research phase;
3. The qualitative research phase; and
4. Integrating the quantitative and qualitative findings.

Before proceeding with the first phase of this research, I evaluated many current engineering-related competency models. These competency models were presented in publications, journals, and articles on the internet by various governments and professional engineering bodies. These competency models formed the foundation of my study, supporting me in conducting the study in the most up-to-date and accurate manner. They were also a precious resource for developing the questionnaire that was used in the quantitative research.

The quantitative research constituted the first phase of my study. I collected and analysed the perceived essential competencies of current practitioners by using a questionnaire. In addition, the participants' profiles and descriptive statistics were then revealed using descriptive analysis. These quantitative data were indispensable for the study because the findings contributed to an outline of the essential competencies for Hong Kong energy engineers to tackle the challenges and opportunities ahead.

Figure 4.1: The Procedures of the Explanatory Sequential Mixed Methods Research Design (adapted from Creswell and Plano Clark, 2018, p. 85)

Phase	Procedure	Product
1A) Quantitative Data Collection	• Questionnaire development • Snowball sampling • Invitation of potential participants • Cross-sectional online survey (n = 57) • Qualtrics software	• Survey data of 57 participants
1B) Quantitative Data Analysis	• Descriptive analysis • SPSS software v.25	• Profiles of participants • Descriptive statistics • Perceived essential competencies shortlist
2) Connecting the Quantitative and Qualitative Research	• Quantitative findings interpretation • Interview guide and protocol development	• Interview guide • Interview protocol
3A) Qualitative Data Collection	• Invitation of potential interviewees • Individual semi-structured online interviews (n = 19) • Online conferencing software	• Audio recordings of 19 interviews • Transcripts of 19 interviews
3B) Qualitative Data Analysis	• Coding and thematic analysis	• Codes and themes • Grouping of similar themes • Structure of competency layers
4) Integrating the Quantitative and Qualitative Findings	• Integration of quantitative and qualitative findings • Interpretation of findings integration	• Competency model • Discussion • Implications • Recommendations for future research

The qualitative research phase followed the quantitative research, but according to the research design, the second phase connected both research. I studied and interpreted the quantitative findings, then developed an appropriate interview instrument and guide for the qualitative research.

The third phase consisted of the follow-up qualitative research. I invited the volunteer quantitative research respondents to participate in the individual semi-structured interviews during this phase. I followed the instructions in the interview guide to ask the interviewees about the reasons for their quantitative responses. The interview data were significant because each interviewee contributed insights from their experiences and perceptions, which brought meaning to the determined competencies. Moreover, I anticipated that the thematic analysis would reveal a competency model structure.

Ivankova and Stick (2007) have claimed that a more complete picture of research can be achieved by complementing quantitative and qualitative findings. Integrating the quantitative and qualitative results constituted the last phase of my study. I anticipated that the quantitative and qualitative research findings might not be consistent; this phenomenon is common because different research approaches embed different worldviews, values, and methods. Hence, I expected a more comprehensive competency model for Hong Kong energy engineers could be constructed accordingly.

I anticipated starting the data collection activities during the COVID-19 epidemic, but I did not expect the seriousness of the pandemic's impact. The survey and the interviews could not be conducted traditionally. Many restaurants and shops were forced to close, and many employees were instructed to work from home. To continue my study, I had to adopt the following digital methods to collect the survey and interview data:

1) The survey was conducted by sending out invitation emails with an embedded hyperlink to the online questionnaire; and
2) The interviews were conducted online via conference software.

Quantitative Research Phase

The quantitative research constituted the first phase of my study and sought to collect and evaluate the essential competencies as perceived by local energy engineers. Since I could not find any secondary data from other sources, I surveyed to collect quantified data on necessary competencies from the participants. Based on the proposal of Black (1999), the process for the quantitative research included the steps of questionnaire development, population and sampling, recruitment of participants, the survey process, and data analysis.

Questionnaire Development

Before I started to collect the quantitative data, a questionnaire had to be drafted. I identified and categorized competencies from existing engineering competency models to generate a competency pool for my questionnaire development. As mentioned earlier, I studied many current engineering-related competency models from publications, journals, and articles. I listed all the competencies from these published competency models, learned their definitions and behavioural descriptions, eliminated duplicate competencies, and extended and combined various similar and relevant competencies. Then, I created a competency pool that I could use for my questionnaire development.

The questionnaire aimed to collect practitioners' perceptions about the essential competencies required by the Hong Kong energy sector. To develop the questionnaire systematically, I decided to follow the eight guidelines proposed by DeVellis (2017). These steps are elaborated as follows.

Step 1: Determine clearly what it is that has to be measured

To collect the perceptions of practitioners of the Hong Kong energy sector, I designed this questionnaire to focus on understanding what kinds of competencies they perceived to be important to the local energy industry and how vital these competencies were. Thus, it was clear to me that the objectives of my questionnaire were to determine the essential competencies and to measure their level of importance.

Step 2: Generate an item pool

By studying the engineering competency models from various governments and professional engineering bodies worldwide, I collected 50 competency items for this questionnaire. After elaborating on these competencies, I developed a list of 50 competency statements.

Step 3: Determine the format for measurement

Takahashi et al. (2016) have claimed that a semantic differential scale is an effective method for assessing perceptions, especially for non-living entities. Therefore, I adopted a scale to measure the competencies' importance level. In my questionnaire, the competency items were presented as declarative statements, and the intention was to invite respondents to attach a degree of importance to each competency item. The statements 'Not important at all' and 'Crucial' represented the opposite ends of a continuum of the significance level; the response options provided seven gradations for participants to choose the significance level of each competency item. A sample of such a question is presented in Figure 4.2.

Figure 4.2: Question Sample of the Questionnaire


Q15

"Pay attention to the technology development and current issues in the engineering area continuously."

	1	2	3	4	5	6	7	
Not important at all	○	○	○	○	○	○	○	Crucial

Step 4: Have the initial item pool reviewed by experts

To improve the content validity, I invited two experts to review my pool of competency items. These two experts are familiar with the engineering sector in Hong Kong. One of the experts is a professor teaching at the School of Business of the Hong Kong Baptist University, has extensive human resources experience in a Fortune 500 electrical engineering company and has expertise in competency modelling. The other expert is my old friend, who has more than 30 years of work experience in the computer engineering sector in Hong Kong and is an active committee member of the Information Technology Division of the Hong Kong Institution of Engineers. Both experts evaluated the competency items for clarity, meaning, and relevance. After carefully studying my 50 competency items, they commented that 22 competency items overlapped with other similar competencies. I, therefore, merged these 22 competency items so that only 28 competency items remained in the competency pool. Furthermore, I rephrased the competency sentences, making minor word choice and sentence structure changes to improve their readability.

Step 5: Consider inclusion of validation items

DeVellis (2017) proposed that some relevant measures could be included in a questionnaire to detect flaws or distortions in the responses and verify the questionnaire's validity. After discussions with the experts and careful consideration, I added one more question after the 28 competency questions in my questionnaire. This additional question balanced the requirement for distortion detection and overburdening the survey participants. This final question presented participants with 12 competencies and asked them to select the five most important ones. It also asked participants to rank these five competencies in the order of perceived importance. This ranking was used to verify the consistency of the first 28 competency items.

Step 6: Administer items to a development sample

After the validation item was added, I passed my questionnaire to a professional English language editor for proofreading. Based on the editor's feedback, I refined some wording so as to improve the consistency and readability of the statements. I wanted to ensure that there were no grammatical or semantic errors in my competency statements.

As most Hong Kong energy engineers are native Chinese speakers, I wanted to provide both English and Chinese versions of my questionnaire. The participants were allowed to select either version when completing the questionnaire. Therefore, I invited another editor/translator to translate my English questionnaire into Chinese to ensure that participants selecting the

Chinese version would be presented with the same questions as those completing the English version.

I had planned to arrange a pilot study to test the feasibility of the sampling methods, the survey instrument, and the data collection procedures. This pilot study would also give me the last chance to refine the survey process so that the survey could be conducted smoothly. Unfortunately, the COVID-19 outbreak in Hong Kong just after Christmas 2019 made it impractical for me to recruit extra participants for a pilot study. Hence, I returned to my experts and invited them to participate in the pilot study (one in English and the other in Chinese). They indicated that the questions were meaningful to them and that both versions of my questionnaire were easy to read and understand.

Again, the COVID-19 pandemic situation also disrupted my original implementation plan. I could not make use of the traditional way to reach potential participants. Instead, I used the online method to distribute my questionnaire to potential participants. Thus, I needed to choose an appropriate online platform to generate questionnaires.

I had no experience using online survey software, but I recognized several popular programs, including SurveyMonkey, Qualtrics, and Google Forms. To locate appropriate software for my research efficiently, I defined my selection criteria and then read the user reviews on the internet to reach a decision. As a novice user, my selected online survey software had to provide robustly and user-friendly features for developing my questionnaire, and its survey logistics had to be flexible. To reduce resistance to completing my questionnaire, I expected my online survey software to support multiple devices, including mobile phones and tablets. I also expected the software program to support data export functions for various data formats, such as SPSS, Excel, etc., because I needed to export the data collected for further analysis. Lastly, software licensing was another issue for me to consider. In short, the following were my selection criteria for online survey software:

1) Provide survey functions and logistics flexibility;
2) Support multiple devices and platforms;

3) Facilitate data export functionality; and
4) Offer free software licence.

After analysing the comments on the internet, it was clear that Qualtrics scored on the first three criteria. About software licensing, Qualtrics offered a free licence with full functionality for all students of our university.

I found that the questionnaire drafting process in Qualtrics was smooth because its user interface, survey editing functions, survey distribution flow, and data analytics functions were robust and flexible. Qualtrics guided me through creating a questionnaire; I only had to input the questions and their options, and Qualtrics took care of the rest. The software offered many question types for me to select, and I was free to design the question flow. Qualtrics also supported multiple languages. For my questionnaire, I spent only one full day completing two sets of online survey forms on the Qualtrics platform, one in English and one in Chinese (see Appendixes C and D, respectively).

Even though I was not satisfied with the pilot study since my invited experts completed it, I was still confident that the impact of the overlapping identities would not be significant, owing to the professional background of both experts. I record this unsatisfactory arrangement as a limitation of this study in Chapter 6.

The remaining two steps of the questionnaire development – Step 7: Evaluate the items and Step 8: Optimize scale length – are related to the details of the quantitative research and will be discussed in the quantitative phase.

Final Questionnaire Structure

My final questionnaire consisted of four sections: demographic characteristics, perceived competencies, willingness to participate in the qualitative research, and referral of other participants. The details of these four sections are discussed in more detail below.

Section 1: Demographic Characteristics

The first section of the questionnaire concerned the respondents' demographic profiles. I wanted to collect respondents' demographic variables, including gender, age group, highest education qualification, employment status, work experience in the engineering sector, involvement in energy industry fields, and engineering work experience, which reflected the respondents' job rank.

Section 2: Perceived Competencies

The second section of the questionnaire assessed the essential competencies. At the beginning of this section, a short paragraph introduces the global and regional threats and opportunities facing the Hong Kong energy sector, such as global warming, the energy technology revolution, and the development of the Guangdong-Hong Kong-Macau Greater Bay Area etc. I then invited the participants to respond to 28 + 1 items, which were used to determine what essential competencies would assist Hong Kong energy engineers address the challenges and seize the opportunities ahead. This survey could also measure the perceived level of importance of these competencies. Each of the first 28 questions contained a declarative statement on a competency item, asking the participants to score in terms of their perceived importance level. A higher score indicated greater importance. For example, the participants were asked to rate, from 1 to 7, the importance of the following competency statement: 'Able to study global, regional, and intercultural issues.' Finally, the last question was added as a validation item. This question presented the participants with 12 competency dimensions and asked them to identify the top five in importance. Then the participants were asked to rank the five chosen competencies in order of perceived importance. This ranking would be utilized to ensure the consistency of the first 28 items.

Section 3: Willingness to Participate in Qualitative Research

This section asked participants about their willingness to participate in the qualitative research. This part was designed to identify potential participants for the qualitative study. Those who agreed to participate in the qualitative research were asked to leave their contact information, including their full name, mobile phone number, and email address.

Section 4: Participants' Referrals

This section aimed to invite more Hong Kong energy engineers to join my research. Therefore, if participants endorsed the purpose of this research in this final section, I asked them to refer my research to other engineers they knew and invited them to participate. This part was voluntary, and I had no control over the referral outcome.

Population and Sampling

After the questionnaires were prepared, the data collection process could begin. The target population of my study was energy engineering practitioners in Hong Kong, so the objectives were to locate them and recruit them to complete a survey about their perceptions of the essential competencies to tackle the challenges facing the Hong Kong energy industry. My original sampling strategy was to apply a random sampling method to recruit around 400 full members (excluding student members and affiliate members) of various Hong Kong professional engineering bodies. I expected that the participants should have work experience in the local energy industry or energy-related engineering works, such that they would be able to share their insights. Through intensive internet searching, consultation with my expert panel members, and known energy engineers in Hong Kong, the following professional engineering bodies were targeted:

- The Association of Energy Engineers (Hong Kong Chapter)
- The Association of Engineering Professionals in Society
- The Chartered Institution of Building Services Engineers (Hong Kong Branch)
- The Energy Institute (Hong Kong Branch)
- Engineers Australia Hong Kong Chapter
- The Hong Kong Association of Energy Engineers
- The Hong Kong Institution of Engineers
- The Institute of Measurement and Control, Hong Kong Section
- The Society of Operations Engineers, Hong Kong Region

Starting in mid-March 2021, I tried to contact the above professional bodies. I successfully contacted the Association of Energy Engineers (Hong Kong Chapter), the Hong Kong Association of Energy Engineers, the Hong Kong Institution of Engineers, and the Institute of Measurement and Control (Hong Kong Section). I then asked their help to distribute my invitations to their members via email. Unfortunately, due to the fourth-wave outbreak of the COVID-19 epidemic in Hong Kong, employees of most companies, organizations, and even government departments were forced to work from home at that time. The operations of professional engineering bodies were seriously affected; they either directly refused my invitations or replied that they could not help due to their limited resources during the lockdown or 'work-from-home' period. I fully understood their difficult situations and respected their decisions. I had no other options for reaching my target population; nonetheless, I needed to consider another sampling strategy.

As the pandemic seemed unlikely to be over soon, I anticipated that the random sampling method could not be used in my study. However, my research had to proceed, and I had to find another random sampling method to recruit survey participants. By reviewing the literature on sampling, I found no alternative probability sampling methods to ensure generalizability to other populations. After further reviewing the literature on probability and non-probability sampling techniques, I noticed that, fortunately, some researchers had suggested another sampling technique under challenging situations. Venette (2013) stated:

> *If you are trying to recruit people who are difficult to identify or have to meet certain criteria to participate, then snowball sampling can be used to ease data collection.*

Black (1999) also pointed out that the advantage of snowball sampling was the possibility of recruiting members of clusters that are difficult to identify. However, snowball sampling is a non-probability method; samples with the desired traits provide referrals to recruit similar samples. This method is not an ideal sampling method for quantitative research. Elfil and Negida (2017) argued that snowball samples are selected based on the subjective judgement of the researcher instead of using random selection. Venette (2013) further argued that it is acceptable to use snowball sampling to approximate a random sample when the following two conditions are met: a) the selection criterion for first-wave participants helped ‘randomize’ the sampling process, and b) the participants after several referrals are included in the sample to increase the randomness. He shared some valuable opinions on using snowball sampling:

> *Snowballing can be used to approximate a random sample. There are two main ways that this can happen. The first happens when the first wave of participants are given a selection criterion that helps ‘randomize’ the sampling process. An example would be to have the person recommend potential participants who live the farthest away. After a few rounds, you get a pretty good mix … (Venette, 2013)*

I was not alone in facing this difficulty; many researchers worldwide struggled to access their target populations, working/studying from home or in quarantine. In practice, many researchers also adopted snowball sampling to recruit their research participants during this difficult time. For instance, Kennedy-Shaffer et al. (2021) adopted snowball sampling for their serological surveys early in the COVID-19 outbreaks when subjects were difficult to reach. Leighton et al. (2021) proposed connecting with their target population by applying snowball sampling using some social media platforms. Brivio et al. (2021) recruited their study participants using snowball sampling through convenient web-based and mobile app channels. Hence, snowball sampling is an acceptable and practical method to recruit participants under challenging circumstances.

After careful consideration of the balance amongst the random sampling requirement, the continuity of the study, the resources at hand, and the COVID-19 infection risk reduction, I had no choice but to adopt the snowball sampling strategy for my research. I also anticipated that the sample size would be smaller than the random sampling strategy during this difficult period.

Participants’ Recruitment

To reduce the gap between snowball sampling and random sampling, I tried my best to ensure the randomization of the selection of my ‘first-wave’ participants. My initial participants were not selected by purposive sampling; I made use of my past working relationships in the energy engineering sector to recruit ten energy engineering practitioners. The backgrounds of these ten engineers were not homogeneous in terms of gender, age group, work experience, fields in the energy industry, etc. I believe this sampling arrangement kept the first wave of participants as randomized as possible. Most importantly, these ten Hong Kong energy engineers were asked to inform others about my research in the hope that I might be able to increase my sample size, as they knew Hong Kong energy engineers. Since their backgrounds were heterogeneous, I expected that the representativeness of their recommended participants would be broad enough.

Survey Process

I was approved (see Appendix A) to conduct my research on Friday, 26 March 2021, by the Trans-Disciplinary DProf Research Ethics Committee of Middlesex University. On Monday, 29 March 2021, I immediately sent my bilingual invitation emails (see Appendix B) to the ten potential participants. The survey process was launched simultaneously, and I planned to complete it by the end of April 2021. The survey process lasted five weeks, including the five days of the Easter holiday. These ten potential participants represented the first round of my snowball sample participating in the survey. In the emails, I introduced the purpose and details of my search, attaching a participant information sheet (see Appendix G) and embedding the hyperlinks to the English and Chinese online questionnaires. After the participants had read all the material and accepted the informed consent (see Appendix E), they could immediately click on either the English or Chinese hyperlink to start the questionnaire on their computers, mobile phones or tablets. I anticipated the convenient user experience would reduce resistance to participating in my research. Towards the end of the questionnaire, I encouraged the participants to invite other Hong Kong engineers they knew to join and contribute to my study.

With the severe pandemic spread during this survey period, I worried about the number of responses. Hence, I sent out two emails to the potential participants of the first wave to remind them to respond to the questionnaire before the closing date. The first reminder was emailed on 9 April 2021, 14 days after the survey was launched, while the second reminder was emailed on 23 April 2021, seven days before the closing date.

Data Analysis

I sent out ten invitation emails to potential participants in the first round of my snowball sample on 29 March 2021; the respondents were referred to the Qualtrics platform to complete the questionnaire. The survey closed to new participants on 30 April 2021. In total, I received responses from 57 participants who completed the questionnaire. The data were extracted from the Qualtrics platform and imported to another system for statistical analysis. All statistical analyses in this research were performed using IBM SPSS Version 25.0, which the library of Middlesex University provided.

A descriptive analysis was conducted to identify the essential competencies associated with Hong Kong energy engineers. Responses to the 28 competencies were ranked by the perceived importance using the seven-point semantic differential scale. These quantitative data were imported to the IBM SPSS platform and evaluated using various analyses. As the snowball sampling method had been adopted, I could not determine who had been invited to participate in the subsequent rounds. Hence, I cannot provide the response rate for this quantitative research.

Despite my hopes of recruiting more participants for my survey, only 57 quantitative data were collected by snowball sampling during the challenging COVID-19 period. Many researchers have argued that a small sample undermines a study's internal and external validity (Al-Subaihi, 2003; Nayak, 2010; Faber and Fonseca, 2014; Weber and Hoo, 2018). For my study, however, quantitative research aimed to identify the competencies for energy transition perceived by local energy engineering practitioners. The analysis approach I adopted was descriptive analysis, and I intended to use the statistical figures to highlight the competencies the survey respondents considered essential. Regarding descriptive studies, some researchers have discussed sample size requirements. Israel (1992) stated:

Another consideration with sample size is the number needed for the data analysis. If descriptive statistics are to be used, e.g., mean, frequencies, then nearly any sample size will suffice. On the other hand, a good size sample, e.g., 200–500, is needed for multiple regression, analysis of covariance, or log-linear analysis, which might be performed for more rigorous state impact evaluations. The sample size should be appropriate for the analysis that is planned.

Eng (2003) argued that the sample size of descriptive studies is important because it affects the precision of the collected values of means or proportions, the minimum expected difference reflecting the difference between the upper and lower limits of a pre-determined confidence interval. In other words, a 95% confidence interval, for example, represents a range within which 95% of findings would fall if the study were repeated many times with the same sample size. In addition, the following equation has been proposed to estimate the sample size to describe one or more characteristics in one particular group:

$$N = \frac{4\sigma^2(z_{\text{crit}})^2}{\mathrm{D}^2}$$

where N indicates the single study group's sample size; σ denotes the group's assumed standard deviation of the measurement; Z_{crit} represents the standard normal distribution's z-score with the pre-determined confidence interval (e.g. Z_{crit} = 1.96 if the confidence interval = 95%); D is the total width of the expected confidence interval.

To determine whether the sample size of my survey was sufficient, I applied the equation of Eng (2013) to my study. Since my survey is designed to estimate the mean values of competencies' perceived importance, I calculated the mean and standard deviation values from the quantitative data collected. From the statistics of this survey in Table 5.8, the standard deviations for the 28 competency items ranged from 0.82 to 1.28. I used 1.28 as the standard deviation value for the above equation to get a larger sample size. I adopted a 95% confidence interval, which many studies have generally adopted. Hence, the Z_{crit} was assigned to 1.96 accordingly. In order to have limits with a 95% confidence level that are no more than 0.35 above or below the mean value of the group's perceived importance, the value of D was assigned to be 0.7 in this study. By substituting the above values into the equation, the calculated sample size was approximately equal to 52. In my survey, 57 respondents completed the questionnaire. Therefore, I believe this number satisfies the minimum sample size required to maintain my study's internal and external validity.

Descriptive Analysis

For the quantitative analysis, I executed a descriptive analysis, which studied the nominal data to allow a quick understanding of the unique features of the respondents' demographic characteristics and to compare the responses to different competencies by different respondent profiles. This analysis shed light on the statistical information for various variables, such as age group, work experience, and other attributes mentioned in the questionnaire. The data are presented using appropriate statistics, such as the mean (standard deviation), the median (inter-quartile range), and the frequency (percentage), respectively.

Connecting the Quantitative and Qualitative Research Phase

Over the years, many definitions of mixed methods research have emerged that involve different elements of research methods, processes, purposes, and philosophies. Johnson et al. (2007) suggested a composite understanding based on 19 definitions by 21 famous mixed methods researchers. They studied these definitions of what was being mixed, where the mixing happened in the research process, the extent of the mixing, why elements were being mixed, and what elements drove the research. Incorporating these various aspects, they concluded that mixed methods research could be defined as follows:

> *Mixed methods research is a type of research in which a researcher or team of researchers combines elements of qualitative and quantitative research approaches for the purposes of breadth and depth of understanding and corroboration. (p. 123)*

O'Cathain et al. (2007) commented that integrating data or findings from different components of a study is a core characteristic of mixed methods research. Fetters et al. (2013) further proposed that, in practice, quantitative and qualitative research integration can be implemented at three different levels, summarized in Table 4.1. The first integration level is located at the research design, which is the conceptualization of the research.

Table 4.1: Levels of Integration in Mixed Methods Research (adapted from Fetters et al., 2013, p. 2136)

Integration Level	*Approaches*
Design	3 Basic designs Exploratory sequential Explanatory sequential Convergent 4 Advanced frameworks Multistage Intervention Case study Participatory—Community-based participatory research, and transformative
Methods	Connecting Building Merging Embedding
Interpretation and Reporting	Narrative—Weaving, contiguous and staged Data transformation Joint display

Integration at the design level could be accomplished through three basic designs and four advanced frameworks. As my study adopted the explanatory sequential mixed methods research design, one of the three basic designs, it naturally satisfies the first level of integration.

Integration at the methods level is another type of integration. Creswell et al. (2011) conceived integration through linking methods in data collection and analysis. There are four linking methods approaches: connecting, building, merging, and embedding (see Table 4.2). Researchers can use one or more approaches in their studies to achieve integration.

Table 4.2: Integration Through Methods in Mixed Methods Research (adapted from Fetters et al., 2013, p. 2140)

Approach	*Description*
Connecting	One database links to the other through sampling
Building	One database informs the data collection approach of the other
Merging	The two databases are brought together for analysis
Embedding	Data collection and analysis link at multiple points

The authors commented that method-level integration is commonly related to a study's research design, the connecting approach is naturally adopted in sequential designs, the merging approach can occur in any design, and the embedding approach generally happens in an interventional design. On the connecting approach, Fetters et al. (2013) clearly stated:

> *Integration through 'connecting' occurs when one type of data links with the other through the sampling frame. For example, consider a study with a survey and qualitative interview. The interview participants are selected from the population of participants who responded to the survey. […] That is, if the baseline survey data are analysed, and then the participants sampled based on findings from the analysis, then the design is explanatory sequential. (pp. 2139–40)*

Coincidently, my research design exactly matches the above description; it satisfies the definition of integration through connecting.

Moreover, regarding the building approach mentioned in Table 4.2, the authors defined that integration through building occurs when the findings of one data collection method inform the approach strategy of the other. In my study, the survey participants contributed a shortlist of perceived essential competencies, which offers a broad understanding of the research topic. To identify the arguments of their perceived competencies, I used the quantitative findings to develop the interview guide and questions for the qualitative research. The objective was to allow my purposively recruited interviewees to answer the interview questions using their judgments and experience. Their insights provided an in-depth understanding of the research topic. Hence, my research design also matches the definition of integration through the building approach.

The interpretation and reporting level presents another position for integration. Fetters et al. (2013) summarized that researchers could incorporate three techniques at this level into their studies. They further defined these three techniques as follows.

- Integrating through narrative: In this technique, researchers integrate the quantitative and qualitative findings in a single or series of reports. Furthermore, there are three approaches to implementing this approach in research reports:
    - Weaving approach – quantitative and qualitative results are presented together, concept by concept, to better interpret the findings.
    - Contiguous approach – both sets of findings are reported in a single report, with the quantitative and qualitative results presented in separate sections.
    - Staged approach – this approach is usually adopted in multistage mixed methods studies; the results of each stage are reported, analyzed and presented separately.
- Integrating through data transformation: Researchers usually walk through two steps in this technique. First, one type of data must be converted into the other type of data (e.g., converting quantitative into qualitative or qualitative into quantitative); second, the transformed data are then integrated with the data not converted. In this technique, a comparison is commonly used in integrating both findings.
- Integrating through joint display: By using visual aids such as figures, tables, matrixes or graphs, researchers integrate quantitative and qualitative findings to extract new insights beyond the knowledge obtained from the quantitative and qualitative results.

In my research, I adopted both techniques in my thesis – integrating through data transformation and joint display. In Chapter 5, which presents the quantitative findings and discussion, the statistical data are analysed, summarized, consolidated, and then converted into a set of competencies which the survey respondents commonly recognize. These competencies are compared and analysed further with the qualitative phase findings.

Regarding integrating through joint display, I adopt this technique in Chapter 5, which discusses integrating the quantitative and qualitative findings. Using a Venn diagram, the competencies are transformed from quantitative data and integrated with the competencies extracted from the qualitative findings.

The explanatory sequential mixed methods research design was adopted in the study, which commenced with quantitative research, followed by qualitative research. I employed this design to explore the essential competencies and the reasons behind them, which the qualitative research could identify. Creswell and Creswell (2018) claimed that this specific research sequence facilitates an 'understanding [of] the story behind the numbers'. Hence, a vital step in such a research design is to 'connect' the quantitative research with the qualitative research by utilizing the quantitative findings to guide the qualitative research design. More precisely, the quantitative findings were used to develop the interview guide, which was used in the qualitative research of this study.

Development of the Interview Guide

I developed an initial semi-structured interview guide based on the research objectives and the existing knowledge regarding the competencies of energy engineers. The quantitative findings contributed a shortlist of perceived essential competencies from the practitioners, which provided the focus for the qualitative research. Participants' perceptions could be further investigated in the qualitative research, in which participants shared their justifications and experiences in greater depth. For example, I did not mention the details of the challenges and opportunities of the Hong Kong energy sector, and the survey participants could make their own assumptions based on their perceived competencies. However, I needed to understand the participants' assumptions on the challenges and opportunities facing the Hong Kong energy sector in the qualitative research. Hence, the following questions were added to the semi-structured interview guide:

- In your opinion, which challenges/opportunities are facing the Hong Kong energy sector?
- To what extent do these challenges/opportunities impact the industry?
- And why?

To verify the validity of my instrument, I again invited my experts to review my interview guide. Except for several minor modifications to the interview flow and wording errors, my interview guide indicated that the flow and all the questions were relevant and meaningful to the qualitative research. The interview guide was then proofread by the English professional editor and translated by the Chinese professional editors to ensure the consistency of both versions and that the interviewees would correctly understand them. The final interview guide was completed by 7 May 2021 and is attached as Appendix F.

Qualitative Research Phase

To study another facet of competencies, I adopted the qualitative research of this study: 1) to understand the interpretation/perceptions about the challenges and opportunities facing the Hong Kong energy sector; and 2) to better understand why these essential competencies were identified in the quantitative research, and therefore, to attach meaning to them.

Whiting (2008) suggested that the individual semi-structured interview is the most appropriate inquiry method to achieve the above purposes while exploring additional topics and facilitating a more detailed response. The activities of this phase comprised the sampling and sample size, the recruitment of participants, the interview process, the translation and transcription of the data, and the data analysis.

Sampling and Sample Size

Morse and Field (1996) proposed that sampling in qualitative research should follow two guidelines: appropriateness and adequacy. Sample appropriateness means that the sampling criteria should focus on participants with high knowledge levels or rich experience of the research topic to ensure high-quality data. Adequacy of sampling refers to the amount of data collected, which should be sufficient to offer a comprehensive and in-depth description of the research topic.

As my study adopted an explanatory sequential mixed methods design, the purpose of the qualitative phase was to gain more insights into the quantitative findings (Creswell and Plano Clark, 2018). To satisfy the appropriateness guideline, I recruited participants with a good understanding of the quantitative findings. Therefore, I purposively invited participants from the quantitative samples to be interviewed for the qualitative research. Participants had to meet the following selection criteria for eligibility: 1) the willingness to be interviewed and to share their perceptions and opinions on the competencies of local energy engineers; and 2) the background to be as close to the survey respondents as possible in terms of demographic characteristics such as gender, age group, work experience, specific fields in the energy sector, etc. This sampling strategy aimed to collect qualitative data with comparable demographic characteristics to the quantitative data, and the qualitative and quantitative data would be compared during the integration phase of this study.

Adequacy was another guideline for sampling, which affected the sample size. In respect of qualitative research, Patton (2002) claimed that sample adequacy is achieved only if sufficient data has been collected to reach data saturation. Data are considered saturated when no new information and insights emerge by conducting further interviews. Even though data saturation is a golden rule for justifying sampling issues in qualitative research, there were no definitive rules for the sample size to reach data saturation. Safman and Sobal (2004) suggested that 20 to 30 participants are required for data extensiveness in a qualitative study using in-depth interviews, while other researchers have recommended that 13 or more samples are needed to achieve data saturation (Guest et al., 2006; Fugard and Potts, 2015; Braun and Clarke, 2016).

To study the perceived competencies proposed by the survey respondents, I recruited some survey respondents as participants in the qualitative research of this study. Collins et al. (2007) noted for studies that adopted explanatory sequential mixed methods research design, the sub-sampling part of the quantitative samples for participating in the qualitative phase of the same research could be a triangulation-validity issue. The explanation for this issue is related to the nature of the explanatory sequential mixed methods design, which I adopted in my study. Creswell and Plano Clark (2018) described the design of explanatory sequential mixed methods research, in which quantitative research is first conducted, followed by qualitative research. There are three typical methods to connect both types of research within a study:

- The quantitative findings determine the participant recruitment in the qualitative research.
- The quantitative findings inform the design of the instrument used in the qualitative research.
- The quantitative findings refine the qualitative and mixed methods questions.

In addition, Kemper et al. (2003) have commented on sampling in sequential mixed methods research:

> *In sequential mixed models' studies, information from the first sample (typically derived from a probability sampling procedure) is often required to draw the second sample (typically derived from a purposive sampling procedure). (p. 284)*

Teddlie and Yu (2007) claimed:

> *In our examination of the literature, we found more examples of QUAN-QUAL studies in which the methodology and/or results from the QUAN strand influenced the methodology subsequently employed in the QUAL strand. In many of these cases, the final sample used in the QUAN strand was then used as the sampling frame for the subsequent QUAL strand. In these studies, the QUAL strand used a subsample of the QUAN sample.*

Creswell and Creswell (2018) shared a similar idea:

> *The data collection [in explanatory sequential mixed methods design] proceeds in two distinct phases with rigorous quantitative sampling in the first phase and with purposeful sampling in the second, qualitative phase. One challenge in this strategy is to plan adequately what quantitative results to follow up on and what participants to gather qualitative data from in the second phase. The key idea is that the qualitative data collection builds directly on the quantitative results. The quantitative results that then are built on may be extreme or outlier cases, significant predictors, significant results relating variables, insignificant results, or even demographics. […] Another challenge is whether the qualitative sample should be individuals that are in the initial quantitative sample. The answer to this question should be that they are the same individuals, because the intent of the design is to follow up the quantitative results and explore the results in more depth. The idea of explaining the mechanism – how the variables interact – in more depth through the qualitative follow-up is a key strength of this design.*

Supported by the above arguments, for studies that adopted explanatory sequential mixed methods research design, using a sub-sample from the quantitative sample is an acceptable sampling strategy for the study's qualitative research. This sampling strategy did not violate the validity of the method triangulation adopted in this study. It is the characteristic and the strength of the explanatory sequential mixed methods research design.

Recruitment of Participants

At the end of my questionnaire, I had a question inviting those who had completed the survey if they wished to participate in the qualitative research phase, which consisted of an in-depth online interview at a later date. Those who agreed to participate in the interview were asked to leave their contact details. Of those 57 survey respondents, 35 provided their contact information indicating their interest in participating in the in-depth online interview. Referring to my sampling criteria mentioned previously, amongst these 35 potential participants, I purposively selected 23 whose backgrounds roughly matched the survey respondents' demographic profile to join the in-depth interview. The interviews were scheduled between 10 May and 28 May 2021. I made contact and interviewed the participants one-by-one until no more themes emerged, indicating data saturation.

In total, I interviewed 19 out of the 23 participants that I initially set out to interview. Having 19 interviewees is acceptable in qualitative research, given that the aim is to build a convincing analytical narrative based on 'richness, complexity and detail' rather than statistical logic. Hence, I believe that my 19 qualitative samples meet the minimum sample size criterion for data saturation mentioned previously.

Interview Process

Before the interview, I prepared myself to be a good interviewer by reading the literature. Bryman (2006) emphasized that the essential skill in conducting interviews is active listening, which requires the interviewer to be mindful by not interrupting the interviewees so that the interviewees can recount their experiences without interference. I also learned that being critical but not challenging is important, especially when clarifying ambiguity with interviewees and demonstrating empathy when necessary. Moreover, I had to become acquainted with the topics of the interviews to follow up on any specific topic of interest (Kvale, 1996).

The interview process was carried out between 10 May and 28 May 2021, and the format was individual, semi-structured online interviews. I contacted the potential interviewees to confirm their willingness to take part in the interviews and requested them to sign and return the informed consent form. The participants were invited to select a convenient date and timeslot and were asked to prepare a mobile device or computer with some online interviewing software such as Zoom, WhatsApp or WeChat.

At the beginning of the interview, I double-checked the signed informed consent form (see Appendix E), stressing that participation in the interview was voluntary and anonymous, and the interviewees could skip any questions if they preferred not to answer. I also emphasised that there were no right or wrong answers to my questions, but I was only interested in participants' personal perspectives. I also reminded participants about the purpose of the research, that is, contextual information about the global and regional energy sector and the challenges and opportunities ahead. All information would be kept strictly confidential, while the conversation would be audio-recorded and transcribed for further analysis.

To elicit an initial response from the participants, I opened each interview with a broad, open-ended question that the interviewee was familiar with. For example, 'Could you please tell me about your work experience in energy engineering?' and 'In your opinion, which competencies are required for you to perform this job?' This opening would allow the interviewees to start talking in a friendly atmosphere before moving on to more complex questions. Following that, inquiries on the obstacles and prospects faced by the Hong Kong energy industry, the competencies needed to respond to the challenges and opportunities ahead, and justifications for specific answers in the preceding questionnaire were then addressed. Still, not all questions in semi-structured interviews are necessarily asked in the same flow. I listened carefully to the interviewees' replies and modified the asking order for each interview. To ensure that all questions were discussed with the interviewees, I conducted the interviews in their chosen language (English, Cantonese or Mandarin). The interviews' durations ranged from 46 to 83 minutes, depending on the information supplied by the participants.

Towards the end of the interview process, very few new codes and themes emerged, which indicated that theme saturation was beginning to appear. Eventually, I interviewed 19 participants from diverse professional backgrounds.

Translation and Transcription

I conducted most of the interviews in Cantonese or Mandarin, the official language spoken in Hong Kong. Then I translated and transcribed each conversation in English with Sonix, a translation and transcription software. However, this software's translation and transcription accuracy is only around 75%, and I handled the remaining work. Due to my language background, I was confident that all the interview conversations' translation and transcription quality was satisfactory. I was born in Hong Kong and culturally and linguistically grew up in a local family; Cantonese is my mother tongue and my primary medium of communication in everyday life. English has been my second language since primary school, and I received my master’s degree at a UK university. In addition, I have worked for over two decades in Mainland China, where most people communicate in Mandarin. With my trilingual training of over 20 years, I was able to handle the linguistic meaning and precision during the translation and transcription process.

Data Analysis

Once the interviews were transcribed, I imported all transcripts into qualitative data analysis software, NVivo Version 12, a platform for storing large bodies of text, graphics, audio, and videos. The significant benefit of using NVivo is that it helped facilitate the coding organization and allocated categories and subcategories systematically so that multiple codes could be retrieved quickly, obviating the need for extensive paper transcripts. With the aid of the software, codes can constantly be compared with each other to look for co-occurring coding that suggests emerging themes or proximity, increasing the data validity and authenticity.

Gilbert (2002) has expressed concerns about the utilization of software. A dominant concern is that the homogenizing coding approach generates fragments of wording (Fielding, 2002), decontextualising the meaning and losing the richness of words. It results in the loss of shades of textual meaning. Another concern about the extensive use of computer assistance is that it diverts the researcher's attention, generating many themes rather than focusing on exploring meaning in depth (Hinchliffe et al., 1997).

I agree that NVivo is a helpful tool for managing extensive data, facilitating efficiency in data location, mapping out how themes relate to each other and achieving efficiency in data analysis procedures. As a freshman of NVivo, after five days of intensive learning and using, I observed that this software does not help much with automatic theme identification. That manual analysis was also required for intellectual interpretation and analysis. However, after considering the cost-effectiveness, I preferred to use the manual method to conduct the qualitative data analysis.

There are different approaches to analysing qualitative data, such as grounded theory, phenomenology, ethnography, action research, narrative analysis, discourse analysis, thematic analysis, and content analysis. Amongst these approaches, I adopted thematic analysis in my study for the following reasons: 1) Thematic analysis helped me to recognize participants' different perspectives on competencies; 2) it highlights similarities and differences so that a clear and organized structure of a competency model can be produced; 3) as an inexperienced qualitative researcher, this approach offers me an easy way to understand and learn about qualitative analysis.

Thematic Analysis

Braun and Clarke (2006) defined thematic analysis as a core descriptive method of 'identifying, analysing and reporting patterns within data' and proposed six-step guidelines for conducting thematic analysis. These guidelines have been extensively used in many multidisciplinary studies. They are often used as a first step to describe and understand phenomena before discovering patterns and developing themes. These guidelines are based on the inductive analysis approach; no predetermined coding frame or analytic preconceptions were used in the data coding process. King (2004) and Braun and Clarke (2006) have commented that thematic analysis is an effective method for exploring the viewpoints of various research participants, identifying similarities and differences, and generating insights. It is beneficial if there is little or no knowledge about the topic under study.

I followed these step-by-step guidelines in this study to reveal the themes from the interview transcripts. The details of these six steps are discussed below.

Step 1: Familiarizing oneself with one's data

This first step implies preparation for the thematic analysis. In this study, there were 19 individual semi-structured online interviews. Immediately after each interview, I spent about half an hour writing my notes and reflections about what had happened during the interview. All anonymous online interviews were audio-recorded in MP3 format and translated and transcribed using the Sonix software, which can translate more than 40 languages and transcribes audio using artificial intelligence technology. A one-hour interview audio file took approximately 20 minutes to translate and transcribe into text, but the translation and transcription accuracy was only about 75%. Hence, I had to spend another two hours correcting mistakes.

To familiarize myself with the interview contents, I listened to the interview recordings several times and read all of the text to obtain a general understanding of the information and have an opportunity to reflect on its overall meaning. While reading the transcripts, I also wrote notes in the margins on issues that arose from the text and highlighted statements, phrases, or words that seemed significant for the research questions.

Step 2: Generating the initial codes

After all the interview transcripts had been iteratively read, I was familiar with the data through reading and reflection, the next step was dissecting the actual text into meaningful text segments using a coding framework. In qualitative research, coding is the reiterative process of 'making notations next to bits of data that strike you as particularly relevant to answering your research questions' (Merriam and Tisdell, 2015). During the reading, I employed three coding methods to generate the initial codes: Open coding was the first method, which involved reading the transcripts line by line, followed by naming and then categorizing the concepts to generate a set of 'codes'. The process of constant comparison is essential in the coding process, where the ideas are compared against one another for similarities and differences and grouped as a code. The second method is axial coding, which 'aims to integrate codes around the axes of central categories' in context, strategy, process, and consequences (Ezzy, 2002). It also considers the relationships between the codes. The last method is selective coding, which refers to the 'identification of the core category or story around which the analysis focuses' (Ezzy, 2002). It involves selecting one core category and associating all other categories. The fundamental concept is to create a single storyline around which everything revolves. The analysis process is not unidirectional but consists of cycles of moving back and forth until the themes are saturated. In this study, I coded the transcripts separately, using the above thematic analysis procedures.

In this step, a manual coding process was adopted to analyse the qualitative data from the interviews. I created a list of significant statements, phrases, and words for each interview to allow codes to emerge during the data analysis. I also used Microsoft Word and Excel software to organise the interviewees' data and highlight meaningful quotes.

Step 3: Searching for themes

After all the transcripts were coded, I studied the text segments again and systematically extracted the lowest-level codes derived from the actual text segments. This process allowed me to identify patterns and recurrent codes across interviewees. Then, these lowest-level codes were grouped to summarize more abstract themes that represent clusters of similar code domains. The resulting network of thematic nodes, crosslinks, and hierarchies enabled the identification of the overarching domains or significant issues raised by interviewees about the research questions. This step helped me to gain a rich understanding of the context.

Step 4: Reviewing themes

I approached this step in three ways. First, I reviewed the extracted codes, identifying patterns, and named each overarching sub-theme. Similar sub-themes across most interviews were highlighted, and all minor sub-themes were kept for further analysis. Second, I reviewed each code with different aims to check whether codes were coherent within the sub-themes and recaptured any data that had been overlooked. Third, I reviewed the sub-themes by assembling similar data into broader groupings (themes). An overall thematic summary table outlining the inter-relationships between themes and sub-themes was then generated (see Table 5.25).

Step 5: Defining and naming themes

Before the last step of producing the report, themes were repeatedly reviewed and revised with the research questions. Eventually, proper, concise names were devised, highlighting the main content of each topic.

Integrating the Quantitative and Qualitative Research Phase

Patton (1999) has argued that no single research method fully resolves the dilemma of rival explanations since each approach discloses distinct parts of reality. Multiple research approaches can supply additional evidence for the study. Hence, the nature of mixed methods research is to incorporate both the quantitative and qualitative findings together (Johnson et al., 2007).

Tashakkori and Creswell (2017) have argued that a mixed methods study starts with solid mixed methods research questions, which ask 'what and how' or 'what and why'. Similarly, Tashakkori et al. (2020) also stated:

> *Mixed methods research questions are often concerned with unknown aspects of a phenomenon; they include a combination of what, why and how inquiries and typically require the collection and analysis of both narrative and numerical data to find useful answers. (p. 105)*

In this study, my first and second research questions are:

- To deal with the energy transition's challenges and opportunities facing the Hong Kong energy sector, what competencies are perceived to be essential by energy engineering practitioners in Hong Kong?
- How do they consider their perceived competencies are essential?

These questions are 'what' and 'why' question types. Furthermore, Patton (1999) and Denzin (2007) proposed four types of triangulation: data triangulation – using multiple data sources in terms of time, space or subjects;

investigator/analyst triangulation – using multiple researchers instead of a single investigator/analyst in data collection and analysis; theory triangulation – using multiple theoretical frameworks in data interpretation; methods triangulation – using multiple research methods in a study. Regarding methods triangulation, Patton (1999) clearly stated:

> *The logic of triangulation is based on the premise that no single method ever adequately solves the problem of rival explanations. Because each method reveals different aspects of empirical reality, multiple methods of data collection and analysis provide more grist for the research mill. […] It is also possible to cut across inquiry approaches and achieve triangulation by combining qualitative and quantitative methods ...*

Denzin (2007) further classified two types of methods triangulation, which are within-method and between-method. Within-method triangulation means that two or more strategies are employed within one method to examine data in a study. For example, several questions using different scales (strategies) within a survey questionnaire (method) measure the same concept or phenomenon. Between-method triangulation, by comparison, combines dissimilar methods to illuminate the same concept or phenomenon.

The nature of mixed methods research is to integrate quantitative and qualitative findings. The findings from either quantitative or qualitative research remain narrow-minded rather than offering broader and different viewpoints to the research questions. In this research, for example, failure to integrate the findings collected from the survey and semi-structured interviews may put the study at risk of providing an incomplete understanding of the competency model for Hong Kong energy engineers. Hence, integration in my research aims to triangulate the quantitative and qualitative findings to determine whether the two research phases are congruent or divergent.

Cohen, Manion, and Morrison (2011) have suggested that triangulation uses two or more data collection methods in the same study of some aspect of human behaviour. Triangular techniques in the social sciences attempted to explain more fully the richness and complexity of human behaviour by studying it from more than one viewpoint and using both quantitative and qualitative data. Triangulation is a powerful way of demonstrating concurrent validity, particularly in qualitative research (p. 195).

Based on the above arguments, I chose the between-method triangulation approach as the triangulation strategy for my study. This strategy suited the mixed methods research methodology I used for this study. Both quantitative and qualitative research methods were used to study the essential competencies of Hong Kong energy engineers.

To achieve my triangulation strategy in this study, I used three different sources of evidence, including 1) the related competency models from various governments and professional bodies for questionnaire development, 2) the quantitative data from the online survey, and 3) the qualitative data from the interviews. Since the objectives of my triangulation strategy were to try to reduce the limitations of using a single method as much as possible and to use qualitative findings to complement quantitative results in exploring the essential competencies, I needed both quantitative data (from data source 2) and qualitative data (from data source 3) for between-method triangulation. Furthermore, to ensure that quantitative and qualitative data were relevant to my study, I investigated a wide range of engineering competency models in Chapter 2, including models from governments, professional bodies, talent development associations, engineering companies, commercial recruitment firms, and academic institutions. After reviewing these published models, I noticed that only the ones established by governments and professional bodies were relevant to my study. These relevant competency models provided me with reliable references of competency items that I used to develop my questionnaire (and obtaining quantitative data) and interview questions (and obtaining qualitative data) for this study.

Hence, this study analysed the quantitative and qualitative data separately, and the integration of both findings occurred during the last phase to achieve the aim of this research, that is, to develop a competency model for energy engineering practitioners in Hong Kong.

Tashakkori and Teddlie (2003) developed a framework to support the comprehension of the integration of quantitative and qualitative data. Such integration required researchers to carefully compare and contrast the findings from each research process, paying close attention to the consistency or discrepancy between findings (O'Cathain at al., 2010). The nature and application of integration resulted in three possible outcomes: convergent findings, complementary findings, and divergent findings. The various consequences of integration are described in the following paragraphs.

Convergent findings occur when quantitative and qualitative results support each other; in this case, both quantitative and qualitative results lead to the same conclusion (Tashakkori and Teddlie, 2003). In my study, if the quantitative and qualitative research findings are identical or match with each other, this study has a convergent conclusion from both research phases. According to the design of this research, the important findings are derived from the quantitative data, while the qualitative data supports the quantitative evidence, further validating these assumptions (Tashakkori and Teddlie, 2003). As a result, the mutual verification of both research results and a potential increase in validity produced by such verification are regarded as the primary goals of the mixed methods design.

Complementary findings emerge when the quantitative and qualitative results are related to different objects or phenomena. Both results might also be compatible and thus supplement one another (Tashakkori and Teddlie, 2003). In my research, if some findings from one research phase are different from the other, while they could supplement each other, this study produced a complementary conclusion. Various methods disclose distinct perspectives and can illuminate various facets of a phenomenon. This study carefully identifies and reconciles the consistent and compatible findings from the quantitative and qualitative approaches to provide a coherent interpretation and explanation of the perceived competencies. Finally, a competency model based on interpretation and compatibility is constructed.

Divergent findings emerge when the quantitative and qualitative results are not compatible with each other. In this case, the designs of the two approaches should be re-examined. If the incompatible results can be attributed to methodological flaws, such as the small sample size or instrument errors, the researcher can treat this as a study limitation. Otherwise, other reasons for inconsistent results might emerge, such as an initiation that uncovered paradoxes and contradictions to reframe new questions. In this case, the inconsistencies in the results directly reflect the complexity of the research phenomenon, which a single approach cannot capture. Still, new knowledge or hypotheses are probable to be generated. Furthermore, this can lead to new insights discovery or new hypotheses generation for further investigation.

Ethical Measures

To conduct this study ethically, I carefully considered and implemented the following measures.

No data collection activities began until the final ethical approval for this research study was obtained from the Trans-Disciplinary DProf. Research Ethics Committee on 26 March 2021 (see Appendix A).

In April, I informed all survey participants of the purpose, procedures, and their involvement in this study. Before the survey, they were asked to sign a bilingual written consent form (see Appendix E). In the consent form, participants were informed of their right to withdraw at any time at their discretion. Also, the researcher was responsible for ensuring the confidentiality and anonymity of the data by using a coding system for the data collection and keeping the consent forms (which had subjects' names, telephone numbers and email addresses) in password-protected and encrypted files, stored on Microsoft OneDrive. No hard copy was used for the questionnaire, and all digital questionnaire data were password protected, encrypted and stored on Microsoft OneDrive.

The participants in the qualitative study were informed that the researcher would only conduct the individual online interviews; no third party would join the interviews. They were also informed of their right to withdraw from the study at any time at their discretion. During the interview, the researcher encouraged the participants to talk about their justifications for the perceived essential competencies of Hong Kong energy engineers. Participants were assured that there were no right or wrong answers and that the researcher was only interested in hearing their perspectives and ideas on the research topic. All online interviews were audio-recorded in digital format, and all digital recordings were protected by strong passwords and encryption and stored on Microsoft OneDrive. The researcher only processed the transcription, while the digital transcripts were password protected, encrypted, and stored on Microsoft OneDrive. All transcripts identified the interviewees by a code rather than by name. In addition, each interviewee received a copy of their interview recording for reference.

Throughout the research study, all data, such as digital questionnaire data, digital interview recordings, and transcripts, were accessed only on private premises and using private computers. After five years, all data will be erased permanently.

Summary and Discussion

In this chapter, I explained every research activity in detail. As I had adopted an explanatory sequential mixed methods design for my study, I planned that the quantitative research would constitute the first phase of my research. The purpose was to collect the perceived essential competencies from energy engineering practitioners in Hong Kong using a survey. The survey instrument was a questionnaire; the list of competency items was extracted from government and professional bodies' published engineering competency models worldwide.

Due to the COVID-19 pandemic in Hong Kong, I relocated the traditional survey to an online platform to secure participants' safety. In addition, my planned recruitment of participants was derailed entirely, as the pandemic was unlikely to be over soon. To continue my research, I was obliged to employ a new way of recruiting the sample of survey respondents while still ensuring the sample's representativeness and safe social distancing. By studying the literature on sampling, I solved this dilemma by employing snowball sampling, an acceptable equivalent random sampling method, if the first wave of participants was selected as randomly as possible. By sending out emails with hyperlinks to my online questionnaire, I invited ten local energy engineering participants in my network to join the survey. I also asked them to forward my invitations to their friends working in this sector. A total of 57 respondents participated in my survey. Descriptive analysis was then used to analyse the collected quantitative data. The findings provided me with the essential competencies perceived by Hong Kong energy engineers.

The study's second phase planned to connect the quantitative research to the qualitative research. The purpose of this phase was to design an appropriate instrument for use in qualitative research. By studying the quantitative findings, I developed a set of interview protocols and interview questions.

The qualitative research constituted the third phase of this study. Individual semi-structured interviews were used for the qualitative data collection. I wanted to know why the participants selected the competencies identified in the quantitative research. These reasons provided the meaning to the essential competencies.

Again, I could not physically interview my invited interviewees due to the spread of the COVID-19 pandemic in Hong Kong at that time. Hence, online interviews were the only solution. Regarding the samples, I purposively recruited some survey respondents to be interviewed. The interview conversations were recorded and subsequently transcribed, and then I applied thematic analysis to study the qualitative data and extract the themes of the competencies. The themes obtained from the thematic analysis provided meaning in terms of the selected competencies identified in the quantitative research and informed me about the categories of competencies.

Chapter 5: Findings

Overview

As my study adopted an exploratory sequential mixed methods methodology, the quantitative research was conducted first, followed by the qualitative research. The last but critical phase was the integration of both research findings. This chapter presents, in chronological order, the findings of these three phases. I first discuss the quantitative findings, followed by the qualitative findings, and demonstrate the integration of both findings.

The Quantitative Findings

The quantitative research constituted the first part of this study: It aimed to collect the general perceptions of local energy engineering practitioners on the essential competencies required to tackle the challenges of the energy transition. These perceived competencies were analysed and influenced the qualitative research design. In this section, I present the demographic profiles of the survey respondents, the quantitative findings, and the essential competencies identified by the participants.

The first research question that guided the quantitative research was: 'What competencies do Hong Kong energy engineers perceive to be essential for the challenges and opportunities facing the local energy sector?' Its purpose was to investigate the essential competencies perceived by energy engineering practitioners in Hong Kong. A total of 57 respondents' data were collected through an online questionnaire on the Qualtrics platform and were imported into IBM SPSS Version 25 for data analysis. The following sections present the survey respondents' demographic profiles and the descriptive analysis findings.

Survey Respondents' Demographic Profiles

The participants in this study were Hong Kong energy engineering practitioners recruited by snowball sampling. After I sent out ten invitation emails to the first round of potential participants around the end of March 2021, these ten potential participants volunteered to forward my invitation to other local engineers they knew. The participants were invited to complete an online survey comprising 36 items, seven demographic questions and 28 close-ended questions. As I had no control over participants' invitations, I cannot provide a response rate for this survey. A total of 57 respondents' data had been collected on the Qualtrics platform by the end of the survey period.

Table 5.1 reveals the gender of the respondents who participated in the survey. Of the 57 respondents, 48 were males, and eight were females, representing 84.2% and 14.0%, respectively. One respondent preferred not to reply to the question about gender representing 1.8%. This data reflects that the energy sector in Hong Kong is male-dominated. This finding matches the phenomenon mentioned in the report, Work to Do: Women in Male-Dominated Industries in Hong Kong (The Women's Foundation, 2014).

Table 5.1: Demographic Characteristics – Gender

Gender	Count (n)	Percentage (%)
Male	48	84.2
Female	8	14.0
Others	0	0.0
Prefer not to reply	1	1.8
Total	**57**	**100.0**

The age group statistics are presented in Table 5.2. As the table indicates, the age of the respondents who participated in this survey varies between 21 and 70. More specifically, the age group 31–40 years showed the highest frequency, with 29 respondents accounting for 50.9% of the respondents. This age group was followed by the age group 21–30 years and then the age group 41–50 years, accounting for 21.1% (n = 12) and 12.3% (n = 7), respectively. The age groups between 21 and 50 accounted for 84.3% of all respondents, while the remaining respondents were distributed between the age group 51–60 years, at 7.0% (n = 4), and the age group 61–70 years, at 5.3% (n = 3). No respondents younger than 21 or older than 70 were indicated, and two did not provide their ages, representing 3.5% (n = 2). According to the Organization for

Economic Corporation and Development's definition of working age (15 – 64), over 90% of the respondents belong to the working-age population.

Table 5.2: Demographic Characteristics – Age Group

Age group	Count (n)	Percentage (%)
< 21	0	0.0
21 – 30	12	21.1
31 – 40	29	50.9
41 – 50	7	12.3
51 – 60	4	7.0
61 – 70	3	5.3
> 70	0	0.0
Prefer not to reply	2	3.5
Total	**57**	**100.0**

The educational attainment of the respondents is presented in Table 5.3. In this survey, 28 respondents had obtained bachelor's degrees, accounting for 49.1%, followed by 15 master's degrees or equivalent holders, at 26.3%. Those with doctoral and associated degrees or equivalent account for the same percentage of total respondents, namely 8.8% (n = 5) in both cases. No respondents had post-doctoral qualifications, and three had obtained other qualifications, 5.3% (n = 3). One respondent did not disclose their educational information in the survey, 1.8% (n = 1). This phenomenon indicates that the energy engineering sector revolves around well-educated practitioners.

Table 5.3: Demographic Characteristics – Educational Attainment

Educational attainment	Count (n)	Percentage (%)
Associate degree / High diploma / High certificate	5	8.8
Bachelor's degree	28	49.1
Master's degree / Professional diploma / Advanced diploma	15	26.3
Doctor degree	5	8.8
Post-doctor	0	0.0
Others	3	5.3
Prefer not to reply	1	1.8
Total	**57**	**100.0**

Table 5.4 presents the statistics on the respondents' current employment status. Almost all respondents are employed full-time, at 89.5% (n = 51). Of the six remaining respondents, two are self-employed, at 3.5% (n = 2), one is employed part-time, at 1.8% (n = 1), and the other is looking for a job or jobless, at 1.8% (n = 1). The last two respondents are categorized as 'other employment status', at 3.5% (n = 2). No retired respondents participated in this survey. Hence, it can be assumed that the employment rate in the energy sector is extremely high.

Table 5.4: Demographic Characteristics – Employment Status

Employment status	Count (n)	Percentage (%)
Unemployed / looking for a job	1	1.8
Part-time employed	1	1.8
Full-time employed	51	89.5
Self employed	2	3.5
Retired	0	0.0
Others	2	3.5
Total	**57**	**100.0**

Table 5.5 presents the respondents' work experience in the engineering sector. As evident from the table, the respondents in the range of 9 to 12 years of experience indicated the highest frequency, with 14 practitioners (24.6%), followed by those who had less than five years of experience, then those with more than 20 years of work experience in the engineering sector, and lastly those with 13 (22.8%) and 11 years (19.3%), respectively. The top three percentages account for two-thirds of the sample, while the distribution of the remaining one-third is: those who had 5–8 years of experience, which accounted for 14.0% (n = 8); those who had 13–16 years of experience, which accounted for 12.4% (n = 7), and those who had 17–20 years of work experience, which accounted for 7.0% (n = 4). This pattern indicates that engineers are well-trained and experienced. This experience is expected to be an asset for developing the whole industry. The years of work experience match the pattern for the age categories of the participants. A high percentage of the participants had spent many years in the engineering sector.

Table 5.5: Demographic Characteristics – Work Experience

Work experience	Count (n)	Percentage (%)
< 5 years	13	22.8
5 – 8 years	8	14.0
9 – 12 years	14	24.6
13 – 16 years	7	12.3
17 – 20 years	4	7.0
> 20 years	11	19.3
Total	**57**	**100.0**

Even though the territory of Hong Kong is tiny, there are various fields in her energy sector. Table 5.6 presents the statistics about the field(s) in the energy sectors represented by the survey respondents. As energy engineering practitioners might move to different fields during their careers to continue contributing to the Hong Kong energy sector, the respondents could have selected more than one option in replying to this question. In analysing the data, I observed an exceptional data item where one respondent selected all fields except the 'Others' option. After studying all the responses from this participant, I believe the possibility of being involved in seven fields in the energy sector is extremely low, and therefore excluded this abnormal data item from the findings. Hence, in this survey, 56 respondents provided a total of 65 data items, where 49 respondents had selected one field, five respondents had selected two fields, and two respondents had selected three fields. In this data set, the field most frequently selected was 'New energy related', at 30.8% (n = 20), followed by the two second largest fields, namely 'Electrical equipment related' and 'Electrical valued-added equipment/services related', at 13.8% (n = 9), respectively. The order of the remaining fields is: 'Power equipment related' – 12.3% (n = 8), 'Others' – 10.7% (n = 7), 'Power supply related' – 9.2% (n = 6), and 'Petroleum products related' – 9.2% (n = 6). No respondents are involved in the field of 'Gas fuels related'. The respondents of this sample cut across different fields in which energy engineers are engaged, such as petroleum-related, electricity supply-related, equipment and services-related, and new energy-related. The data matches the energy supply in Hong Kong, which is dominated by electricity, with a developing trend in new energy.

Table 5.6: Demographic Characteristics – Field(s) of the Energy Sector

Field(s) in energy sector	Count (n)	Percentage (%)
Petroleum products related	6	9.2
Gas fuels related	0	0.0
Power supply related	6	9.2
Power equipment related	8	12.3
Electrical equipment related	9	13.8
Electrical valued-added equipment/services related	9	13.8
New energy related	20	30.8
Others	7	10.8
Total	**65**	**100.0**

The purpose of collecting the decision span of engineering work experience in the questionnaire was to indirectly reflect the level of rank or job duties of the respondents in the corporation. Since the job titles of similar job duties in different corporations might not be the same, while the same job titles from various companies might have different job duties, it is not easy to understand the rank level of respondents in their enterprises. Therefore, I assumed from this survey question that the practitioners of higher rank or with more job duties should have a larger decision span throughout the corporation. The measurement unit of decision span was defined as the approximate number of people in the corporation affected by a decision of the respondents. In Table 5.7, the statistics of the decision span are presented. More than half of the respondents' decision span lay between 10 and 99 people, at 50.9% (n = 29), while the second largest group's decision span was less than nine people, at 36.8% (n = 21). The seven remaining respondents are distributed in the following two large decision span groups: 1) between 1000 and 9999 people, which shared 7.0% (n = 4); and 2) between 100 and 999 people, which occupied the remaining portion, 5.3% (n = 3).

Table 5.7: Demographic Characteristics – Decision Span

Decision span	Count (n)	Percentage (%)
< 9 people	21	36.8
10 – 99 people	29	50.9

100 – 999 people	3	5.3
1000 – 9999 people	4	7.0
> 10000 people	0	0.0
Total	**57**	**100.0**

Overall, the demographic profile of this sample can be summarized as follows: over 84% are male; ages ranged from 21 to 70 while the median age group was between 31 and 40; more than 84% possessed bachelor's degrees or above; almost 90% were full-time employed; there is a wide spread of work experience, from less than five years to over 20 years, with the median length of work experience between nine and 12 years; 80% is involved in areas related to new energy, power and electricity; and over 87% manage fewer than 100 people.

Findings of the Descriptive Analysis

After reviewing the survey respondents' demographic profiles, it was necessary to identify the competencies that they viewed as essential for energy engineering practitioners in Hong Kong. Table 5.8 provides an item-level summary of the descriptive statistics for each competency, including the count, percentage, mean value and standard deviation for each item. This table was ordered by mean values; relatively essential competencies perceived by the respondents could also be observed. The mean values of all competency items, except the last one, lay between 5.16 and 5.98 (out of 7), reflecting that the respondents' general perceptions of these competencies tend to be significant. The standard deviation values of all items lay between 0.82 and 1.28 (close to 1), which indicates a relatively high central tendency.

Table 5.8: Item-Level Statistics Summary of the Survey (n = 57)

Perceived competence	Responses																
	1		2		3		4		5		6		7		Mean	SD
	n	%	n	%	n	%	n	%	n	%	n	%	n	%		
Safety awareness	0	0.0	0	0.0	2	3.5	1	1.8	15	26.3	17	29.8	22	38.6	5.98	1.03
Compliance	0	0.0	0	0.0	2	3.6	3	5.5	12	21.8	17	30.9	21	38.2	5.95	1.08
Lifelong learning	0	0.0	1	1.8	0	0.0	3	5.3	16	28.1	17	29.8	20	35.1	5.89	1.06
Teamwork	0	0.0	0	0.0	2	3.5	3	5.3	15	26.3	20	35.1	17	29.8	5.82	1.04
Ethics and professional conduct	0	0.0	0	0.0	2	3.5	5	8.8	12	21.1	20	35.1	18	31.6	5.82	1.09
Technology awareness	0	0.0	0	0.0	2	3.6	3	5.4	15	26.8	19	33.9	17	30.4	5.82	1.05
Professional knowledge	0	0.0	1	1.8	2	3.5	3	5.3	10	17.5	26	45.6	15	26.3	5.81	1.11
Effective communication	0	0.0	0	0.0	3	5.3	4	7.0	15	26.3	16	28.1	19	33.3	5.77	1.15
Organizing	0	0.0	0	0.0	1	1.8	4	7.0	17	29.8	20	35.1	15	26.3	5.77	0.98
Productivity control	0	0.0	0	0.0	0	0.0	7	12.3	17	29.8	19	33.3	14	24.6	5.70	0.98
Information management	0	0.0	0	0.0	0	0.0	4	7.0	21	36.8	21	36.8	11	19.3	5.68	0.87
Directing	0	0.0	0	0.0	2	3.5	4	7.0	14	24.6	28	49.1	9	15.8	5.67	0.95
Craftsmanship	0	0.0	1	1.8	1	1.8	5	8.9	12	21.4	28	50.0	9	16.1	5.64	1.03
Judgement & decision making	0	0.0	1	1.8	2	3.6	4	7.1	16	28.6	19	33.9	14	25.0	5.64	1.15
Engineering practices	0	0.0	0	0.0	0	0.0	4	7.0	24	42.1	21	36.8	8	14.0	5.58	0.82
Social awareness	0	0.0	0	0.0	0	0.0	6	10.9	20	36.4	21	38.2	8	14.5	5.56	0.88
Self-management	0	0.0	0	0.0	0	0.0	6	10.7	25	44.6	13	23.2	12	21.4	5.55	0.95
Environment & sustainability awareness	0	0.0	0	0.0	3	5.3	5	8.8	15	26.3	26	45.6	8	14.0	5.54	1.02
Engineering projects management	0	0.0	1	1.8	0	0.0	6	10.5	18	31.6	24	42.1	8	14.0	5.54	0.98
Research skills	0	0.0	1	1.8	2	3.6	4	7.1	18	32.1	22	39.3	9	16.1	5.52	1.08
Self-motivation	0	0.0	0	0.0	2	3.5	7	12.3	18	31.6	23	40.4	7	12.3	5.46	0.98
Vision & insight	0	0.0	0	0.0	1	1.8	9	15.8	16	28.1	26	45.6	5	8.8	5.44	0.93
Change management	0	0.0	0	0.0	3	5.3	10	17.5	16	28.1	17	29.8	11	19.3	5.40	1.15
Intercultural abilities	0	0.0	0	0.0	2	3.5	14	24.6	17	29.8	13	22.8	11	19.3	5.30	1.15
Creativity	0	0.0	0	0.0	3	5.4	10	17.9	20	35.7	17	30.4	6	10.7	5.23	1.04
Academic knowledge	0	0.0	1	1.8	3	5.3	9	15.8	17	29.8	24	42.1	3	5.3	5.21	1.06
Worldviews	0	0.0	3	5.3	2	3.5	10	17.5	18	31.6	16	28.1	8	14.0	5.16	1.28
Foreign languages abilities	0	0.0	2	3.5	5	8.8	13	22.8	21	36.8	12	21.1	4	7.0	4.84	1.18
Remarks: Responses rated from 1 (Not important at all) to 7 (Crucial)																	

To further study essential competencies perceived by survey respondents, I categorized the quantitative data by various demographic factors, reflecting the competencies perceived by different demographic groups. The findings are presented as follows.

Gender is the first demographic factor to be investigated. Table 5.9 displays the descriptive statistics categorized by gender, highlighting the difference in perceived competencies between male and female engineers. For female engineers, the top seven (25%) competencies' mean values varied from 6 to 6.25, while the corresponding mean values of male engineers lay between 5.79 and 5.98 only. It reflects that their perceived importance levels were not close. Additionally, I was surprised to notice that, amongst the top ten essential competencies, only four competencies were in common, and their rankings were slightly different from each other. These four common competencies were: safety awareness, compliance, professional knowledge, and ethics and professional conduct.

Table 5.9: Descriptive Statistics – by Gender

Perceived competence (Male)	n	Mean	SD
Safety awareness	48	5.98	1.04
Lifelong learning	48	5.96	1.07
Teamwork	48	5.92	0.96
Compliance	46	5.89	1.08
Organizing	48	5.83	1.00
Technology awareness	47	5.81	1.06
Effective communication	48	5.79	1.09
Ethics and professional conduct	48	5.77	1.04
Professional knowledge	48	5.71	1.15
Productivity control	48	5.69	0.99
Information management	48	5.65	0.89
Directing	48	5.63	0.98
Craftsmanship	47	5.62	1.07
Judgement & decision making	47	5.62	1.13
Self-management	47	5.57	0.90
Self-motivation	48	5.56	1.01
Engineering practices	48	5.52	0.82
Environment & sustainability awareness	48	5.52	1.05
Engineering projects management	48	5.52	0.99
Change management	48	5.48	1.17
Social awareness	46	5.48	0.89
Research skills	47	5.45	1.12
Vision & insight	48	5.40	0.89
Intercultural abilities	48	5.38	1.08
Worldviews	48	5.29	1.27
Creativity	47	5.23	1.05
Academic knowledge	48	5.23	1.04
Foreign languages abilities	48	4.81	1.21

Perceived competence (Female)	n	Mean	SD
Professional knowledge	8	6.25	0.71
Compliance	8	6.13	1.13
Engineering practices	8	6.00	0.76
Ethics and professional conduct	8	6.00	1.41
Social awareness	8	6.00	0.76
Safety awareness	8	6.00	1.07
Directing	8	6.00	0.76
Judgement & decision making	8	5.88	1.36
Vision & insight	8	5.88	0.99
Research skills	8	5.88	0.83
Technology awareness	8	5.75	1.04
Effective communication	8	5.75	1.58
Craftsmanship	8	5.75	0.89
Environment & sustainability awareness	8	5.75	0.89
Information management	8	5.75	0.71
Lifelong learning	8	5.63	1.06
Engineering projects management	8	5.63	1.06
Productivity control	8	5.63	0.92
Self-management	8	5.50	1.31
Organizing	8	5.50	0.93
Creativity	8	5.38	1.06
Teamwork	8	5.25	1.39
Academic knowledge	8	5.13	1.36
Self-motivation	8	5.00	0.53
Foreign languages abilities	8	5.00	1.07
Change management	8	4.88	0.99
Intercultural abilities	8	4.75	1.49
Worldviews	8	4.50	1.20

After comparing the perceived essential competencies between male and female engineers, the data were further investigated by age group. All data were distributed into five age groups, 21-30, 31-40, 41-50, 51-60, and 61-70, respectively. The 21-30 and 31-40 age groups accounted for 72% of the sample data. Except for the 41-50 age group, all age groups' mean values of their top three competencies are over 6. All three survey respondents in the 61-70 age group rated the top two competencies 7 points, which were ethics and professional conduct, and safety awareness. The comparisons of the perceived essential competencies amongst various age groups are displayed in Table 5.10.

Concerning each age group's top ten essential competencies, no competency in common is found among all five age groups. Instead, five competencies in common are noticed in four age groups, three competencies in common are observed in three age groups, and nine competencies in common are recognized in two age groups. The details of the above findings are presented in Table 5.11.

Table 5.10: Descriptive Statistics – by Age Group

Perceived competence (Age 31 - 40)	n	Mean	SD
Lifelong learning	29	6.21	0.82
Safety awareness	29	6.14	0.83
Organizing	29	6.00	0.80
Directing	29	5.97	0.73
Ethics and professional conduct	29	5.93	1.03
Compliance	28	5.89	1.10
Information management	29	5.86	0.74
Professional knowledge	29	5.83	0.97
Technology awareness	29	5.83	0.93
Teamwork	29	5.83	1.04
Research skills	28	5.82	0.86
Effective communication	29	5.79	1.18
Engineering practices	29	5.69	0.89
Productivity control	29	5.69	0.97
Engineering projects management	29	5.66	0.77
Craftsmanship	29	5.62	1.08
Self-management	28	5.61	0.99
Environment & sustainability awareness	29	5.59	0.82
Judgement & decision making	29	5.59	1.02
Vision & insight	29	5.55	0.78
Change management	29	5.52	1.12
Social awareness	28	5.46	0.84
Self-motivation	29	5.45	0.99
Creativity	28	5.43	1.00
Academic knowledge	29	5.21	0.98
Intercultural abilities	29	5.17	1.36
Worldviews	29	4.86	1.33
Foreign languages abilities	29	4.62	1.01

Perceived competence (Age 21 - 30)	n	Mean	SD
Technology awareness	11	6.27	1.19
Judgement & decision making	11	6.09	1.22
Professional knowledge	12	6.08	1.16
Effective communication	12	6.00	1.21
Craftsmanship	11	6.00	1.10
Compliance	11	6.00	1.18
Lifelong learning	12	5.92	0.90
Teamwork	12	5.92	1.24
Self-management	12	5.83	0.83
Environment & sustainability awareness	12	5.83	0.72
Social awareness	11	5.82	0.87
Safety awareness	12	5.75	0.97
Information management	12	5.75	0.97
Engineering practices	12	5.67	0.65
Productivity control	12	5.67	1.07
Organizing	12	5.67	1.07
Worldviews	12	5.67	0.98
Self-motivation	12	5.58	0.90
Vision & insight	12	5.58	1.08
Change management	12	5.58	1.08
Research skills	12	5.58	1.24
Intercultural abilities	12	5.58	1.08
Ethics and professional conduct	12	5.42	1.00
Engineering projects management	12	5.42	0.90
Academic knowledge	12	5.33	0.98
Directing	12	5.33	1.07
Creativity	12	5.25	1.22
Foreign languages abilities	12	5.00	1.28

Perceived competence (Age 41 - 50)	n	Mean	SD
Productivity control	7	5.43	1.13
Compliance	7	5.43	0.98
Teamwork	7	5.29	0.76
Ethics and professional conduct	7	5.29	1.38
Social awareness	7	5.29	0.95
Safety awareness	7	5.29	1.70
Self-motivation	7	5.14	1.35
Organizing	7	5.14	1.35
Information management	7	5.14	0.90
Engineering practices	7	5.00	0.82
Technology awareness	7	5.00	1.15
Effective communication	7	5.00	1.15
Craftsmanship	7	5.00	1.15
Intercultural abilities	7	5.00	0.58
Creativity	7	4.86	1.21
Engineering projects management	7	4.86	1.68
Vision & insight	7	4.86	1.21
Directing	7	4.86	1.35
Professional knowledge	7	4.71	1.38
Self-management	7	4.71	0.49
Lifelong learning	7	4.71	1.60
Judgement & decision making	7	4.71	1.50
Worldviews	7	4.71	1.60
Academic knowledge	7	4.57	1.62
Change management	7	4.57	1.51
Research skills	7	4.57	1.51
Environment & sustainability awareness	7	4.43	1.62
Foreign languages abilities	7	4.43	1.72

Perceived competence (Age 51 - 60)	n	Mean	SD
Compliance	4	6.50	1.00
Lifelong learning	4	6.00	0.82
Effective communication	4	6.00	0.82
Safety awareness	4	6.00	1.15
Directing	4	6.00	0.82
Professional knowledge	4	5.75	0.96
Self-management	4	5.75	0.96
Ethics and professional conduct	4	5.75	0.96
Judgement & decision making	4	5.75	0.96
Productivity control	4	5.75	0.96
Organizing	4	5.75	0.96
Worldviews	4	5.75	0.50
Engineering practices	4	5.50	1.00
Technology awareness	4	5.50	0.58
Teamwork	4	5.50	1.00
Craftsmanship	4	5.50	0.58
Environment & sustainability awareness	4	5.50	1.00
Engineering projects management	4	5.50	1.00
Research skills	4	5.50	0.58
Intercultural abilities	4	5.50	0.58
Self-motivation	4	5.25	0.50
Social awareness	4	5.25	1.26
Foreign languages abilities	4	5.25	0.50
Academic knowledge	4	5.00	0.82
Vision & insight	4	5.00	0.00
Change management	4	5.00	0.82
Information management	4	4.75	0.50
Creativity	4	4.50	0.58

Perceived competence (Age 61 - 70)	n	Mean	SD
Ethics and professional conduct	3	7.00	0.00
Safety awareness	3	7.00	0.00
Professional knowledge	3	6.67	0.58
Teamwork	3	6.67	0.58
Environment & sustainability awareness	3	6.67	0.58
Judgement & decision making	3	6.67	0.58
Self-motivation	3	6.33	0.58
Effective communication	3	6.33	1.15
Social awareness	3	6.33	0.58
Engineering projects management	3	6.33	1.15
Foreign languages abilities	3	6.33	0.58
Worldviews	3	6.33	0.58
Academic knowledge	3	6.00	0.00
Craftsmanship	3	6.00	0.00
Vision & insight	3	6.00	1.00
Productivity control	3	6.00	1.00
Compliance	3	6.00	1.00
Engineering practices	3	5.67	0.58
Technology awareness	3	5.67	1.15
Self-management	3	5.67	1.53
Lifelong learning	3	5.67	1.53
Change management	3	5.67	1.15
Directing	3	5.67	0.58
Information management	3	5.67	1.15
Creativity	3	5.33	0.58
Organizing	3	5.33	1.15
Intercultural abilities	3	5.33	1.15
Research skills	3	4.67	0.58

Table 5.11: Top Ten Important Competencies - by Age Group

Perceived competency	**Age 21-30**	**Age 31-40**	**Age 41-50**	**Age 51-60**	**Age 61-70**
recognized by 4 age groups to be important:					
Ethics and professional conduct		✓	✓	✓	✓
Safety awareness		✓	✓	✓	✓
Professional knowledge	✓	✓		✓	✓
Teamwork	✓	✓	✓		✓
Compliance	✓	✓	✓	✓	
recognized by 3 age groups to be important:					
Effective communication	✓			✓	✓
Judgement & decision-making	✓			✓	✓
Lifelong learning	✓	✓		✓	
recognized by 2 age groups to be important:					
Social awareness			✓		✓
Self-motivation			✓		✓
Environment & sustainability awareness	✓				✓
Productivity control			✓	✓	
Directing		✓		✓	
Self-management	✓			✓	
Organizing		✓	✓		
Information management		✓	✓		
Technology awareness	✓	✓			

The data were further analysed by educational attainment aspect. Table 5.12 demonstrates the perception differences among various educational attainments. In this analysis, respondents possessing bachelor's and master's degrees accounted for 75.4%. The mean values of almost competencies of these two groups were over 5, which provided a dominant indication in this respect.

Regarding each educational attainment group's top ten essential competencies, safety awareness is the only critical competency agreed upon by all five groups; four groups support that compliance, lifelong learning, professional knowledge, and effective communication are important competencies; three competencies in common are observed in three groups, and two groups recognize another six competencies as necessary. Table 5.13 summarizes the above findings.

Table 5.12: Descriptive Statistics – by Educational Attainment

Perceived competence (Bachelor)	n	Mean	SD
Lifelong learning	28	6.18	0.82
Safety awareness	28	6.11	0.92
Effective communication	28	6.00	1.05
Teamwork	28	5.96	1.04
Professional knowledge	28	5.93	1.15
Information management	28	5.93	0.77
Compliance	26	5.92	1.20
Judgement & decision making	27	5.89	1.01
Directing	28	5.86	0.76
Research skills	27	5.85	0.95
Organizing	28	5.82	0.82
Technology awareness	27	5.81	1.11
Engineering practices	28	5.75	0.80
Environment & sustainability awareness	28	5.71	0.71
Ethics and professional conduct	28	5.68	1.12
Self-management	27	5.67	0.92
Craftsmanship	27	5.67	1.24
Self-motivation	28	5.61	0.92
Intercultural abilities	28	5.61	1.20
Social awareness	26	5.58	0.86
Engineering projects management	28	5.57	0.79
Productivity control	28	5.57	0.96
Vision & insight	28	5.50	0.96
Change management	28	5.43	1.03
Creativity	27	5.37	1.11
Academic knowledge	28	5.32	1.02
Worldviews	28	5.25	1.11
Foreign languages abilities	28	4.71	1.18

Perceived competence (Master/PD/AdvDip)	n	Mean	SD
Productivity control	15	6.07	0.96
Ethics and professional conduct	15	6.00	1.07
Technology awareness	15	5.93	1.28
Teamwork	15	5.93	0.88
Safety awareness	15	5.93	1.10
Organizing	15	5.93	1.10
Compliance	15	5.93	1.03
Professional knowledge	15	5.80	1.01
Effective communication	15	5.73	1.22
Engineering projects management	15	5.73	1.22
Craftsmanship	15	5.67	0.72
Judgement & decision making	15	5.67	1.35
Change management	15	5.67	1.45
Self-management	15	5.60	1.06
Directing	15	5.60	0.83
Lifelong learning	15	5.53	1.36
Social awareness	15	5.53	0.99
Information management	15	5.53	0.74
Vision & insight	15	5.47	1.06
Engineering practices	15	5.40	0.74
Creativity	15	5.40	0.83
Environment & sustainability awareness	15	5.33	1.40
Self-motivation	15	5.27	0.96
Foreign languages abilities	15	5.27	1.39
Academic knowledge	15	5.20	1.32
Research skills	15	5.07	1.22
Intercultural abilities	15	5.07	0.96
Worldviews	15	5.07	1.67

Perceived competence (AD/HD/HC)	n	Mean	SD
Ethics and professional conduct	5	6.40	0.55
Self-motivation	5	6.20	1.10
Lifelong learning	5	6.20	1.10
Craftsmanship	5	6.20	0.45
Safety awareness	5	6.20	0.84
Professional knowledge	5	6.00	0.71
Engineering practices	5	6.00	0.71
Teamwork	5	6.00	1.00
Social awareness	5	6.00	0.71
Effective communication	5	5.80	1.30
Environment & sustainability awareness	5	5.80	0.84
Engineering projects management	5	5.80	1.10
Productivity control	5	5.80	0.84
Organizing	5	5.80	1.30
Compliance	5	5.80	0.84
Technology awareness	5	5.60	0.55
Vision & insight	5	5.60	0.55
Change management	5	5.60	0.89
Directing	5	5.60	1.67
Information management	5	5.60	1.34
Worldviews	5	5.60	1.34
Academic knowledge	5	5.40	0.55
Self-management	5	5.40	1.14
Creativity	5	5.40	1.14
Judgement & decision making	5	5.20	1.30
Research skills	5	5.20	1.48
Intercultural abilities	5	5.00	1.41
Foreign languages abilities	5	4.40	1.14

Perceived competence (Doctor)	n	Mean	SD
Compliance	5	6.20	1.10
Technology awareness	5	6.00	0.00
Ethics and professional conduct	5	6.00	1.22
Organizing	5	6.00	0.71
Lifelong learning	5	5.80	1.10
Safety awareness	5	5.80	1.10
Productivity control	5	5.80	0.84
Research skills	5	5.80	0.45
Professional knowledge	5	5.60	1.14
Effective communication	5	5.60	1.14
Social awareness	5	5.60	0.89
Judgement & decision making	5	5.60	1.14
Engineering practices	5	5.40	1.14
Self-management	5	5.40	1.14
Teamwork	5	5.40	1.14
Environment & sustainability awareness	5	5.40	1.52
Directing	5	5.40	1.52
Information management	5	5.40	0.55
Engineering projects management	5	5.20	1.10
Vision & insight	5	5.20	0.84
Academic knowledge	5	5.00	0.71
Self-motivation	5	5.00	0.00
Craftsmanship	5	5.00	1.22
Change management	5	5.00	0.71
Foreign languages abilities	5	5.00	0.71
Intercultural abilities	5	4.80	0.84
Worldviews	5	4.80	1.30
Creativity	5	4.40	0.89

Perceived competence (Others)	n	Mean	SD
Compliance	3	5.67	1.15
Craftsmanship	3	5.33	0.58
Vision & insight	3	5.33	0.58
Technology awareness	3	5.00	0.00
Self-motivation	3	5.00	1.73
Self-management	3	5.00	0.00
Lifelong learning	3	5.00	1.00
Environment & sustainability awareness	3	5.00	1.00
Safety awareness	3	5.00	2.00
Directing	3	5.00	1.00
Worldviews	3	5.00	1.00
Engineering practices	3	4.67	0.58
Ethics and professional conduct	3	4.67	0.58
Creativity	3	4.67	1.15
Social awareness	3	4.67	0.58
Research skills	3	4.67	0.58
Intercultural abilities	3	4.67	1.53
Academic knowledge	3	4.33	1.53
Professional knowledge	3	4.33	1.15
Effective communication	3	4.33	1.15
Teamwork	3	4.33	1.15
Engineering projects management	3	4.33	0.58
Judgement & decision making	3	4.33	0.58
Productivity control	3	4.33	0.58
Organizing	3	4.33	1.15
Information management	3	4.33	0.58
Foreign languages abilities	3	4.33	0.58
Change management	3	4.00	1.00

Table 5.13: Top Ten Important Competencies – by Educational Attainment

Perceived competency	Associate Degree or equivalent	Bachelor's degree	Master's Degree or equivalent	Doctor Degree	Others
recognized by 5 education levels to be important:					
Safety awareness	✓	✓	✓	✓	✓
recognized by 4 education levels to be important:					
Compliance		✓	✓	✓	✓
Lifelong learning	✓	✓		✓	✓
Professional knowledge	✓	✓	✓	✓	
Effective communication	✓	✓	✓	✓	
recognized by 3 education levels to be important:					
Technology awareness			✓	✓	✓
Ethics and professional conduct	✓		✓	✓	
Teamwork	✓	✓	✓		
recognized by 2 education levels to be important:					
Directing		✓			✓
Craftsmanship	✓				✓
Self-motivation	✓				✓
Organizing			✓	✓	
Productivity control			✓	✓	
Research skills		✓		✓	

Employment status was the next factor considered for descriptive analysis. Table 5.14 presents the perception differences among respondents with various employment status. The data indicate that most respondents are full-time employed, while other employment status accounts for less than 10%. Except for 'Foreign languages abilities', all competencies' mean values ranged from 5.14 to 6.00, while the standard deviation lay between 0.81 and 1.32.

With regard to common competencies among various groups with different employment status, no important competency is recognized by all employment status groups; three competencies are recognized by four employment status groups as important; five competencies are recognized by three employment status groups as important; and seven competencies are recognized by two employment status groups as important. The details of the above findings are presented in Table 5.15.

Table 5.14: Descriptive Statistics – by Employment Status

Perceived competence (Full-time)	n	Mean	SD
Safety awareness	51	6.00	1.04
Lifelong learning	51	5.96	1.06
Compliance	50	5.86	1.09
Teamwork	51	5.80	1.06
Organizing	51	5.80	0.94
Ethics and professional conduct	51	5.78	1.03
Professional knowledge	51	5.76	1.05
Technology awareness	51	5.76	1.05
Effective communication	51	5.76	1.18
Information management	51	5.71	0.88
Directing	51	5.65	0.98
Productivity control	51	5.65	0.98
Craftsmanship	51	5.61	1.08
Judgement & decision making	51	5.57	1.15
Self-management	50	5.56	0.93
Engineering practices	51	5.55	0.81
Engineering projects management	51	5.53	0.95
Research skills	50	5.52	1.11
Self-motivation	51	5.51	1.01
Environment & sustainability awareness	51	5.49	1.03
Social awareness	50	5.48	0.86
Change management	51	5.43	1.15
Vision & insight	51	5.41	0.92
Intercultural abilities	51	5.29	1.15
Creativity	50	5.26	1.07
Worldviews	51	5.18	1.32
Academic knowledge	51	5.14	1.08
Foreign languages abilities	51	4.78	1.22

Perceived competence (Self employed)	n	Mean	SD
Professional knowledge	2	7.00	0.00
Ethics and professional conduct	2	7.00	0.00
Environment & sustainability awareness	2	7.00	0.00
Safety awareness	2	7.00	0.00
Engineering projects management	2	7.00	0.00
Judgement & decision making	2	7.00	0.00
Compliance	2	7.00	0.00
Teamwork	2	6.50	0.71
Social awareness	2	6.50	0.71
Academic knowledge	2	6.00	0.00
Engineering practices	2	6.00	1.41
Effective communication	2	6.00	1.41
Craftsmanship	2	6.00	0.00
Directing	2	6.00	1.41
Productivity control	2	6.00	1.41
Worldviews	2	6.00	0.00
Technology awareness	2	5.50	0.71
Self-motivation	2	5.50	0.71
Self-management	2	5.50	2.12
Lifelong learning	2	5.50	2.12
Creativity	2	5.50	0.71
Vision & insight	2	5.50	0.71
Organizing	2	5.50	2.12
Foreign languages abilities	2	5.50	0.71
Change management	2	5.00	0.00
Information management	2	5.00	0.00
Research skills	2	5.00	1.41
Intercultural abilities	2	5.00	1.41

Perceived competence (Others)	n	Mean	SD
Professional knowledge	2	7.00	0.00
Technology awareness	2	7.00	0.00
Ethics and professional conduct	2	6.50	0.71
Productivity control	2	6.50	0.71
Compliance	2	6.50	0.71
Craftsmanship	2	6.00	0.00
Social awareness	2	6.00	0.00
Information management	2	6.00	1.41
Research skills	2	6.00	0.00
Academic knowledge	2	5.50	0.71
Engineering practices	2	5.50	0.71
Lifelong learning	2	5.50	0.71
Effective communication	2	5.50	0.71
Teamwork	2	5.50	0.71
Environment & sustainability awareness	2	5.50	0.71
Safety awareness	2	5.50	0.71
Judgement & decision making	2	5.50	0.71
Vision & insight	2	5.50	2.12
Directing	2	5.50	0.71
Organizing	2	5.50	0.71
Foreign languages abilities	2	5.50	0.71
Self-management	2	5.00	0.00
Engineering projects management	2	5.00	1.41
Change management	2	5.00	1.41
Intercultural abilities	2	5.00	1.41
Self-motivation	2	4.50	0.71
Creativity	2	4.50	0.71
Worldviews	2	4.50	0.71

Perceived competence (Part-time)	n	Mean	SD
Academic knowledge	1	7	0
Engineering practices	1	7	0
Technology awareness	1	7	0
Self-management	1	7	0
Effective communication	1	7	0
Teamwork	1	7	0
Ethics and professional conduct	1	7	0
Social awareness	1	7	0
Judgement & decision making	1	7	0
Change management	1	7	0
Productivity control	1	7	0
Organizing	1	7	0
Compliance	1	7	0
Intercultural abilities	1	7	0
Professional knowledge	1	6	0
Craftsmanship	1	6	0
Creativity	1	6	0
Environment & sustainability awareness	1	6	0
Engineering projects management	1	6	0
Vision & insight	1	6	0
Directing	1	6	0
Information management	1	6	0
Research skills	1	6	0
Self-motivation	1	5	0
Lifelong learning	1	5	0
Safety awareness	1	5	0
Foreign languages abilities	1	5	0
Worldviews	1	5	0

Perceived competence (No/Finding job)	n	Mean	SD
Vision & insight	1	6	0
Directing	1	6	0
Academic knowledge	1	5	0
Engineering practices	1	5	0
Self-motivation	1	5	0
Self-management	1	5	0
Lifelong learning	1	5	0
Effective communication	1	5	0
Teamwork	1	5	0
Environment & sustainability awareness	1	5	0
Safety awareness	1	5	0
Productivity control	1	5	0
Information management	1	5	0
Research skills	1	5	0
Foreign languages abilities	1	5	0
Intercultural abilities	1	5	0
Creativity	1	4	0
Engineering projects management	1	4	0
Change management	1	4	0
Organizing	1	4	0
Worldviews	1	4	0
Professional knowledge	1	3	0
Ethics and professional conduct	1	3	0
Technology awareness	0		
Craftsmanship	0		
Social awareness	0		
Judgement & decision making	0		
Compliance	0		

Table 5.15: Top Ten Important Competencies – by Employment Status

Perceived competency	Full time	Self employed	Others	Part time	Finding /No jobs
recognized by 4 employment status groups to be important:					
Teamwork	✓	✓		✓	✓
Ethics and professional conduct	✓	✓	✓	✓	
Academic knowledge		✓	✓	✓	✓
recognized by 3 employment status groups to be important:					
Compliance	✓	✓	✓		
Professional knowledge	✓	✓	✓		
Technology awareness	✓		✓	✓	
Effective communication	✓			✓	✓
Social awareness		✓	✓	✓	
recognized by 2 employment status groups to be important:					
Safety awareness	✓	✓			
Information management	✓		✓		
Lifelong learning	✓				✓
Judgement & decision-making		✓		✓	
Environment & sustainability awareness		✓			✓
Self-management				✓	✓
Engineering practices				✓	✓

Based on the descriptive analysis of various groups' work experience, Table 5.16 presents the different perceptions among all groups. Unlike the employment status grouping, the number of samples in each work experience group is relatively balanced. Except for the 17–20 years work experience group, all competencies' mean values are close, lying between 4.38 to 6.33.

Concerning the top ten competencies among the six work experience groups, all groups recognise safety awareness as essential; five groups recognise compliance as important. Eight competencies are identified as necessary by four groups, four competencies are observed as important by three groups, and five common competencies are recognized as important by two groups. The details of the above findings are presented in Table 5.17.

Table 5.16: Descriptive Statistics – by Work Experience

Perceived competence (Exp. 9 - 12 yrs)	n	Mean	SD
Lifelong learning	14	6.29	0.99
Safety awareness	14	6.21	0.80
Organizing	14	6.21	0.80
Research skills	14	6.21	0.70
Professional knowledge	14	6.14	0.86
Effective communication	14	6.14	1.23
Directing	14	6.07	1.07
Information management	14	6.00	0.78
Productivity control	14	5.86	0.95
Technology awareness	14	5.79	0.89
Craftsmanship	14	5.79	1.05
Compliance	14	5.79	1.12
Engineering practices	14	5.71	0.99
Teamwork	14	5.71	0.99
Self-management	14	5.64	1.01
Ethics and professional conduct	14	5.64	1.22
Engineering projects management	14	5.57	0.85
Vision & insight	14	5.50	0.94
Creativity	14	5.43	1.16
Social awareness	14	5.43	0.85
Judgement & decision making	14	5.36	1.08
Change management	14	5.36	1.34
Self-motivation	14	5.29	0.91
Environment & sustainability awareness	14	5.21	1.12
Academic knowledge	14	4.86	1.03
Foreign languages abilities	14	4.71	0.73
Intercultural abilities	14	4.64	1.22
Worldviews	14	4.43	1.55

Perceived competence (Exp. < 5 yrs)	n	Mean	SD
Technology awareness	12	6.33	0.78
Compliance	12	6.25	0.75
Professional knowledge	13	6.00	1.15
Craftsmanship	12	6.00	0.85
Lifelong learning	13	5.77	0.83
Effective communication	13	5.77	1.09
Safety awareness	13	5.77	0.93
Productivity control	13	5.77	1.01
Teamwork	13	5.69	1.11
Ethics and professional conduct	13	5.69	1.03
Environment & sustainability awareness	13	5.69	0.75
Information management	13	5.69	0.95
Judgement & decision making	12	5.67	1.15
Research skills	13	5.62	1.19
Academic knowledge	13	5.54	0.78
Engineering practices	13	5.54	0.66
Vision & insight	13	5.54	1.05
Social awareness	12	5.50	0.80
Self-management	13	5.46	0.88
Change management	13	5.46	1.05
Organizing	13	5.46	0.97
Self-motivation	13	5.38	0.77
Engineering projects management	13	5.31	0.75
Directing	13	5.31	0.95
Intercultural abilities	13	5.31	1.03
Worldviews	13	5.08	1.04
Creativity	13	4.85	1.28
Foreign languages abilities	13	4.77	1.42

Perceived competence (Exp. > 20 yrs)	n	Mean	SD
Compliance	11	6.18	0.87
Ethics and professional conduct	11	6.00	1.10
Safety awareness	11	6.00	1.26
Teamwork	11	5.91	0.83
Judgement & decision making	11	5.91	0.94
Self-motivation	11	5.64	1.03
Lifelong learning	11	5.64	1.03
Effective communication	11	5.64	1.12
Engineering projects management	11	5.64	0.92
Worldviews	11	5.64	0.92
Professional knowledge	11	5.55	1.21
Technology awareness	11	5.55	0.93
Directing	11	5.55	0.69
Productivity control	11	5.55	0.82
Self-management	11	5.45	0.82
Craftsmanship	11	5.45	0.69
Social awareness	11	5.45	0.82
Environment & sustainability awareness	11	5.45	1.21
Vision & insight	11	5.45	0.82
Organizing	11	5.45	1.21
Intercultural abilities	11	5.45	0.82
Academic knowledge	11	5.36	1.12
Engineering practices	11	5.36	0.50
Foreign languages abilities	11	5.36	1.36
Information management	11	5.18	0.87
Creativity	11	5.09	0.83
Change management	11	5.09	1.14
Research skills	11	4.91	0.83

Perceived competence (Exp. 5 - 8 yrs)	n	Mean	SD
Lifelong learning	8	6.25	0.89
Professional knowledge	8	6.13	0.64
Teamwork	8	6.00	1.41
Judgement & decision making	8	6.00	1.31
Organizing	8	6.00	0.93
Worldviews	8	6.00	0.76
Self-management	8	5.88	1.13
Effective communication	8	5.88	1.13
Social awareness	8	5.88	0.99
Environment & sustainability awareness	8	5.88	0.83
Safety awareness	8	5.88	1.13
Information management	8	5.88	0.83
Engineering projects management	8	5.75	1.28
Directing	8	5.75	1.04
Craftsmanship	8	5.63	0.92
Change management	8	5.63	0.92
Research skills	8	5.63	0.92
Intercultural abilities	8	5.63	1.30
Academic knowledge	8	5.50	1.07
Engineering practices	8	5.50	1.07
Technology awareness	8	5.50	1.41
Self-motivation	8	5.50	1.41
Ethics and professional conduct	8	5.50	1.07
Creativity	8	5.38	0.74
Productivity control	8	5.38	1.06
Compliance	8	5.38	1.60
Vision & insight	8	5.25	0.89
Foreign languages abilities	8	4.38	0.92

Perceived competence (Exp. 13 - 16 yrs)	n	Mean	SD
Teamwork	7	6.14	0.90
Ethics and professional conduct	7	5.86	1.07
Safety awareness	7	5.86	1.35
Intercultural abilities	7	5.86	1.21
Engineering practices	7	5.71	0.95
Self-motivation	7	5.71	0.95
Information management	7	5.71	0.95
Compliance	6	5.67	1.03
Technology awareness	7	5.57	1.40
Directing	7	5.57	0.98
Organizing	7	5.57	0.79
Lifelong learning	7	5.43	1.72
Effective communication	7	5.43	0.98
Self-management	6	5.33	1.03
Environment & sustainability awareness	7	5.29	1.11
Engineering projects management	7	5.29	1.50
Productivity control	7	5.29	1.11
Creativity	6	5.17	0.98
Social awareness	6	5.17	0.98
Change management	7	5.14	1.35
Judgement & decision making	7	5.00	1.41
Vision & insight	7	5.00	1.15
Craftsmanship	7	4.86	1.77
Worldviews	7	4.86	1.57
Professional knowledge	7	4.71	1.38
Foreign languages abilities	7	4.71	1.38
Research skills	6	4.67	1.51
Academic knowledge	7	4.57	1.27

Perceived competence (Exp. 17 - 20 yrs)	n	Mean	SD
Ethics and professional conduct	4	7.00	0.00
Productivity control	4	6.75	0.50
Social awareness	4	6.50	0.58
Compliance	4	6.50	1.00
Technology awareness	4	6.25	0.96
Environment & sustainability awareness	4	6.25	0.96
Safety awareness	4	6.25	0.96
Judgement & decision making	4	6.25	0.96
Change management	4	6.25	0.96
Professional knowledge	4	6.00	0.82
Craftsmanship	4	6.00	0.00
Creativity	4	6.00	0.82
Engineering projects management	4	6.00	0.82
Vision & insight	4	6.00	0.00
Organizing	4	6.00	1.15
Engineering practices	4	5.75	0.96
Lifelong learning	4	5.75	0.96
Directing	4	5.75	0.96
Academic knowledge	4	5.50	1.29
Self-management	4	5.50	1.29
Teamwork	4	5.50	1.29
Information management	4	5.50	0.58
Research skills	4	5.50	0.58
Intercultural abilities	4	5.50	1.29
Worldviews	4	5.50	1.00
Self-motivation	4	5.25	1.26
Effective communication	4	5.25	1.71
Foreign languages abilities	4	5.25	1.26

Table 5.17: Top Ten Important Competencies – by Work Experience

Perceived competency	**Exp. < 5 yrs**	**Exp. 5-8 yrs**	**Exp. 9-12 yrs**	**Exp. 13-16 yrs**	**Exp. 17-20 yrs**	**Exp. >20 yrs**
recognized by 6 work experience groups to be important:						
Safety awareness	✓	✓	✓	✓	✓	✓
recognized by 5 work experience groups to be important:						
Compliance	✓		✓	✓	✓	✓
recognized by 4 work experience groups to be important:						
Ethics and professional conduct	✓			✓	✓	✓
Teamwork	✓	✓		✓		✓
Effective communication	✓	✓	✓			✓
Lifelong learning	✓	✓	✓			✓
Organizing		✓	✓	✓	✓	
Technology awareness	✓		✓	✓	✓	
Professional knowledge	✓	✓	✓		✓	
Information management	✓	✓	✓	✓		
recognized by 3 work experience groups to be important:						
Judgement & decision-making		✓			✓	✓
Productivity control	✓		✓		✓	
Craftsmanship	✓		✓		✓	
Environment & sustainability awareness	✓	✓			✓	
recognized by 2 work experience groups to be important:						
Engineering projects management					✓	✓
Self-motivation				✓		✓
Worldviews		✓				✓
Social awareness		✓			✓	
Directing			✓	✓		

The following data item to be analysed was the fields involved in the energy sector. Table 5.18 presents the perception differences from all groups of fields involvement in the energy sector. The descriptive analysis indicates no significant differences in the mean values amongst the seven groups, ranging from 4.50 to 6.57.

Table 5.18: Descriptive Statistics – by Fields in the Energy Sector

Perceived competence (New Energy)	n	Mean	SD
Lifelong learning	21	6.19	0.87
Safety awareness	21	6.14	0.79
Professional knowledge	21	6.00	0.77
Directing	21	5.95	0.86
Organizing	21	5.95	0.86
Craftsmanship	21	5.90	1.00
Teamwork	21	5.86	1.06
Information management	21	5.86	0.79
Technology awareness	21	5.76	1.09
Effective communication	21	5.76	1.18
Ethics and professional conduct	21	5.76	1.14
Research skills	20	5.75	0.91
Engineering practices	21	5.67	0.91
Self-management	20	5.60	1.05
Compliance	20	5.60	1.19
Engineering projects management	21	5.57	0.81
Creativity	20	5.55	0.89
Productivity control	21	5.52	1.03
Environment & sustainability awareness	21	5.48	0.81
Change management	21	5.48	1.21
Judgement & decision making	21	5.43	0.98
Vision & insight	21	5.43	0.87
Social awareness	20	5.40	0.94
Self-motivation	21	5.38	0.92
Academic knowledge	21	4.90	1.00
Worldviews	21	4.81	1.44
Intercultural abilities	21	4.76	1.30
Foreign languages abilities	21	4.67	1.02

Perceived competence (Elect. Equip.)	n	Mean	SD
Intercultural abilities	10	6.30	0.82
Compliance	9	6.22	0.97
Teamwork	10	6.10	0.74
Organizing	10	6.10	0.88
Effective communication	10	6.00	1.05
Self-motivation	10	5.90	0.88
Ethics and professional conduct	10	5.90	0.88
Productivity control	10	5.90	0.99
Information management	10	5.90	0.99
Self-management	9	5.89	1.05
Social awareness	9	5.89	0.93
Safety awareness	10	5.80	1.14
Judgement & decision making	10	5.80	1.55
Engineering practices	10	5.70	0.82
Technology awareness	10	5.70	1.42
Directing	10	5.70	0.82
Creativity	9	5.67	0.87
Engineering projects management	10	5.60	1.26
Lifelong learning	10	5.50	1.51
Academic knowledge	10	5.40	1.35
Environment & sustainability awareness	10	5.40	1.35
Change management	10	5.40	1.17
Research skills	9	5.22	1.72
Vision & insight	10	5.20	1.14
Worldviews	10	5.20	1.55
Professional knowledge	10	5.10	1.37
Craftsmanship	10	5.10	1.45
Foreign languages abilities	10	4.50	1.43

Perceived competence (Elect. VA)	n	Mean	SD
Compliance	8	6.38	0.74
Directing	10	6.10	0.74
Organizing	10	6.10	0.99
Intercultural abilities	10	6.10	0.99
Lifelong learning	10	6.00	0.94
Effective communication	10	6.00	0.67
Judgement & decision making	9	6.00	0.71
Self-motivation	10	5.90	0.88
Teamwork	10	5.90	0.74
Technology awareness	9	5.89	0.93
Social awareness	8	5.88	0.83
Ethics and professional conduct	10	5.80	1.23
Safety awareness	10	5.80	0.79
Engineering projects management	10	5.80	0.92
Self-management	9	5.78	0.83
Productivity control	10	5.70	0.82
Information management	10	5.70	0.82
Engineering practices	10	5.60	0.70
Academic knowledge	10	5.50	0.71
Environment & sustainability awareness	10	5.50	1.08
Vision & insight	10	5.50	0.71
Change management	10	5.50	1.08
Worldviews	10	5.50	1.27
Research skills	9	5.22	0.97
Craftsmanship	9	5.11	1.45
Professional knowledge	10	5.10	1.60
Creativity	9	5.00	0.87
Foreign languages abilities	10	4.90	1.37

Perceived competence (Power Equip.)	n	Mean	SD
Intercultural abilities	9	6.33	0.87
Lifelong learning	9	6.22	0.83
Worldviews	9	6.22	0.83
Teamwork	9	6.11	0.78
Organizing	9	6.11	0.93
Professional knowledge	9	6.00	0.50
Judgement & decision making	9	6.00	1.12
Safety awareness	9	5.89	1.05
Information management	9	5.89	1.05
Technology awareness	9	5.78	1.48
Self-motivation	9	5.78	1.48
Effective communication	9	5.78	0.97
Environment & sustainability awareness	9	5.78	0.83
Self-management	8	5.75	1.04
Compliance	8	5.75	1.75
Ethics and professional conduct	9	5.67	1.12
Craftsmanship	9	5.67	1.12
Engineering projects management	9	5.67	0.87
Directing	9	5.67	1.12
Social awareness	8	5.63	1.06
Research skills	8	5.63	0.74
Vision & insight	9	5.56	1.01
Engineering practices	9	5.44	0.88
Change management	9	5.44	1.01
Productivity control	9	5.44	1.01
Academic knowledge	9	5.33	1.22
Creativity	8	5.13	0.83
Foreign languages abilities	9	4.78	1.09

Perceived competence (Others Energy)	n	Mean	SD
Ethics and professional conduct	7	6.00	1.15
Compliance	7	6.00	0.82
Professional knowledge	7	5.86	1.35
Technology awareness	7	5.86	0.90
Productivity control	7	5.86	0.90
Engineering practices	7	5.71	0.49
Teamwork	7	5.71	1.38
Safety awareness	7	5.71	1.38
Information management	7	5.71	0.95
Lifelong learning	7	5.57	0.98
Effective communication	7	5.57	1.40
Craftsmanship	7	5.57	0.79
Social awareness	7	5.57	0.53
Judgement & decision making	7	5.57	0.79
Directing	7	5.57	0.79
Research skills	7	5.57	0.53
Environment & sustainability awareness	7	5.43	0.79
Engineering projects management	7	5.43	0.79
Foreign languages abilities	7	5.43	0.79
Intercultural abilities	7	5.43	0.53
Academic knowledge	7	5.29	1.38
Self-motivation	7	5.29	1.38
Self-management	7	5.29	0.49
Organizing	7	5.29	1.25
Worldviews	7	5.29	1.25
Vision & insight	7	5.14	0.69
Change management	7	5.14	1.21
Creativity	7	4.57	1.13

Perceived competence (Petroleum)	n	Mean	SD
Technology awareness	7	6.57	0.53
Professional knowledge	7	6.14	1.07
Effective communication	7	6.14	1.07
Compliance	6	6.00	0.63
Teamwork	7	5.86	1.21
Craftsmanship	7	5.86	1.35
Vision & insight	7	5.86	1.07
Engineering practices	7	5.71	0.95
Self-motivation	7	5.71	0.76
Lifelong learning	7	5.71	0.95
Ethics and professional conduct	7	5.71	0.76
Organizing	7	5.71	0.76
Academic knowledge	7	5.57	0.79
Safety awareness	7	5.57	0.79
Information management	7	5.57	0.98
Intercultural abilities	7	5.57	1.27
Worldviews	7	5.57	0.98
Self-management	6	5.50	0.55
Social awareness	6	5.50	0.55
Environment & sustainability awareness	7	5.43	1.13
Judgement & decision making	7	5.43	1.51
Change management	7	5.43	1.27
Productivity control	7	5.43	0.98
Research skills	6	5.33	1.63
Engineering projects management	7	5.29	0.95
Directing	7	5.29	1.60
Creativity	6	4.83	1.60
Foreign languages abilities	7	4.71	0.95

Perceived competence (Power Supply)	n	Mean	SD
Ethics and professional conduct	7	6.57	0.79
Safety awareness	7	6.57	0.79
Compliance	6	6.50	0.84
Environment & sustainability awareness	7	6.43	0.79
Professional knowledge	7	6.14	0.69
Technology awareness	7	6.14	0.90
Engineering projects management	7	6.14	0.90
Judgement & decision making	7	6.14	1.07
Craftsmanship	7	6.00	0.58
Social awareness	6	6.00	0.89
Teamwork	7	5.86	1.07
Vision & insight	7	5.86	0.69
Productivity control	7	5.86	1.07
Academic knowledge	7	5.71	0.95
Lifelong learning	7	5.71	0.95
Directing	7	5.71	0.95
Information management	7	5.71	0.95
Engineering practices	7	5.57	0.79
Worldviews	7	5.57	0.98
Self-management	6	5.50	1.38
Creativity	6	5.50	0.84
Self-motivation	7	5.43	0.98
Effective communication	7	5.43	1.40
Change management	7	5.43	0.79
Organizing	7	5.43	0.98
Intercultural abilities	7	5.29	1.11
Research skills	6	5.17	0.75
Foreign languages abilities	7	4.71	1.60

Concerning the top ten essential competencies, all seven groups recognized no competency in common. Three competencies are agreed upon as important by six groups. Five competencies are identified as important by four groups, three common competencies are observed as important by three groups, and two groups find another three competencies as necessary. The details of the above findings are summarized in Table 5.19.

The decision span was the last aspect of descriptive analysis. Table 5.20 presents the perception differences of the respondents from the different decision span groupings. The data indicate that the decision span of most respondents is fewer than 100 people; the mean values of all except three competencies lay between 5.05 and 6.14, with a relatively low standard deviation.

Table 5.19: Top Ten Important Competencies – by Fields in the Energy Sector

Perceived competence	New Energy related	Elect. Equip. related	Elect. VA related	Power Equip. related	Other Energy related	Petroleum related	Power Supply related
recognized by 6 field groups to be important:							
Effective communication	✓	✓	✓	✓	✓	✓	
Teamwork	✓	✓	✓	✓	✓	✓	
Technology awareness	✓		✓	✓	✓	✓	✓
recognized by 5 field groups to be important:							
Ethics and professional conduct	✓	✓			✓	✓	✓
Organizing	✓	✓	✓	✓		✓	
Lifelong learning	✓		✓	✓	✓	✓	
Professional knowledge	✓			✓	✓	✓	✓
Compliance		✓	✓		✓	✓	✓
recognized by 4 field groups to be important:							
Safety awareness	✓			✓	✓		✓
Information management	✓	✓		✓	✓		
Craftsmanship	✓				✓	✓	✓
Judgement & decision making			✓	✓	✓		✓
Self-motivation		✓	✓	✓		✓	
recognized by 3 field groups to be important:							
Directing	✓		✓		✓		
Intercultural abilities		✓	✓	✓			
Social awareness		✓			✓		✓
recognized by 2 field groups to be important:							
Productivity control		✓			✓		
Environment & sustainability awareness				✓			✓
Engineering practices					✓	✓	

Table 5.20: Descriptive Statistics – by Decision Span

Perceived competence (Span 10 - 99)	n	Mean	SD	Perceived competence (Span <=9)	n	Mean	SD
Organizing	29	6.14	0.79	Compliance	20	5.90	1.21
Technology awareness	29	6.10	1.01	Safety awareness	21	5.76	1.34
Ethics and professional conduct	29	6.07	0.92	Lifelong learning	21	5.67	1.28
Lifelong learning	29	6.03	0.87	Teamwork	21	5.67	1.06
Safety awareness	29	6.03	0.78	Craftsmanship	20	5.65	0.81
Effective communication	29	5.97	1.05	Professional knowledge	21	5.62	1.16
Compliance	28	5.96	1.07	Directing	21	5.57	1.08
Information management	29	5.90	0.77	Technology awareness	20	5.50	1.05
Productivity control	29	5.86	1.06	Ethics and professional conduct	21	5.43	1.29
Social awareness	28	5.86	0.80	Productivity control	21	5.43	0.98
Professional knowledge	29	5.83	1.07	Information management	21	5.43	0.98
Teamwork	29	5.83	1.07	Engineering practices	21	5.38	0.80
Judgement & decision making	29	5.83	0.93	Self-management	21	5.38	1.07
Engineering practices	29	5.72	0.88	Effective communication	21	5.38	1.28
Environment & sustainability awareness	29	5.72	1.03	Research skills	21	5.38	1.24
Directing	29	5.72	0.96	Organizing	21	5.33	1.06
Self-management	28	5.71	0.85	Environment & sustainability awareness	21	5.29	0.90
Engineering projects management	29	5.69	0.85	Engineering projects management	21	5.19	1.12
Change management	29	5.69	1.11	Vision & insight	21	5.19	0.93
Research skills	28	5.68	0.86	Intercultural abilities	21	5.19	1.08
Vision & insight	29	5.66	0.94	Social awareness	20	5.15	0.81
Creativity	28	5.57	1.00	Judgement & decision making	20	5.15	1.39
Self-motivation	29	5.55	0.95	Self-motivation	21	5.10	1.04
Craftsmanship	29	5.55	1.24	Academic knowledge	21	5.05	1.24
Intercultural abilities	29	5.31	1.26	Change management	21	5.05	1.16
Worldviews	29	5.31	1.37	Worldviews	21	4.76	1.18
Academic knowledge	29	5.17	1.00	Creativity	21	4.57	0.93
Foreign languages abilities	29	5.10	1.05	Foreign languages abilities	21	4.43	1.16

Perceived competence (Span 1000 - 9999)	n	Mean	SD
Professional knowledge	4	7.00	0.00
Safety awareness	4	6.50	1.00
Self-motivation	4	6.25	0.50
Lifelong learning	4	6.25	1.50
Effective communication	4	6.25	0.96
Teamwork	4	6.25	0.96
Ethics and professional conduct	4	6.25	0.96
Craftsmanship	4	6.25	0.50
Judgement & decision making	4	6.25	0.96
Environment & sustainability awareness	4	6.00	0.82
Engineering projects management	4	6.00	1.15
Compliance	4	6.00	1.15
Worldviews	4	6.00	0.82
Academic knowledge	4	5.75	0.50
Creativity	4	5.75	0.50
Social awareness	4	5.75	1.26
Directing	4	5.75	0.50
Productivity control	4	5.75	0.50
Intercultural abilities	4	5.75	1.26
Engineering practices	4	5.50	0.58
Technology awareness	4	5.50	0.58
Self-management	4	5.50	1.29
Organizing	4	5.50	1.29
Information management	4	5.50	1.00
Foreign languages abilities	4	5.50	1.00
Vision & insight	4	5.25	0.50
Research skills	4	5.25	0.96
Change management	4	5.00	0.82

Perceived competence (Span 100 - 999)	n	Mean	SD
Teamwork	3	6.33	0.58
Safety awareness	3	6.33	0.58
Judgement & decision making	3	6.33	0.58
Academic knowledge	3	6.00	0.00
Self-motivation	3	6.00	0.00
Effective communication	3	6.00	1.00
Creativity	3	6.00	0.00
Engineering projects management	3	6.00	0.00
Productivity control	3	6.00	0.00
Compliance	3	6.00	0.00
Engineering practices	3	5.67	0.58
Technology awareness	3	5.67	1.53
Lifelong learning	3	5.67	0.58
Ethics and professional conduct	3	5.67	0.58
Craftsmanship	3	5.67	0.58
Change management	3	5.67	1.53
Directing	3	5.67	0.58
Organizing	3	5.67	0.58
Information management	3	5.67	0.58
Professional knowledge	3	5.33	1.15
Self-management	3	5.33	0.58
Social awareness	3	5.33	0.58
Vision & insight	3	5.33	1.15
Research skills	3	5.33	2.08
Intercultural abilities	3	5.33	0.58
Worldviews	3	5.33	1.15
Environment & sustainability awareness	3	5.00	1.73
Foreign languages abilities	3	4.33	2.08

Based on the data, two common competencies are perceived by all decision-span groups, while five competencies are agreed on by three out of four decision-span groups. Two decision-span groups perceive eight essential competencies. Table 5.21 summarizes the above findings.

Table 5.21: Top Ten Important Competencies – by Decision Span

Perceived competence	Span <=9	Span 10 - 99	Span 100 - 999	Span 1000 - 9999
recognized by 4 decision span groups to be important:				
Safety awareness	✓	✓	✓	✓
Compliance	✓	✓	✓	✓
recognized by 3 decision span groups to be important:				
Effective communication		✓	✓	✓
Teamwork	✓		✓	✓
Lifelong learning	✓	✓		✓
Ethics and professional conduct	✓	✓		✓
Productivity control	✓	✓	✓	
recognized by 2 decision span groups to be important:				
Judgement & decision making			✓	✓
Engineering projects management			✓	✓
Self-motivation			✓	✓
Academic knowledge			✓	✓
Craftsmanship	✓			✓
Professional knowledge	✓			✓
Information management	✓	✓		
Technology awareness	✓	✓		

After performing descriptive analyses on the quantitative data, it was important to identify the competencies that the respondents viewed as very important for tackling the challenges and opportunities facing the local energy sector. The findings of a series of descriptive analyses are summarized in Table 5.22. These consolidated descriptive findings combine the different perspectives of the survey respondents by various groupings, providing an initial picture of the competency model for local energy engineering practitioners.

Table 5.22 presents 16 competencies in common derived from the previous descriptive analyses. Two of these 16 competencies, namely 'Compliance' and 'Ethics and professional conduct', are recognized by all seven groupings.

Table 5.22: Competencies Findings from Quantitative Analysis

Perceived competency	Gender	Age	Edu. level	Job status	Work Exp.	Field	Decis. Span
recognized by 7 groupings to be important:							
Compliance	2/2	4/5	4/5	3/5	5/6	5/7	4/4
Ethics and professional conduct	2/2	4/5	3/5	4/5	4/6	5/7	3/4
recognized by 6 groupings to be important:							
Safety awareness	2/2	4/5	5/5		6/6	4/7	4/4
Professional knowledge	2/2	4/5	4/5	3/5	4/6	5/7	
Teamwork		4/5	3/5	4/5	4/6	6/7	3/4
Effective communication		3/5	4/5	3/5	4/6	6/7	3/4
Lifelong learning		3/5	4/5		4/6	5/7	3/4
recognized by 4 groupings to be important:							
Technology awareness			3/5	3/5	4/6	6/7	
recognized by 2 groupings to be important:							
Organizing					4/6	5/7	
Information management					4/6	4/7	
Judgement & decision-making		3/5				4/7	
recognized by 1 grouping to be important:							
Academic knowledge				4/5			
Productivity control							3/4
Social awareness				3/5			
Craftsmanship						4/7	
Self-motivation						4/7	

The competencies listed in Table 5.22 are potential items in developing a competency model for Hong Kong energy engineers. The fraction in each grouping represents the degree of recognition. Taking the competency of

‘Compliance’ as an example, the fraction ‘4/5’ in the age grouping means that ‘Compliance’ is ranked as a top ten competency in four age groups out of five. The competencies in Table 5.22 were first sorted by the number of groups recognizing them as important, and then by the degree of recognitions. Hence, the order of competencies in Table 5.22 could be treated as the level of importance perceived by the survey respondents.

The Qualitative Findings

After the quantitative research findings were presented and discussed in the previous section, my next focus is the corresponding details of the qualitative research. In this section, I present the qualitative findings based on the analyses of the interviews conducted with 19 volunteer participants recruited during the quantitative research. This qualitative research had two objectives: The first was to investigate the interviewees’ perceptions of the energy transition’s difficulties and prospects facing the Hong Kong energy sector, and the second was to interpret and justify respondents’ perceived essential competencies. Hence, I start by presenting the interviewees’ profiles and then explain the themes of challenges and opportunities facing the Hong Kong energy sector and the perceived essential competencies for our energy engineers. Finally, I conclude with the interpretation of the qualitative findings.

The second research question directed the qualitative research: ‘Why do they [Hong Kong energy engineers] consider their perceived competencies essential?’ To answer this question, I conducted 19 individual semi-structured online interviews with respondents who had participated in the previous quantitative research, using the interview guide (see Appendix F) to obtain more details about their ideas on the challenges and opportunities facing the energy sector and the justification of their perceived essential competencies. All interviews were conducted in Chinese, and the conversations were audio recorded, transcribed, and translated into English.

The initial coding took place during the interview process. I took brief notes on the main points mentioned by each interviewee. These interview notes were used to draft the early version of the codes. These codes were referenced for the manual coding procedure, which was subsequently cross-checked with the interview transcripts.

I then transcribed the interview recordings, which allowed me to become more familiar with the data. During the phrase-by-phrase transcription, I observed the repeating patterns of meaning and potential areas of interest to the research questions. The codes could be determined from the topics the interviewees mentioned explicitly, while the emerging codes were identified by categorizing the previous codes or generating new ones.

Starting with the first interview, I began the manual coding by taking notes on the main points from the interviewees' reflections. In the transcription stage, I developed a set of keyword codes derived from the interview data or the actual words spoken by the interviewees. These codes were created using the research questions as references. I then added some manual codes and refined them as the transcriptions progressed. However, near the end of the coding process, the new codes' frequency diminished significantly.

The thematic analysis then developed the themes by grouping and categorizing the relevant codes. Some codes formed the main themes, while other codes formed sub-themes. I organized these themes and sub-themes in a thematic summary table which displayed their relationships (see Table 5.25).

Interviewees' Demographic Profiles

Of the 57 survey respondents, 35 provided their contact information indicating their interest in participating in the in-depth interview. From a total of 35 potential participants, I purposively selected 23, whose backgrounds roughly matched the survey respondents' demographic profile, to join the in-depth interview. The interviews took place between 10 May and 28 May 2021, and I made contact and interviewed the participants one-by-one until no more themes emerged, indicating data saturation. In total, I interviewed 19 out of the 23 participants that I initially set out to interview.

Of these 19 interviewees, most are male (73.7%), most of their ages ranged between 21 and 50 (89.4%), and most possessed a bachelor's degree or above (78.9%). Most interviewees were full-time employed (94.7%), representing seven or more different fields in the Hong Kong energy sector. Their work experiences were rich: 84.2% of them have nine years or more work experience in the engineering sector, and their job positions were not junior, as 73.7% of them stated that their decision spans were ten or more staff members, including three interviewees whose decisions affected more than 1000 staff members. The detailed demographic information of all interviewees is presented in Table 5.23.

Table 5.23: Demographic Characteristics of 19 Interviewees

Call Sign	**Gender**	**Age grp**	**Educational attainment**	**Employment status**	**Work experience**	**Fields in energy sector**	**Decision span**
AND	Male	61-70	AD/HD/HC	Full-time employed	>20yrs	Others	1000-9999
BT	Male	41-50	Master/PD/AdvDip	Full-time employed	17-20yrs	Electrical VA equip.	10-99
CCK	Male	31-40	Others	Full-time employed	5-8yrs	Petroleum	10-99
CJK	Female	21-30	Bachelor	Full-time employed	<5yrs	Others	<=9
DY	Female	61-70	Master/PD/AdvDip	Self employed	>20yrs	Power supply	1000-9999
FSC	Male	31-40	Bachelor	Full-time employed	9-12yrs	New energy	10-99
GFH	Male	31-40	Bachelor	Full-time employed	13-16yrs	New energy	10-99
HY	Male	31-40	Master/PD/AdvDip	Full-time employed	9-12yrs	New energy	10-99
LCJ	Male	31-40	Bachelor	Full-time employed	9-12yrs	New energy	1000-9999
LZP	Male	41-50	AD/HD/HC	Full-time employed	17-20yrs	New energy	10-99
PNG	Male	31-40	Master/PD/AdvDip	Full-time employed	17-20yrs	Power supply	10-99
SBT	Male	31-40	Bachelor	Full-time employed	9-12yrs	New energy	<=9
SM	Female	31-40	Master/PD/AdvDip	Full-time employed	9-12yrs	New energy	<=9
SW	Male	31-40	Bachelor	Full-time employed	9-12yrs	New energy	10-99
TBY	Male	31-40	AD/HD/HC	Full-time employed	9-12yrs	New energy	10-99
XJJ	Male	31-40	Bachelor	Full-time employed	13-16yrs	Power equipment	<=9
XY	Male	21-30	Bachelor	Full-time employed	5-8yrs	New energy	100-999
ZLL	Female	31-40	Bachelor	Full-time employed	9-12yrs	New energy	<=9
ZM	Female	31-40	Bachelor	Full-time employed	9-12yrs	Electrical equip.	10-99

Remarks: AD/HD/HC means Associate Degree/High Diploma/High Certificate; Master/PD/Adv Dip means Master's Degree/Postgraduate Diploma/Advanced Diploma; Elect. VA equip. related means Electrical value-added equipment and services related.

To confirm the background similarity of the qualitative and the quantitative participants, I compared the demographic characteristics of both samples. Based on the demographic statistics illustrated in Table 5.24, the participants' backgrounds in the qualitative sample were similar to those in the quantitative sample; the percentages of most demographic characteristics are close. More importantly, as a substantial proportion of new energy-related participants were recruited, they clearly illustrated their perspectives on the energy transition in Hong Kong in their remarks.

Table 5.24: Demographic Statistics of the Qualitative and Quantitative Samples

Demographic characteristics		**QUAL sample**		**QUAN sample**	
		n	%	n	%
Gender	Male	14	73.7%	48	84.2%
	Female	5	26.3%	8	14.0%
	Others	0	0.0%	0	0.0%
	Prefer not to reply	0	0.0%	1	1.8%
	Total:	19	100.0%	57	100.0%
Age group	<20	0	0.0%	0	0.0%
	21-30	2	10.5%	12	21.1%
	31-40	13	68.4%	29	50.9%
	41-50	2	10.5%	7	12.3%
	51-60	0	0.0%	4	7.0%
	61-70	2	10.5%	3	5.3%
	>70	0	0.0%	0	0.0%
	Prefer not to reply	0	0.0%	2	3.5%
	Total:	19	100.0%	57	100.0%
Educational attainment	AD/HD/HC	3	15.8%	5	8.8%
	Bachelor	10	52.6%	28	49.1%
	Master/PD/AdvDip	5	26.3%	15	26.3%
	Doctor	0	0.0%	5	8.8%
	Post-doctor	0	0.0%	0	0.0%
	Others	1	5.3%	3	5.3%
	Prefer not to reply	0	0.0%	1	1.8%
	Total:	19	100.0%	57	100.0%
Employ. status	Unemployed	0	0.0%	1	1.8%
	Part-time employed	0	0.0%	1	1.8%
	Full-time employed	18	94.7%	51	89.5%
	Self employed	1	5.3%	2	3.5%
	Retired	0	0.0%	0	0.0%
	Others	0	0.0%	2	3.5%
	Total:	19	100.0%	57	100.0%
Working exp.	< 5yrs	1	5.3%	13	22.8%
	5-8yrs	2	10.5%	8	14.0%
	9-12yrs	9	47.1%	14	24.6%
	13-16yrs	2	10.5%	7	12.3%
	17-20yrs	3	15.8%	4	7.0%
	> 20yrs	2	10.5%	11	19.3%
	Total:	19	100.0%	57	100.0%
	Petroleum related	1	5.3%	6	9.2%
	Gas fuel related	0	0.0%	0	0.0%
	Power supply related	2	10.5%	6	9.2%

Fields in energy sector	Power equip. related	1	5.3%	8	12.3%
	Elect. equip. related	1	5.3%	9	13.8%
	Elect. VA equip. related	1	5.3%	9	13.8%
	New energy related	11	57.9%	20	30.8%
	Others	0	0.0%	0	0.0%
	Total:	19	100.0%	57	100.0%
Decision span	<= 9	5	26.3%	21	36.8%
	10-99	10	52.6%	29	50.9%
	100-999	1	5.3%	3	5.3%
	1000-9999	3	15.8%	4	7.0%
	>10000	0	0.0%	0	0.0%
	Total:	19	100.0%	57	100.0%

Remarks: AD/HD/HC means Associate Degree/High Diploma/High Certificate; Master/PD/Adv Dip means Master's Degree/Postgraduate Diploma/Advanced Diploma; Elect. VA equip. related means Electrical value-added equipment and services related.

Findings of the Thematic Analysis

Using the findings of thematic analysis, I elaborated on the challenges and opportunities facing the Hong Kong energy sector. I interpreted the perceived essential competencies, thus enabling me to determine the dimensions of a competency model for Hong Kong energy engineers. The above findings are presented as follows.

Challenges and Opportunities Facing the Hong Kong Energy Sector

In recent years, the Hong Kong energy sector has faced various global and regional issues. I identified 12 themes and 25 sub-themes regarding the challenges and opportunities through thematic analysis. To present the findings in a structured manner, I classified these themes and sub-themes into six categories, namely political, economic, socio-cultural, technological, legal-regulatory, and environmental (PESTLE) aspects. These six categories were adopted from the PESTLE analysis model, a robust marketing analysis framework for evaluating influences in a particular industry.

At the theme level, the political category comprises two themes, namely A) national policies and B) local policies. The economic category includes five themes, namely, C) energy spending, D) conventional energy supply, E) renewable energy investment, F) shortage of professionals, and G) competitive rivalry. Two themes are identified in the socio-cultural category: H) people awareness and I) good of humankind. The remaining technological, legal-regulatory, and environmental categories have one theme: J) renewable energy technology, K) industry standards and L) climate change, respectively.

The following sections explain all themes and their corresponding sub-themes, supported by quotations from the interviews with the 19 interviewees.

Political Category

A) National Policies

As Hong Kong is a special administrative region of the People's Republic of China (PRC), some Chinese national policies also apply to Hong Kong. Hence, the first theme pertains to the national policies of the PRC, which reflect the relevant national policies influencing the Hong Kong energy sector. I identified two sub-themes under this theme: A1) the carbon neutrality policy; and A2) the Belt and Road Initiative.

A1) The carbon neutrality policy

Twelve of the 19 interviewees mentioned this issue during the interviews; all agreed that it is the most significant and its influences are the largest. The carbon neutrality policy will bring radical change to the energy industry. An engineer working in the renewable energy industry expressed his opinion as follows:

> *I think the most important policy of our country is the carbon neutrality policy. We target to reach the peak carbon emission in 2030 and achieve neutral carbon emission in 2060. If this is the case, it would be an earth-shaking change for our entire energy sector. (HY)*

As illustrated in the quotation below, another energy engineer perceived that this policy could bring difficulties and opportunities to Hong Kong, just like the two sides of the same coin:

[In the climate conference, our President committed to the carbon neutrality policy.] If this is the case, everyone will be affected to use renewable energy. Energy management issue will be increased to a strategic level in our country, and it is an indispensable issue. I think it is a global challenge as well as a global opportunity. (XJJ)

Some energy engineering practitioners have a positive perception of this issue because the governments of European countries aim to be climate neutral by 2050, which means they will emit net-zero greenhouse gas by that time. In addition, the Chinese government also pledged to reach carbon neutrality by 2060. An engineer stated:

We also see that the European countries are all in 2050 [to achieve carbon neutrality], and China also commits [carbon neutrality] in 2060 too. So, I think in the coming decades, the renewable energy industry continues to develop. (LCJ)

A2) The Belt and Road Initiative

The Chinese government announced the Belt and Road Initiative in 2013, a foreign policy involving infrastructure development for around 70 countries along the Silk Road and the Maritime Silk Road. Most interviewees, excluding two, thought this initiative would not contribute any advantages to the energy industry. The first dissenting interviewee pointed out that the Belt and Road Initiative provides a win-win situation for the countries involved, including China. He argued that renewable energy technology could be delivered to the countries along both silk roads:

I personally think that the Belt and Road Initiative can export our technology to other countries. It is a mutually beneficial policy. Other countries can enjoy our high-tech products while we can do more business. (HY)

Another interviewee was more optimistic that Belt and Road Initiative could contribute indirectly to the development of renewable energy:

> *I think the major markets of solar panel products are still China, Europe and the United States at present. The Southeast Asia markets are very small and India's market is developing now. The Belt and Road Initiative provides us potentials to develop the markets along the Belt and Road. (LCJ)*

B) Local Policies

The second theme emerging from the data is 'local policies', which relate to the energy policies proposed by the Hong Kong government. Local policies in Hong Kong also influence the energy sector. Two sub-themes were identified: B1) the existing energy policy; B2) the Climate Action Plan 2030+.

B1) Existing energy policy

Almost all participants are not keen on this issue; only three interviewees contributed their ideas on this sub-theme. In general, they perceived that the effectiveness of the Hong Kong government in setting the energy policy was not satisfactory, and they explained their observations. An interviewee pointed out that the Hong Kong government did not have a comprehensive plan. He said:

> *For example, [I observe that] the government wants to promote the usage of electrical vehicles, but there are a lot of regulations they need to amend [beforehand], such as the charging payment to the carpark companies. You know, in Hong Kong, only two power companies are authorized to provide electricity for commercial purposes by law; other companies are not allowed to do so. However, more locations providing charging services is definitely a driver for using electrical vehicles. (BT)*

Another interviewee tried to find another reason to explain this phenomenon; his observations relate to the legislative council. He shared his opinions as follows:

> *Due to the political dispute in the legislative council, government policies cannot be passed and launched in time to cope with the trend. (ZLL)*

A third interviewee provided her suggestions to the government about the renewable energy policy. She emphasized that the governance of the whole industry will result in the development of renewable energy in Hong Kong becoming healthier:

> *I think the government should actively promote to use more renewable energy. She should not only provide preferential policies, but also control the developmental progress. Otherwise, it leads to unbalanced development, possibly undersupply or overcapacity, etc. I think it is necessary to manage the industrial development rationally and scientifically. (PNG)*

B2) The Climate Action Plan 2030+

Hong Kong's Climate Action Plan 2030+ report is an official document developed by the Hong Kong government in January 2017. The purpose of this report was to set targets with schedules for carbon emissions reduction in response to the Paris Agreement. Only one interviewee mentioned this report in our conversations, but he could not provide the report's name. The following is his quotation:

> *Actually, I know that Hong Kong has already signed the [Paris] Agreement and we will implement it. Government has already prepared a plan called whatever 2030+, I forget its name anyway. It is to inform people and us [practitioners] about what to do and when to do it. Of course, we know there are a lot of challenges ahead. At least, there is a solid plan for us to follow. (SW)*

Economic Category

C) Energy Spending

This third theme represents people's perceptions of the energy transition. Energy consumers are one of the important stakeholders in the energy sector; they are most concerned about their spending on energy. Only one sub-theme was included under this theme: C1) more spending on renewable energy.

C1) More spending on renewable energy

Six interviewees mentioned that people would pay more for renewable energy, and their opinions are summarized in two parts. First, partial extra spending offsets the hardware cost of renewable energy. Two interviewees shared their views as follows:

> *The power generation cost of solar panels cannot be compared with conventional energy, or nuclear energy because these old technologies are used for long period of time, the equipment cost has already been returned … [For solar panel technology] the investment on the newly installed solar panels has not yet been totally recovered, the price of the renewable energy included part of the hardware cost. (HY)*

> *At present, the solar power generation cost is a bit higher than the conventional ones. It cannot replace the conventional energy yet. We have to press the [solar power generation] cost even lower than the entire conventional energy. This is a real challenge. (LCJ)*

Second, for renewable energy consumers with solar panels installed on their premises, another portion of their extra spending came from their equipment. Another interviewee explained his idea:

> *All of us are energy consumers; most of us like clean energy but we have to pay more for it … Some of us can afford to set up solar panels at our own houses, but we have to sacrifice some living*

spaces and pay a certain amount for the devices; it is a financial burden. (AND)

D) Conventional Energy Supply

Conventional energy has been engaged in the energy industry for a long time, and it currently provides a significant portion of the energy supply worldwide. This theme highlights the limitations of conventional energy. Two sub-themes are grouped into this theme: D1) finite supply of fossil fuel and D2) inflexible power generation.

D1) Finite supply of fossil fuel

Another important sub-theme is the finite supply of fossil fuel, which eight interviewees identified. As illustrated in the quotation below, one interviewee contrasted the difference between the supply of conventional energy and renewable energy:

In fact, the consumption of conventional energy is becoming less and less gradually. It is a kind of non-renewable energy … At present, the renewable energy is inexhaustible. (GFH)

In addition, another interviewee highlighted that human beings should not rely heavily on conventional energy sources. He stated the following:

[For] petroleum and fossil fuel, the stocks [stored in the world] will be decreased after we use them … These conventional energy sources and coal – we have to gradually use them less. (FSC)

D2) Inflexible power supply

This sub-theme relates to inflexible power generation, which a sophisticated energy engineering interviewee proposed. She explained the reason as follows:

In the past, the power companies invested huge amounts of capital in plants, equipment, and professionals to generate *electricity and sold them to the community. In case the supply ceiling was reached, power companies had to acquire extra power-generating equipment to expand the production capacity. It needed tremendous capital and a long setup time as well. (DY)*

E) Renewable Energy Investment

Conversely, renewable energy also has its limitations. This theme only focuses on the investment issue, which is associated with two sub-themes. The two sub-themes are E1) the high investment risk of renewable energy; and E2) the unstable supply of solar systems.

E1) High investment risk in renewable energy

Renewable energy is a newly developed technology; it still has room for further development. Six interviewees recognized this phenomenon, which the following quotation can represent:

Development of solar panel technology is very fast, and its product life cycle is also very short … A new generation comes up and supersedes the previous generation at once. Maybe the investment of old generation [equipment] has not fully returned yet, it is unwilling to invest in new generation [equipment] … The financial pressure becomes high in a certain period, and the company may face a loss. (XY)

E2) Unstable supply of solar systems

In addition to the previous sub-theme, seven interviewees expressed their worries about the supply of solar systems. According to their observations, this sub-theme relates to various factors associated with the supply chain. As illustrated in the quotations below, three interviewees perceived that three different reasons cause this phenomenon:

[In our supply chain] there exists some capacity mismatch situations between the upstream and downstream. It will cause some production capacity wastage or price increase for some components. It is an unhealthy situation for the industry, and it is necessary to coordinate the whole supply chain. (SM)

The entire solar panel industry is expanding rapidly; various companies are building their production lines. Many companies are facing the insufficient supply of silicon materials. Then, we have to balance the supply and demand in the supply chain. (XY)

The scarcity of silicon resources affects our expansion. Our suppliers cannot provide us with materials in time. It will affect our production and our expansion … The price of upstream materials has risen, but the price of our products cannot be adjusted upward. Our company faces great challenges here. (ZM)

F) Shortage of Professionals

The shortage of renewable energy professionals was the sixth theme of issues faced by the Hong Kong energy sector. It represents an obstacle to renewable energy development. Seven interviewees actively raised this issue for discussion; this demonstrates the severity of this issue. Within this theme, two sub-themes emerged from the data: F1) insufficient supply of professionals, and F2) reluctance to join the energy industry.

F1) Insufficient supply of professionals

Six interviewees shared this common observation. They pointed out that recruiting experienced professionals and their high turnover rate in the energy industry was challenging. One interviewee expressed his opinion as follows:

Talent reserve is another challenge: Because the industry is expanding quickly, energy professionals is in obvious shortage. We observe that professionals' turnover is very fast in the [energy] *industry, then the remaining professionals are scattered amongst various projects, which weaken their productivity. (SBT)*

Moreover, Hong Kong has insufficient energy engineering curricula at universities and vocational schools. An interviewee shared his observation:

Universities and colleges can develop more curricula for students to join the [energy] industry. Power companies can provide some professional educational and training programme for their engineering staffs. (CJK)

F2) Reluctance to join the energy industry

Of the seven interviewees, two of them shared a similar idea. They perceived that the attractiveness of the energy industry for young engineers was low. Their common opinion can be summarized as follows:

A big challenge [to Hong Kong energy sector] is that young engineers prefer not to join this sector, [it is because] the industry is very old and stable. [Hong Kong has] only two power companies, [their] developments [were] flattened, this is the first point. The second point is [that] the renewable energy [industry in Hong Kong] is in an initial stage. No significant growth [is expected] due to the limitations of land and people [in Hong Kong]. (LCJ)

Hong Kong people are moneyist with a conservative mindset, [they are] not willing to enter this sector because [they think] they will not earn big money in this sector. (CCK)

G) Competitive Rivalry

The seventh theme that emerged from the data is the competitive rivalry. It is related to the phenomenon of competition in the energy industry. Two sub-themes were identified: G1) the emergence of new business models and G2) alterations in the business ecosystem.

G1) The Emergence of New Business Models

Three interviewees expressed their positive attitudes about the competition in the energy industry, which would bring vitality to the stable energy industry. Through technological advancements, more players could enter the energy sector; it broke the oligopolistic situation of the Hong Kong energy sector. An interviewee with rich energy engineering experience explained her ideas as follows:

> *In future, small companies can also provide power, [because] they don't need intensive capital to invest in conventional technology to generate power. [What they have to do is] just to collect the power generated from individuals' solar panels, re-package it and then distribute it to the consumers or power utilities. This is a new business model which erodes some market share. (DY)*

G2) Alterations in the Business Ecosystem

Three interviewees contributed their observations of the ecosystem change in the energy sector; they all agreed that this gradual change started after the launch of renewable energy. An interviewee highlighted that the development of renewable energy lowered the economic barriers to power generation in recent decades. Hence, the public can afford to set up solar panels to generate power for their usage. Furthermore, they can sell the excess power to the power companies for resale. This consequence facilitates the decentralization of power generation and changes the ecosystem of the energy industry. He shared his ideas as follows:

> *The energy sector is a very stable sector, there are no big changes for a century … But now, the new technology totally*

changes the overall business climate of this sector, it adds the possibility of energy sources, it also changes the operational model, cost dynamics, technology, finance, and environment protection [requirements]. Everything is changed … Compared with the old model, the society has different demands, viewpoints, and expectations from the energy sector. It seems to disassemble the previous ideas, operational process, and skills, to re-examine and fuse them together into a new model. (SM)

Another interviewee wondered whether the big power companies in Hong Kong could transform themselves successfully to accommodate this change. She commented:

[To tackle this change] I think Hong Kong power companies can move faster a lot … [but] these companies have a long period of glorious days, and energy is a necessity [to the public]. They may consider whether they need to change. [In addition] some management level may retire shortly; they prefer to keep the current situation. (DY)

Socio-Cultural Category

H) People Awareness

The eighth theme that derives from the qualitative data is people's awareness. Under this theme, there are two sub-themes which reflect the consciousness of the public. These sub-themes are H1) environmental consciousness and H2) renewable energy awareness.

H1) Environmental consciousness

The public's environmental consciousness is an important sub-theme perceived by many interviewees; eight interviewees provided their observations that this awareness relates to the focus on extreme weather events in the world. One interviewee illustrated his observations as follows:

Recently, Hong Kong people are more concerned about the temperature, air pollution, ocean pollution, etc. Maybe it relates to the extreme weather events that often occur all over the world … Everyone is a member of our society; we should have awareness to ask for clean energy to protect our living environment. (AND)

H2) Renewable energy awareness

Ten interviewees pointed out that renewable energy awareness is another crucial sub-theme. The public perceives that renewable energy is the only solution to protect their living environment:

Energy transition is a trend, and it will become cleaner and cleaner in the future … In Germany, they will not drive diesel cars and petrol cars anymore, they will switch to the clean energy vehicles in the next ten years. Hong Kong may be a bit later. (AND)

I) Good of Mankind

The 'good of mankind' was the ninth theme that emerged from the qualitative data. It represents the most meaningful theme that changes how the public perceives energy and its distribution. Two sub-themes are included under this theme: I1) humanizing energy and I2) business philosophy.

I1) Humanizing energy

This unique insight was contributed by only one interviewee, who had been working in the energy sector for more than 30 years. Until now, she had been paying attention to the issues of the energy industry. She pointed out that the public anticipated the energy supply to be inexhaustible, particularly with the introduction of renewable energy sources. People shifted their focus from the technological aspect to the social benefits of energy – how energy helped people. The following was her introduction to the concept of humanizing energy:

In fact, there is a global energy professional body called World Energy Council which is a United Nations accredited organization representing the entire energy spectrum in the world. Their recent slogan is 'Humanizing energy'. They propose that all of us rethink energy, using a new humanity perspective during this energy transition period which, I think, is another huge challenge for the energy industry. (DY)

She also elaborated with an example that the inflexibility of traditional power generation and advancement in metering technology invaded the public's freedom in power consumption. She stated:

Traditionally, power companies deliver electricity to consumers' premises, consumers can determine when to use electricity, and which appliances to use. One example in Switzerland, however, through a smart power meter which is installed inside a household, power companies can control consumers' usage of appliances with high loadings during peak hours. From power companies' perspective, the aim is to avoid power demand overload, but it is monitoring and control from the consumers' perspective. (DY)

In addition, she regarded the freedom of power consumption as part of a human right. She proposed considering including energy supply into the governmental services to the Hong Kong people, such as water supply, education, health care, etc. She stated her opinion as follows:

Some people think that using energy is a human right, should the [Hong Kong] government continue to use the traditional commercial way of providing energy to the public? Or the governments in the world have the responsibility to provide fair energy to improve the living of the communities. (DY)

She observed that different countries had reached various economic development levels, and indicated that we have to balance energy usage as a right, economic affordability, and the environmental pollution of a country by using fossil fuel. Moreover, she extended her fairness concept from Hong Kong to the world. The following quotation is from her:

> *[To the people in the world] energy is not evenly distributed. People in some countries have insufficient energy supply, but energy is oversupplied in other countries. Of course, we recognize that environmental pollution is an issue. However, somebody may ask why fossil fuel cannot be used on a small scale in some developing countries. Fossil fuel may be a feasible and cost-effective energy source for them [because they cannot afford the clean but expensive renewable energy], why not? We have to carefully consider the balance between the right of using energy, the economic affordability, and the environmental impacts. Why can we force them to use the renewable energy that they cannot afford? Is it fair? (DY)*

I2) Humanizing business philosophy

In answer to the public awareness of environmental protection, some Hong Kong energy companies have invested more in corporate social responsibility, which puts the focus on the community. As a commercial energy supplier, however, the corporate social responsibility direction weakens a company's profitability, and the business philosophy is also affected. The following explanation was provided:

> *Many energy companies in Hong Kong began to go into the society, go into the crowd. A lot of community works, and persuasive works started … In the past, selling energy to the public was the business of energy companies, but now they are teaching their customers how to save energy, which is an opposite business direction of the past. It makes people confused; it is really a huge challenge to their business philosophy. (AND)*

Technological Category

J) Renewable Energy Technology

Renewable energy technology was the tenth theme of the issues facing the Hong Kong energy sector; it is a positive driver for renewable energy development in Hong Kong. Within this theme, five sub-themes are identified; namely, J1) cost-effective solar systems launched; J2) household solar panels launched; J3) metering technology improved; J4) evolving battery technology and J5) technological limitations.

J1) Cost-effective solar systems launched

Three interviewees referred to the maturity of solar technology: The cost-effectiveness of solar panels is high enough that the current target can be moved to production cost reduction. An energy engineer who works for a solar panel distributor shared his observations. As illustrated in the following quotations, he compared the functionalities and prices of different products:

> *The quality of solar panels made in China is better than other countries … Now, the manufacturers are working hard to further improve the performance of their products and reduce costs. Some of them focus on manufacturing products for market demands while others invest large capital in research to improve the energy conversion efficiency. (LCJ)*

Another interviewee, who is involved in technological cooperation with her supplier, expressed a similar opinion as follows:

> *In the last decade, the cost of solar power generation in China has decreased by 90% ... My overseas supplier is improving their components in order to fulfil the quality requirement of our products. (LZP)*

Similarly, another interviewee agreed about this phenomenon. He added:

> *In terms of cost-effectiveness, I agree that the technology of Chinese solar panels has obvious advantages. (FSC)*

J2) Household solar panels launched

Besides the large-scale solar power station, manufacturers are increasingly developing small-size solar panels for household usage, another facet illustrating the advancement of solar technology. An interviewee observed this trend and stated as follows:

> *Moreover, our company has developed another smaller solar panel for every family to use. Its size is very small, which can be installed on the roof top. This has been the direction of our company for several years. We believe that it will become a development trend, just like every family must have a fridge. (ZM)*

J3) Metering technology improved

Electricity meters are a kind of power consumption monitoring apparatus; every household should have at least one to record how much electricity is consumed regularly for billing purposes. In the past, the staff of power companies had to copy the readings on sites and send these back to their account departments to prepare bills. Along with the advancement of digital technology, many manufacturers developed digital electricity meters which record the power consumption on premises and regularly send the data back to the power companies. An interviewee working in solar panel distribution introduced new metering products associated with solar technology as follows:

> *New [electricity] meters can record [the power flows in] two different channels, one channel [for the power delivered] from the power company and the other [for the power generated] from the solar panels. (LCJ)*

These new instruments support solar energy distribution management and indirectly promote solar energy application.

J4) Evolving battery technology

As solar panels only operate when the sun is shining, storing captured solar energy to be used at night or during weak sunshine periods is essential. At present, batteries are the only way to keep the power generated by solar panels. Hence, battery technology is a critical supporting renewable energy technology, yet it has lagged behind advancements in solar technology. An energy engineer who is working for a solar panel manufacturing company shared his observation:

> *The battery industry is facing its technical limitation, the battery storage used in solar energy reached its bottleneck. The largest challenge is that it is not clear which battery technology can support this huge storage scale, like a power station. (ZLL)*

J5) Technological limitations

An interviewee noted that renewable energy technologies have their limitations, which the energy sector must study to find solutions to improve or minimize these limitations. He explained the limitations as follows:

> *Every energy source has its own limitations. For example, the limitation of wind energy is the geographical condition, locations with strong wind provide its advantages. Solar energy also has its limitations; in most places the normal sunshine time is basically between 8 and 10 hours, no electricity can be generated outside this period … (TBY)*

Legal-regulatory category

K) Industry Standard

The eleventh theme pertains to the standards of the energy industry, which hinder renewable energy development. Under this theme, two sub-themes were determined: J1) striving for the ‘right to speak’; and J2) slowing industrial normalization.

K1) Striving for the ‘right to speak’

Four interviewees shared a similar idea: They emphasized that it was crucial to participate in setting industry standards because it could profoundly affect the technology, industry, and the complete supply chain. An interviewee explained as follows:

> *Large companies usually use their existing technological capabilities or financial capabilities to achieve the right to speak in the industry, then they will use this right to suppress or distort the normal competitive environment of the industry. For the industry, too fast development is not good because industrial standards cannot keep up. Without standards, there will be situations where big fish eat small fish in the industry, just like the semiconductor industry. (GFH)*

K2) Slowing down industrial normalization

The setting of an industry standard deeply affected the development of the industry. Only one interviewee raised the viewpoint that the normalization of the energy industry was highly dependent on the establishment of an industrial standard. The interviewee commented as follows:

> *[In the renewable energy industry] every company is using their material, technology, and expertise to develop their [own] products. This leads to a variety of industrial standards. However, different companies have their own standards, which causes an unfair competitive relationship in striving for interests. Ultimately, it limits the normalization of the industry. (SBT)*

Environmental Category

L) Environmental Pollution and Climate Change

Finally, environmental pollution and climate change comprised the twelfth theme from the data. This theme represents the most critical issue facing the Hong Kong energy sector; its impacts influence everyone globally. Under this theme, L1) conventional energy polluted environment was the only sub-theme.

L1) Conventional energy polluted environment

Only two interviewees referred to this sub-theme, but I'm not at all convinced that this sub-theme is a minor point. Instead, this sub-theme is the most critical threat to human beings. Interviewees mentioned this impact as follows:

[The share of] thermal power generation is still significant [in the world] and the environmental pollution is also serious. (TBY)

Conventional energy is a major pollution source to our environment and climate. (SW)

I tend to believe that this understanding is such common sense that other interviewees thought it was needless to mention this point.

The above themes and sub-themes of the Hong Kong energy sector's challenges and opportunities are summarized in Table 5.25.

Table 5.25: Themes Summary of the Hong Kong Energy Sector's Challenges and Opportunities

Theme Category	**Theme**	**Sub-themes**
Political	A) National policies	A1) Carbon neutrality policy A2) Belt and road initiative
	B) Local policies	B1) Existing energy policy B2) Climate Action Plan 2030+
Economic	C) Energy spending	C1) More spending on renewable energy
	D) Conventional energy supply	D1) Finite supply of fossil fuel D2) Inflexible conventional energy supply
	E) Renewable energy investment	E1) High investment risk in renewable energy E2) Unstable supply of solar systems

	F) Shortage of professionals	F1) Reluctant to join energy industry F2) Insufficient professionals supply
	G) Competitive rivalry	G1) New business model emerged G2) Alterations in business ecosystem
Socio-cultural	H) People awareness	H1) Environmental consciousness H2) Renewable energy awareness
	I) Good of humankind	I1) Humanizing energy I2) Humanizing business philosophy
Technological	J) Renewable energy technology	J1) Cost-effective solar systems launched J2) Household solar panels launched J3) Metering technology improved J4) Evolving battery technology J5) Technological limitations
Legal-regulatory	K) Industry standard	K1) Striving for 'right to speak' K2) Slowing industrial normalization
Environmental	L) Environmental pollution and climate change	L1) Conventional energy polluted environment

Essential Competencies Perceived by the Interviewees

The main goal of the qualitative research was to provide insight into explaining the competencies identified during the quantitative analysis. These insights reflect how the qualitative participants interpreted the challenges faced by the Hong Kong energy sector and the competencies required to tackle these challenges. Because these participants are currently engineering practitioners in the Hong Kong energy sector, the qualitative findings also provide meaning for the local context. Although the findings regarding the challenges and opportunities facing the Hong Kong energy sector were classified into six categories using the PESTLE analysis model, the competencies identified by the interviewees cannot be categorized because they are interwoven with the challenges. In other words, a single challenge might require multiple competencies to address, whereas a single competency could solve numerous challenges.

In addition to the thematic analysis regarding the challenges and opportunities facing the Hong Kong energy sector, I revisited the coding of the interview transcripts to identify the competencies to tackle the difficulties and potentials mentioned above. Based on the definitions of competency terminology from the published engineering competency models, I checked for these against every phrase in the transcripts. If any interviewees mentioned some competencies or solutions close to the definitions of specific competencies, then I recorded the corresponding competencies as findings of this analysis.

My interviewees mentioned a variety of competencies in the interview transcripts, whereas I interpreted them based on the definitions of the published engineering models. However, the descriptions of some competencies differed from the published models' definitions. Hence, these competency items are further studied as follows.

First, some interviewees claimed that professional engineering knowledge is fundamental to their knowledge base and that their daily jobs could not be completed without it. They further mentioned that STEM subjects (an acronym for science, technology, engineering, and mathematics collectively) are the basis of professional engineering knowledge. Secondary or middle school students studied these subjects for their engineering career development. Several interviewees added that engineering projects always affect many people in society, and understanding humanities subjects may also help them carry out their work. Other interviewees shared that artistic subjects and language abilities also enhanced their productivity and effectiveness; the former improved their imagination and creativity, and the latter allowed them to absorb up-to-date global engineering technology and work with their engineering counterparts outside Hong Kong. Hence, I recognize that the so-called 'professional knowledge' competency includes fundamental engineering knowledge and is supported by other academic knowledge, including STEM, humanities, artistic, and language subjects.

Second, some interviewees indicated that organizing ability was necessary for their jobs. They further elaborated that they had to handle multiple tasks simultaneously, especially when implementing complicated engineering projects. They had to ensure that every part of a task was handled correctly and that each project step was implemented accurately. Hence, every project task must be well planned and prioritized, then delegated to their associates and regularly monitored. Other interviewees also emphasized the need for execution ability for energy engineers, stating that they had to execute brand-new projects, requiring them to finish promptly and effectively. They noted that a clear execution plan was essential for the successful implementation of a project and that the interlinked tasks, as well as their responsible parties and durations, were well-planned. They might have encountered obstacles during implementation, but they had to overcome them. After careful comparison, I observed that the nature of execution capabilities was close to the organizing ability. Hence, I combine these two items into ‘organizing and execution abilities'.

Third, interviewees with extensive experience in the energy sector stated that the public expected the energy supply to be limitless, especially with the introduction of renewable energy sources. They are changing their minds about energy from a technical to a social aspect. People are more concerned with how energy improves their standard of living, and they should have the freedom to control their power utilization. People in some countries regard the freedom to consume energy as a human right. In addition, people have concerns about the fairness of renewable energy generation and use. Many developing countries cannot afford to generate clean but expensive renewable energy; they are forced to utilize traditional fossil fuels to generate power. For equity, someone suggests that developing countries should be allowed to use a small amount of fossil fuel to power their populations, but this weakens environmental protection efforts. Due to the difficulty of balancing the human right to utilize energy and environmental pollution, different individuals may arrive at other judgements when faced with this dilemma.

Moreover, energy enterprises in Hong Kong have shifted their business philosophies, focusing more on corporate social responsibility in response to the public's environmental concerns. Campaigns to save energy and reduce carbon emissions are started, and many events to protect the environment and educate the community are put on. These actions lower their profitability but demonstrate that Hong Kong energy enterprises place ethics higher in their corporate core values. Referencing the concept of ethics developed by Shaw (2011),

> *Ethics deals with individual character and with the moral rules that govern and limit our conduct. It investigates questions of right and wrong,*

fairness and unfairness, good and bad, duty and obligation, and justice and injustice, as well as moral responsibility and the values that should guide our actions. (p. 7)

I learned that energy engineering professionals in Hong Kong should always be aware of the ethical concerns of their work. Hence, I believe 'ethical awareness' to be a competency identified by this analysis.

Unexpectedly, in this analysis, I also recorded some competencies that I did not come across in the quantitative research, and these competencies were explained as follows. Systems thinking was the first competency not included in the quantitative research since my referenced published competency models did not mention it. To understand this concept, I studied the literature on it and systems thinking is defined as follows.

[Systems thinking is] a discipline for seeing wholes, for shifting away from narrowing the focus to one particular part and instead expanding it to many parts that have impact upon one another. […] Systems thinking views an organization and its respective environment as a complex whole of interrelating, and interdependent parts. It stresses the relationship and the process that make up the organizational context, rather than the separate entities or the sum of the parts. (Senge, 1990)

The rationale for using systems thinking is based on the fact that, systems thinking provides us with methods for describing, analysing, and planning complex system using a structured way of building model. The method offers a way of understanding complex real-world problems; simplify them using structured models and communicating this understanding and the simplification to others. (Holmberg, 2000)

Systems thinking has been employed in many areas, such as environmental and educational systems. In contrast to the traditional analysis approach, which studied systems by breaking them into components, systems thinking is a holistic approach to analysis that focuses on how systems function over time and in a larger context, including human beings. According to the systems thinking approach, system behaviour is a product of reinforcing and balancing processes. Reinforcing processes leads to developing some system components, while the balancing process maintains equilibrium in the system. Paying close attention to feedback is very important to systems thinking. Thus, I consider it to be one of the competencies revealed by the qualitative analysis.

The entrepreneurial mindset is another competency mentioned by the qualitative participants. It enables and empowers people to produce new ideas, solve problems, generate innovative solutions, and act to explore possibilities. Several interviewees were asked to implement their engineering projects, like running their own business; they were expected to achieve the project goals with high quality and limited resources, time, and technology. Under these circumstances, the practitioners sometimes had to develop ingenious notions to handle problems. McGrath and MacMillan (2000) defined the entrepreneurial mindset as the ‘ability to rapidly sense, act, and mobilize, even under highly uncertain conditions’. Entrepreneurs always keep an eye on new prospects but do not chase them all immediately. Instead, they are aware of their limited resources and allocate them using a strategy. Along with the development of renewable energy, energy engineers should also use this competency so that global energy issues can be solved in an innovative way. Therefore, the entrepreneurial mindset is another competency extracted from the qualitative analysis.

National policy awareness is considered another competency revealed by the qualitative analysis. This competency is essential, especially to practitioners in Hong Kong, because the roles and positions are different after returning to China in July 1997. Hong Kong is currently a special administrative region of China; some national policies are applicable in Hong Kong, such as the carbon neutrality policy and the Belt and Road Initiative. Hong Kong has a unique and irreplaceable role in the nation’s 14th Five-Year Plan; the national policies in the plan also influence the strategic directions of some industries, including the energy industry. Hence, Hong Kong energy engineers must develop this competency to synchronize with national development trends.

By adopting the amendments above, Table 5.26 summarises the competencies findings and the corresponding proposers from this analysis.

Table 5.26: Competencies Findings from Qualitative Analysis

	GFH	LCJ	LZP	XJJ	DY	BT	FSC	HY	SM	AND	ZM	SBT	TBY	CCK	PNG	CJK	ZLL	SW	XY	Count
Professional knowledge		√	√		√	√		√	√		√		√	√		√	√			11/19
Creativity	√		√			√		√	√	√					√	√				8/19
Effective communication	√			√	√	√	√	√	√			√								8/19
Organizing and execution abilities	√	√	√				√		√	√				√						7/19
Academic knowledge	√		√	√						√			√			√				6/19
Enterprenuerial mindset	√			√	√	√		√											√	6/19
Self-motivation		√		√				√		√		√						√		6/19
Technology awareness		√				√		√	√	√	√									6/19
Lifelong learning			√	√			√					√			√					5/19
National policies awareness			√	√			√													3/19
Judgement and decision-making			√						√								√			3/19
Compliance	√						√													2/19
Research skills		√											√							2/19
Interculural abilities		√					√													2/19
Change management		√			√															2/19
Ethical awareness					√					√										2/19
Safety awareness	√																			1/19
Craftsmanship											√									1/19
Systems thinking					√															1/19
Information management						√														1/19
Teamwork	√																			1/19
Engineering practices				√																1/19
Count:	8	7	7	7	6	6	6	6	6	6	3	3	3	2	2	3	2	1	1	85

In Table 5.26, the competencies are ordered according to the number of interviewees who cited them in their interviews. After analysing the interview transcripts, I recognized that the participants identified 22 competencies. Amongst these competencies, nine were mentioned by more than 25% of interviewees. These eight competencies are professional knowledge, creativity, effective communication, organizing and execution abilities, academic knowledge, entrepreneurial mindset, self-motivation, technology awareness, and lifelong learning. Of these nine competencies, professional knowledge is the competency that 11 out of 19 interviewees mentioned being essential to dealing with the challenges ahead. The number of interviewees who cited the other seven competencies in their interviews ranged from five to eight. By contrast, only three or fewer participants mentioned the remaining 13 competencies in their interviews.

Structure of Competency Categories

After analysing the interview transcripts for perceived competencies, my next step was to group them into relevant categories. Because there are many approaches to categorizing competencies in the published engineering competency models, I adopted the classical method of grouping competencies in this study rather than applying a marketing analysis model, such as the PESTLE model, to determine competency categories.

Spencer and Spencer (1993) proposed the iceberg competency model in their book *Competence at Work: Models for Superior Performance* to explain the competencies. They defined competencies as underlying characteristics of people which indicated 'ways of behaving or thinking, generalizing across situations, and enduring for a reasonably long period of time.' Hence, they classified competencies into explicit and implicit characteristics, and a person's competencies are the total of that person's explicit and implicit characteristics. Explicit characteristics refer to a person's personality that can be observed at work at any time. Conversely, implicit characteristics refer to the deepest and most long-lasting aspects of a person's personality, even in different job positions. They can explain or predict how a person will think and behave. This classification reveals the implicitness of the competencies and has practical implications for human resources development. They organized competences into five basic types: motives, traits, self-concept, knowledge, and skill. These are defined as follows:

- Motives: The things a person consistently thinks about or wants that cause action. Motives "drive, direct, and select" behaviour toward specific actions or goals and away from others. For example, achievement-motivated people consistently set challenging goals for themselves, take personal responsibility for accomplishing them, and use feedback to improve.
- Traits: Physical characteristics and consistent responses to situations or information. For example, reaction time and good eyesight are physical trait competencies of combat pilots.

- Self-concept: A person’s attitudes, values, or self-image. For example, self-confidence is a person’s belief that he or she can be effective in almost any situation and is part of that person's concept of self.
- Knowledge: Information a person has in specific content areas. It can predict what someone can do, not what he or she will do - for example, a surgeon’s knowledge of nerves and muscles in the human body.
- Skill: The ability to perform a particular physical and mental task. For example, a dentist’s physical skill to fill a tooth without damaging the nerve; a computer programmer’s ability to organize 50,000 lines of code in logical, sequential order.

Referring to the iceberg competency model shown on the left of Figure 2.2, the above-water part of the iceberg represents a person's visible competencies, such as knowledge and skills. The below-water portion denotes the hidden characteristics of a person that strongly influence the individual, such as self-concepts, traits, and motives. Spencer and Spencer (1993) also considered the implicitness degree of these five types of competencies and categorized them into three layers, which are illustrated on the right side of Figure 2.2. Motives and personality traits are positioned in the innermost layer of the individual and therefore are difficult to be inspected and developed. Knowledge and skills, by comparison, are located in the outermost layer and are the simplest ones to be observed and trained. Self-concept is placed between the two layers. According to this classification, Spencer and Spencer (1993) claimed that knowledge and skills competencies tend to be visible and relative surface characteristics of people. In contrast, self-concept, trait, and motive competencies are more hidden, “deeper”, and central to personality.

To classify the essential competencies identified by the interviewees using the preceding five competency definitions, I encountered the following difficulties:

First, I was confused by Spencer and Spencer’s (1993) categorization of knowledge and skills in the same outermost layer. According to the preceding definitions, knowledge refers to the individual’s recognition of specific professional fields, and skill refers to the ability to perform some tasks. I believe these two competency items should have different levels of implicitness. Hence, I questioned whether knowledge and skills should be separated into two distinct layers.

Second, the distinction between the self-concept and the motives and traits layer was ambiguous. Categorizing the interviewees' essential competencies into these two layers was not easy. To illustrate the implicit layering of the competencies, I questioned whether another set of layers should be developed.

Third, it was difficult for me to determine the following six competencies: 'ethical awareness', 'social awareness', 'compliance', 'judgement and decision-making', 'safety awareness', and 'national policy awareness'. I recognized that these competencies share a common characteristic, which is much more inner, and core to personality than motive and trait. Therefore, I questioned whether these six competencies exceed the implicitness spectrum of the five competency types proposed by Spencer and Spencer (1993).

By further studying the literature regarding ethical competency, one finds that many scholars have published articles on this topic. Abbott (1988) claimed that ethical competency was at the heart of the profession's mission. Kulju et al. (2016) added that ethical competency implicitly is a part of all the dimensions of competencies; it is not distinct from other competencies but is a generic competency guiding the others. The above arguments demonstrate the importance of ethical competency in a profession or an organization.

Some researchers have tried to define ethical competency. Kavathatzopoulos (2003) defined ethical competency as the following set of personal and organizational capabilities:

- A high level of awareness on the part of a person can readily apprehend ethical situations, anticipate ethical conflicts before they arise, and recognize them once they are in effect.
- An ability to treat ethical conflicts in the best possible way for all parties concerned, knowing how to think, analyse actual cases, make decisions, and solve moral problems.

- The ability to support and sustain ethical processes in an organization.
- The ability to express oneself clearly and convincingly, argue, motivate, and defend one's decisions.
- Self-confidence and willingness to execute difficult decisions.

Patino-Gonzalez (2009) defined ethical competency as follows:

- The ability to reflect on, analyse, and evaluate ethical issues related to the person, professional behaviour, and the environment;
- To show respect for people and their environment;
- To know about and be sensitive toward social, economic, and political realities; and
- To act with civic spirit and responsibility to improve the quality of life in the community.

Ethical competency requires normative knowledge and the willingness to defend derived behavioural options against occurring resistance. Pohling et al. (2016) defined ethical competency as conscious decisions and actions within a given responsibility situation. It implied feeling obliged to one's moral principles and to act responsibly, considering legal, economic, ecological, and social consequences.

To include the six competencies above, I extend another category, namely ‘morality and ethics’, that anchors a conviction to judge whether the competencies’ intention, decisions, and behaviours are right or wrong. Hence, to clarify the competencies’ visibility, I propose a framework with four competency layers representing various levels of implicitness. These four competency layers are:

1) Engineering and academic knowledge;
2) Professional abilities and skills;
3) Key qualities;
4) Morality and ethics.

The details of these four competency layers are illustrated as follows.

Layer 1: Engineering and Academic Knowledge

The outermost layer of competency is engineering and academic knowledge. It refers to the essential knowledge without which practitioners cannot do their daily jobs. This knowledge is usually learned from secondary and tertiary education institutions that contribute to the knowledge landscape of practitioners. Referring to the iceberg competency model, the competencies in this layer belong to the explicit category.

Layer 2: Professional Abilities and skills

The second competency layer is professional abilities and skills. The competencies under this layer mainly refer to expertise, techniques and skills learnt and developed in the workplace. Competencies in this layer are not generally taught in the classroom. Learners usually acquire these professional abilities using existing workplace tools, machines, documents, equipment, and specialists' knowledge. Sometimes, experienced practitioners perform the mentor role to pass their know-how and industrial / company-specific skills to learners. Compared to the previous layer, the implicitness level of the competency items in this layer is higher since learners must enhance their abilities and skills through extensive practice and exercises. The competencies in this layer can be measured and learned by training; therefore, the competencies in this layer also belong to the explicit category.

Layer 3: Key Qualities

Key qualities are the third layer of competency. Competencies in this layer reflect an individual's inner qualities or capabilities, which are located in a spectrum between the individual-traits end (such as self-motivation) and the job-related end (such as technology awareness). According to Spencer and Spencer's definition, these competencies belong to the self-concept and trait types, which are not easily observed and measured. Thus, this layer belongs to the implicit category. Key qualities represent the characteristics of an individual and a professional. Supported by the competencies in previous layers, the competencies in this layer define how an individual will apply oneself to a job position.

Layer 4: Morality and Ethics

This innermost competency layer is intended to include ethical competencies. According to the typology established by Spencer and Spencer (1993), I could not classify any competencies whose implicitness level exceeded those of the preceding layers. I, therefore, extend this layer for this purpose. The ethical competencies refer to an individual's capabilities to recognise ethical situations, anticipate ethical conflicts, provide strong belief to make correct judgments and difficult decisions, respect people and their environment, be aware of social, economic, and political issues, and act with responsibility to enhance the quality of life in the community. The name of this layer hints that the competencies grouped under this layer can be further divided into two parts, morality and ethics. Most people consider these two terms identical. However, they are not the same, but these two concepts are closely related. Morality is a belief that determines whether one’s intentions, decisions, and behaviours are right or wrong. Morality is also a guiding principle. On the other hand, ethics refers to the rules defining allowable actions or behaviour. Professional bodies usually create specific ethical codes for their respective fields.

The Integration of the Quantitative and Qualitative Findings

Having discussed the quantitative and qualitative findings in previous sections, I intend to integrate both findings to obtain a more comprehensive understanding of developing the competency model for Hong Kong energy engineers, which is the aim of this research. In this section, I explain the purpose of integrating the quantitative and qualitative findings in the context of a mixed methods study and the findings of the integration process.

The Purpose of Integrating the Quantitative and Qualitative Findings

The mixed methods research approach considers both quantitative and qualitative findings as a whole, which provides a different perspective on the research subject to better understand the research topic. Regarding the outcomes of integrating both sets of findings, Erzberger and Kelle (2003) clearly stated that there are three possible results of integrating quantitative and qualitative findings, namely convergence, complementarity, and divergence. Fetters, Curry and Creswell (2013) shared a similar opinion that there are three possible outcomes to the coherence of the quantitative and qualitative findings:

- Confirmation: when the findings from both types of data confirm the results of the other.
- Expansion: when the findings from the two data sources diverge and expand insights into the phenomenon of interest by describing complementary aspects of a central phenomenon of interest.
- Discordance: when both findings are inconsistent, incongruous, and contradict, conflict with, or disagree with each other.

In addition, Patton (1999) argued:

> *Methods triangulation often involves comparing data collected through some kinds of qualitative methods with data collected through some kinds of quantitative methods. This is seldom straightforward because certain kinds of questions lend themselves to qualitative methods, while other kinds of questions lend themselves to quantitative approaches. […] Thus, it is common that quantitative methods and qualitative methods are used in a complementary fashion to answer different questions that do not easily come together to provide a single, well-integrated picture of the situation.*
>
> *In essence, triangulation of qualitative and quantitative data is a form of comparative analysis. […] Subsequently, deciding whether results have converged remains a delicate exercise subject to both disciplined and creative interpretation. Focusing on what is learned by the degree of convergence rather than forcing a dichotomous choice – the different kinds of data do or not converge – typically yields a more balanced overall result. That said, it is worth noting that qualitative and quantitative*

data can be fruitfully combined when they elucidate complementary aspects of the same phenomenon.

The above researchers also stated that the conclusions would have greater credibility if both findings provided similar conclusions or complemented each other to produce a better picture of reality.

Hence, in the integration phase, the quantitative findings are evaluated in light of the study's qualitative findings. Conversely, the qualitative findings are re-examined by considering the insights identified in the quantitative findings. In other words, both findings are 'mixed' to provide a more comprehensive picture of the same research topic.

An analogy of the blind men and an elephant is a good description of the integration phase: It concerns a group of blind people who had never encountered an elephant but wanted to learn about it. They tried to touch the big elephant's body. As the elephant was too large, each blind people could feel only one part of the elephant, such as the ear, the leg, or the tusk. Their observations were different from each other. None of them could provide a complete picture of the elephant unless they combined all their partial observations. The integration process mentioned in this paragraph is the same. The quantitative findings of this study reveal the generalized perceptions of the competencies of Hong Kong energy engineers, whereas the qualitative findings provide a meaningful alternative viewpoint. Hence, integrating both findings can provide a better picture of the research subject.

The Outcome of the Mixed Findings

By contrasting and integrating both research findings, I can achieve a relatively complete and insightful view of the essential competencies of Hong Kong energy engineers and obtain a corresponding competency model for them. Unlike other similar research using a singular research approach, integrating quantitative and qualitative findings enhances the quality of data interpretation and provides a greater understanding of the competency model (Tashakkori and Teddlie, 2003).

Amongst the convergent, complementary, and divergent findings mentioned above, only the first two types of findings are identified in this study and explained in the following sections. Before I present the convergent and complementary findings, both research findings are re-stated.

<table>
<tr><th><u>Quantitative Findings</u></th><th><u>Qualitative Findings</u></th></tr>
<tr><td colspan="2" align="center">Compliance
Lifelong learning
Ethical awareness
Academic knowledge
Information management
Organizing and execution abilities
Judgement and decision-making
Effective communication
Professional knowledge
Technology awareness
Safety awareness
Self-motivation
Craftsmanship
Teamwork</td></tr>
<tr><td>• Social awareness
• Productivity control</td><td>• Creativity
• Research skills
• Intercultural abilities
• Engineering practices
• Change management
• Systems thinking
• Entrepreneurial mindset
• National policy awareness</td></tr>
</table>

Convergent Findings

The contrasts between the two findings of this study explain how quantitative and qualitative findings confirm each other. In quantitative research, survey respondents determined 16 essential competency items, whereas, in qualitative research, interviewees identified 22 items. 13 were observed in both findings. Table 5.27 presents the mean values and standard deviations for these 13 identical competency items in both studies.

Table 5.27: Descriptive Statistics Comparison of the 13 Identical Competencies in Quantitative and Qualitative Samples

Perceived competency	**QUAN sample**			**QUAL sample**		
	n	**Mean**	**SD**	**n**	**Mean**	**SD**
Safety awareness	57	5.98	1.03	19	6.42	0.77
Compliance	57	5.95	1.08	19	6.05	1.18
Lifelong learning	57	5.89	1.06	19	6.21	0.79
Teamwork	57	5.82	1.04	19	6.21	1.03
Technology awareness	57	5.82	1.05	19	5.89	1.10
Professional knowledge	57	5.81	1.11	19	5.79	0.98
Effective communication	57	5.77	1.15	19	5.84	1.30
Organizing	57	5.77	0.98	19	6.00	0.82
Information management	57	5.68	0.87	19	5.74	0.93
Craftsmanship	57	5.64	1.03	19	5.68	0.89
Judgement & decision-making	57	5.64	1.15	19	5.68	0.95
Self-motivation	57	5.46	0.98	19	5.63	0.83
Academic knowledge	57	5.21	1.06	19	4.79	1.03

Remarks: The perceived competencies in this table were ordered by the mean values of the quantitative sample.

In Table 5.27, the 57 survey respondents scored these 13 competencies highly in terms of their importance; the mean scores for these 13 competency items ranged from 5.21 to 5.98 (the highest score was 7), and their standard deviations ranged from 0.87 to 1.15. Coincidentally, the corresponding scores of the 19 interviewees on these 13 competency items were comparable. The mean scores ranged from 4.79 to 6.42, and the standard deviations were between 0.77 and 1.30. It demonstrates that the qualitative research participants agreed with these 13 competencies determined by the quantitative study participants that could help address the energy transition challenges. In other words, the competency model for Hong Kong energy engineers consists of at least these 13 essential competency items. Additionally, by reaching a consensus on both quantitative and qualitative findings, the validity of the competency model for Hong Kong energy engineers is enhanced (Tashakkori and Teddlie, 2003).

Complementary Findings

Aside from the above convergent findings, three competencies are not included in the qualitative findings but are reflected in the quantitative research. These competencies are: ‘social awareness’, ‘ethics and professional conduct’ and ‘productivity control’. Conversely, nine competencies are hidden in the quantitative findings but are uncovered in the qualitative phase. In the quantitative phase, ‘creativity’, ‘entrepreneurial mindset’, ‘national policy awareness’, ‘change management’, ‘engineering practices’, ‘research skills’, ‘systems thinking’, ‘ethical awareness’, and ‘intercultural abilities’ were not included in the top ten competencies within seven different demographic groupings.

As illustrated in Table 5.28, the seven competencies’ mean values of importance level in both samples are very close. It demonstrates that these seven competencies do not bring any divergence into both findings.

Table 5.28: Descriptive Statistics Comparison of the 7 Complementary Competencies in Qualitative and Quantitative Samples

	QUAL sample			**QUAN sample**		
Perceived competency	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**
Productivity control	19	5.79	0.79	57	5.70	0.98
Engineering practices	19	5.63	1.34	57	5.58	0.82
Change management	19	5.63	1.01	57	5.40	1.15
Social awareness	19	5.53	0.96	57	5.56	0.88
Research skills	19	5.53	0.77	57	5.52	1.08
Intercultural abilities	19	5.37	1.07	57	5.30	1.15
Creativity	19	5.05	1.03	57	5.23	1.04

Remarks: The perceived competencies in this table were ordered by the mean values of the qualitative sample.

In addition, I observe that two competency items are closely related: ' ethical awareness' and ‘ethics and professional conduct’. Their mean values of importance level in qualitative and quantitative samples are also very close, 5.84 and 5.82, respectively. According to the behaviour descriptions from the published engineering competency models and the meanings provided by the interviewees, the scope of ‘ethical awareness’ competency covers far beyond the scope of the ‘ethics and professional conducts’ competency. To better describe this competency, the ‘ethics and professional conduct’ is replaced by the ‘ethical awareness’ competency.

Summary and Discussion

In this study, the first research question was: ‘What competencies do Hong Kong energy engineers perceive to be essential for the energy transition’s challenges and opportunities facing the energy sector?’ The purpose of this research question was to understand better what competencies are essential to deal with the forthcoming difficulties and potentials in the Hong Kong energy sector from the local engineering practitioners’ perspective. Hence, quantitative research was adopted to gather their overall perceptions of the above research question.

All 28 items in the questionnaire were responded to by a sample of 57 Hong Kong energy engineering practitioners during the quantitative research. The data collected from this research were imported into IBM SPSS Version 25 for data analysis. The descriptive analysis applied various statistical tools to display the characteristics of the quantitative data. Using descriptive analysis in seven different aspects, I established the demographic profiles of the survey respondents. The demographic characteristics of the 57 survey respondents can be summarized as follows:

- Predominantly male (over 84%)
- Mostly between 21 and 50 years old (over 84%)
- Highly educated (over 84% undergraduate or above)
- Almost all full-time employed (89.5%)
- Work experience evenly distributed (below 5 years to over 20 years)
- Significantly working in new energy, and power-related areas (over 80%)
- Middle to senior management rank (over 63% managed 10+ people)

Moreover, the essential competencies from different groupings were also discovered by descriptive analysis. By summarizing and analysing the statistical information from the quantitative data, the 16 essential competencies perceived by the survey participants can be summarized as follows:

- Compliance
- Ethics and professional conduct
- Safety awareness
- Professional knowledge
- Teamwork
- Effective communication
- Lifelong learning
- Technology awareness
- Organizing
- Information management
- Judgement and decision-making
- Academic knowledge
- Productivity control
- Social awareness
- Craftmanship
- Self-motivation

The second research question in this study was: ‘How do Hong Kong energy engineers consider their perceived competencies are essential?’ This research question aimed to investigate the meaning associated with their perceived competencies as described in the quantitative research. Therefore, qualitative research was used to understand better the perceived difficulties and potentials confronting the Hong Kong energy industry and to identify why the competencies indicated in the survey are essential.

The findings of the qualitative analysis conducted on the interviews were presented in this section. Individual online semi-structured interviews were conducted with each of the 19 participants. The interviews were then transcribed and, if required, translated before being subjected to theme analysis. In summary, based on a thematic analysis of the interview transcripts, the challenges and opportunities confronting the Hong Kong energy industry were classified into 12 themes and 25 sub-themes, which are listed below:

Themes of challenges and opportunities	**Sub-themes**
A) National policies	A1) Carbon neutrality policy A2) Belt and road initiative
B) Local policies	B1) Existing energy policy B2) Climate Action Plan 2030+
C) Energy spending	C1) More spending on renewable energy
D) Conventional energy supply	D1) Finite supply of fossil fuel D2) Inflexible conventional energy supply
E) Renewable energy investment	E1) High investment risk in renewable energy E2) Unstable supply of solar systems
F) Shortage of professionals	F1) Reluctant to join energy industry F2) Insufficient professionals supply
G) Competitive rivalry	G1) New business model emerged G2) Alterations in business ecosystem
H) People awareness	H1) Environmental consciousness

	H2) Renewable energy awareness
I) Good of humankind	I1) Humanizing energy I2) Humanizing business philosophy
J) Renewable energy technology	J1) Cost-effective solar systems launched J2) Household solar panels launched J3) Metering technology improved J4) Evolving battery technology J5) Technological limitations
K) Industry standard	K1) Striving for 'right to speak' K2) Slowing industrial normalization
L) Environmental pollution and climate change	L1) Conventional energy polluted environment

The competencies employed to cope with the aforementioned difficulties and possibilities were then identified by further studying the interview transcripts. My interviewees highlighted 22 competencies, three of which were previously unknown to me. The following is a summary of these 22 competencies:

- Professional knowledge
- Organizing
- Information management
- Research skills
- Change management
- Engineering practices
- Creativity
- Effective communication
- Self-motivation
- Technology awareness
- Lifelong learning
- Teamwork
- Craftmanship
- Intercultural abilities
- Entrepreneurial mindset
- System thinking
- Safety awareness
- Ethics and professional conduct
- Judgement and decision-making
- Compliance
- National policy awareness
- Academic knowledge

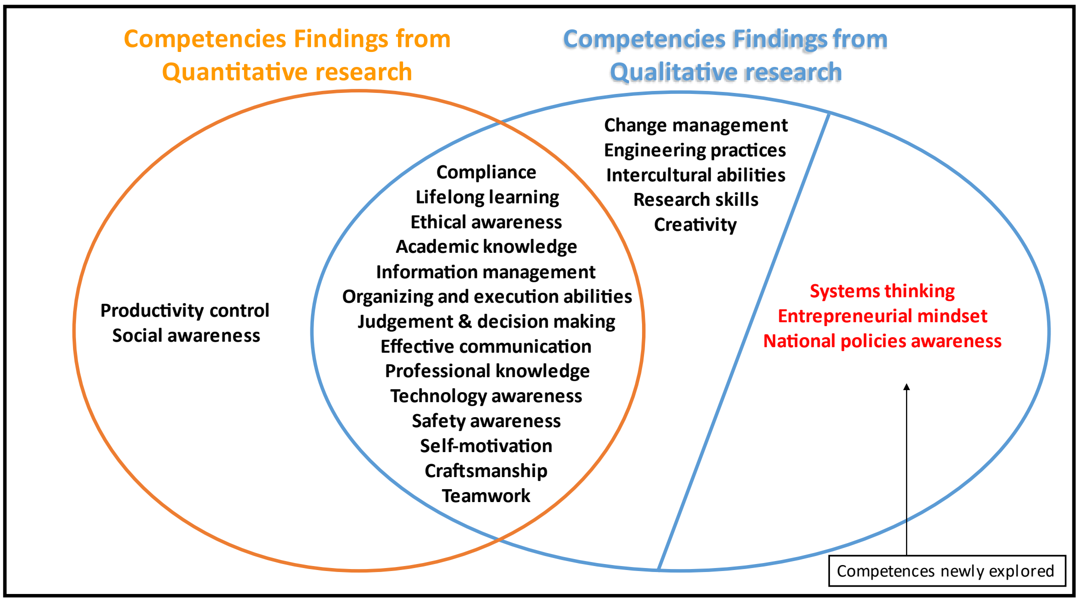
Based on the competencies' visibility, measurability, and trainability characteristics proposed by Spencer and Spencer (1993), four different levels of competencies were established, which were ordered from explicit and trainable to hidden and personality-related: engineering and academic knowledge, professional abilities and skills, key qualities, and morality and ethics. This classification framework was used to categorize the competencies in this study in terms of implicitness.

In this study, the third research question drove the integration phase: 'To what extent do their [Hong Kong energy engineers] interpretations help to explain their perceptions of the essential competencies?' This question led this research to establish a practical and meaningful set of competencies by integrating quantitative and qualitative research findings. Combining the convergent and complementary findings revealed two observations from the mixed findings. First, the convergent findings contributed 14 competencies, which the quantitative and qualitative research participants perceived. These 14 competencies were: organizing and execution abilities, compliance, ethical awareness, safety awareness, teamwork, self-motivation, effective communication, lifelong learning, technology awareness, information management, judgement and decision-making, craftmanship, academic knowledge, and professional knowledge. Second, apart from the above 14 competencies in common, ten more were obtained from the complementary findings. Two of them were revealed by the survey respondents only; these competencies are productivity control and social awareness.

In the interviews, the interviewees proactively mentioned the remaining eight competencies, either neglected by the survey respondents or not covered in the questionnaire. These eight competencies are creativity, research skills, engineering practices, change management, intercultural ability, systems thinking, entrepreneurial mindset, and national policy awareness. The survey respondents do not perceive the first five competencies as essential, while the last three newly uncovered competencies are not mentioned in my questionnaire.

Table 5.29 summarizes the competencies collected from quantitative and qualitative research to demonstrate a clear picture of the mixed findings.

Table 5.29: Mixed Findings of this Study


Competencies Findings from Quantitative research
Competencies Findings from Qualitative research
Productivity control
Social awareness
Compliance
Lifelong learning
Ethical awareness
Academic knowledge
Information management
Organizing and execution abilities
Judgement & decision making
Effective communication
Professional knowledge
Technology awareness
Safety awareness
Self-motivation
Craftsmanship
Teamwork
Change management
Engineering practices
Intercultural abilities
Research skills
Creativity
Systems thinking
Entrepreneurial mindset
National policies awareness
Competences newly explored

Chapter 6: Discussion of the Findings

Overview

The previous chapter reported the study's quantitative, qualitative, and mixed findings. This chapter sketches the competency model for Hong Kong energy engineers based on the findings mentioned above, discusses the considerations in its development, and compares it with the published engineering competency models. It also explains the study's limitations and implications and concludes with recommendations for future research.

Competency Model for Hong Kong Energy Engineers

Based on the literature review presented in Chapter 2, I demonstrated that no articles regarding the competencies of Hong Kong energy engineers had been located; there might be some underlying reasons that local researchers paid limited attention to this research topic. The quantitative and qualitative approaches of a mixed methods research methodology provided me with two different research lenses, which led to a more comprehensive and insightful understanding of the complex nature of the competency model than using a single approach alone could have. Based on the integration of the quantitative and qualitative findings mentioned in the last chapter, a competency model will be developed to achieve the aim of this study.

A competency model is an organizational framework that lists competencies required for effective performance in a specific job, family, and organization (Chouhan and Srivastava, 2014). Competency models are frequently utilized in HRM to improve individual and organizational effectiveness. Staskevica (2019) claims that the development of competency models facilitates guidelines to meet the changing demands of the labour market and the required standard. In this sense, the Hong Kong energy sector stakeholders can use this competency model to accommodate the challenges and opportunities generated by the energy transition.

Development of the Competency Model

In Table 5.29, this study identified 24 competency elements, of which both quantitative and qualitative research supported 13, three were extracted only from the quantitative findings, and eight were derived solely from the qualitative findings. In addition, the qualitative findings revealed a four-competency-layers framework used to categorize these 24 competencies. These four competency layers are 1) Engineering and academic knowledge; 2) Professional abilities and skills; 3) Key qualities; 4) Morality and ethics. The order of these four layers is associated with their implicitness, measurability, and trainability levels. Explicit competencies in layers 1 and 2 are relatively easy to develop and measure, but the implicit competencies in layers 3 and 4 are somewhat difficult to cultivate.

These 24 competency elements were categorized into four competency layers, as follows:

- ‘Engineering and academic knowledge’ was the first competency layer of this model. It refers to the knowledge acquired from secondary and post-secondary education institutes that contribute to the academic and engineering knowledge landscape. The quantitative findings could only provide this layer's general concept of ‘professional knowledge’. However, the qualitative findings elaborated more on this notion, as follows. First, energy engineers must be equipped with four fundamental academic subjects, or STEM subjects, science, technology, engineering, and mathematics. Second, an understanding of humanities subjects also contributes to the competencies of energy engineers since engineering projects always affect many people in society. Third, artistic subjects are also important for engineering practitioners because imagination and creativity competencies can be motivated by these subjects. Lastly, language subjects can also be included in this layer, as these subjects allow the practitioners to access up-to-date worldwide engineering technologies and work with engineering counterparts outside Hong Kong. Therefore, the one competency item in this layer was extended to four competency items: professional/STEM knowledge, humanities knowledge, languages, and artistic knowledge.

- The second competency layer is ‘Professional abilities and skills’, which means the skills, techniques, and expertise developed or learned from the jobs through training and practice. Learners often learn by utilizing machinery, tools, documents, and specialists’ experience sharing. In this layer, the quantitative findings contributed three competencies: organizing ability, information management and productivity control. However, the qualitative findings offered additional competencies to this layer: research skills, information management, change management, engineering practices and execution. As the nature of organizing and execution competencies are close to each other, I combined these two competencies into ‘organizing and execution abilities’. Therefore, in this layer, there are six competency items: organizing and execution ability, information management ability, research skills, change management ability, engineering practices skills, and productivity control ability.

- ‘Key qualities’ are defined as the third competency layer. It represents the individual’s inner qualities or abilities, which lie between individual traits (e.g., self-motivation) and job-related traits (e.g., technology awareness). ‘Key qualities’ influence how an individual uses knowledge and skills in a position or task. In the quantitative findings, I observed six competencies in this layer: teamwork, effective communication, lifelong learning, technology awareness, craftsmanship, and self-motivation. On top of these six competencies, I identified another four competencies from the qualitative findings: intercultural ability, entrepreneurial mindset, systems thinking, and creativity. Hence, I combined them so that this layer contains ten competency items.

- 'Morality and ethics' is the last competency layer. It can be further divided into two parts: i) Morality is a guiding principle or belief to determine right or wrong in behaviour, decisions, and intentions; ii) Ethics means the rule sets that govern permissible acts or behaviour. In this layer, five competency items were found in the quantitative findings: ethics and professional conduct, social awareness, compliance, judgement and decision-making, and safety awareness. I identified one additional competency item from the qualitative findings: national policy awareness. Therefore, there are six competency items in this layer.

To better understand this competency model, Figure 6.1 outlines the diagram of its structure, the competency layers and their associated competency elements, and Table 6.1 illustrates the definitions of the competency elements in the model.

Figure 6.1: Competency Model for Hong Kong Energy Engineers

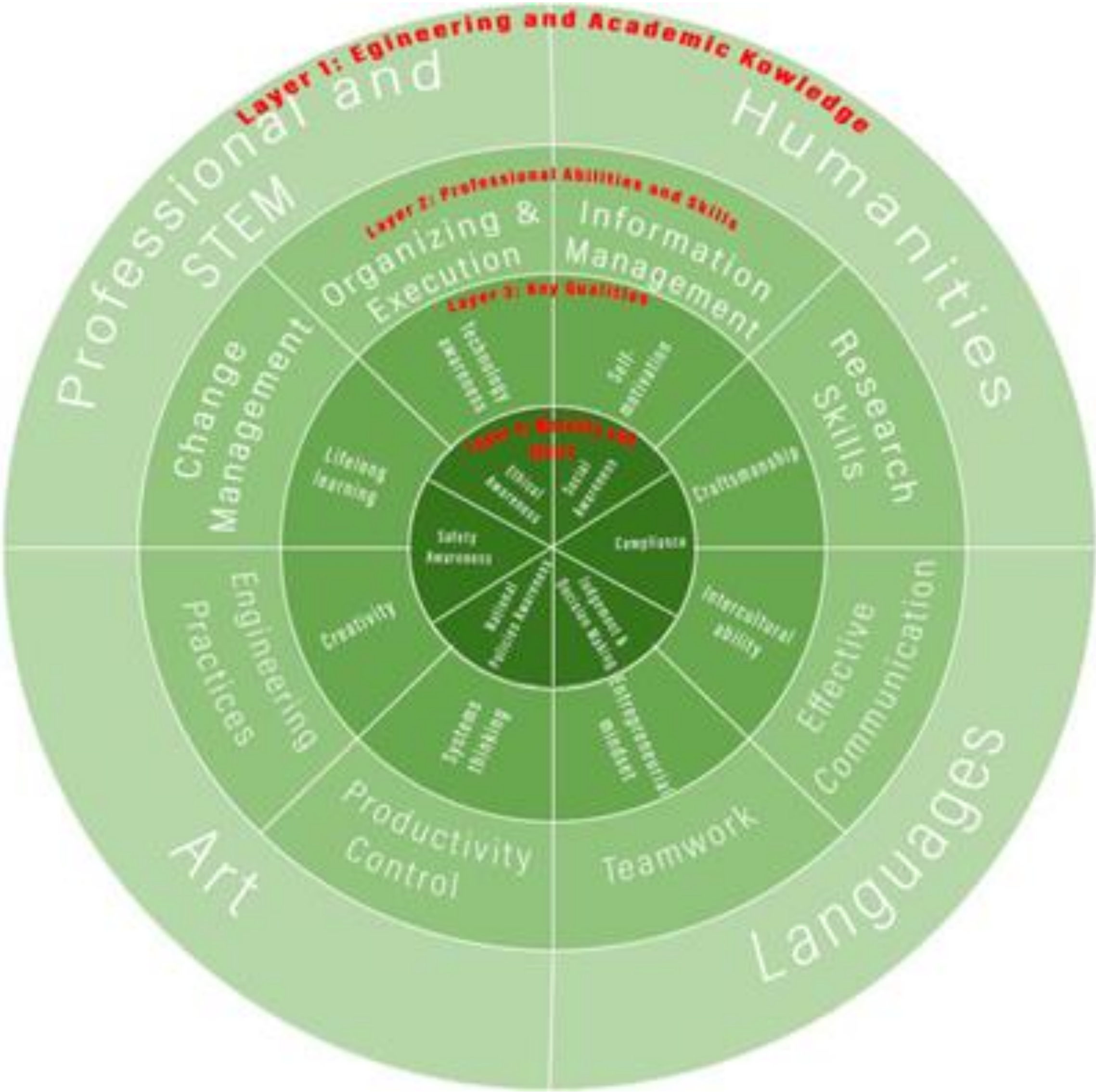


Table 6.1: Definitions of the Competency Items of the Model

Competency Model for Hong Kong Energy Engineers

This competency model is a narrative description of the essential competencies for energy engineering practitioners to deal with the challenges and opportunities facing the Hong Kong energy sector. It is comprised of four competency layers and 24 competencies. Each competency mentioned in this competency model includes its title and definition, describing the associated knowledge, skills, abilities, and observable behaviours that represent the competency identified.

Layer 1: Engineering and Academic Knowledge

Professional/STEM knowledge: Master the knowledge, skills and tools to solve engineering problems; proficient in the academic knowledge pertinent to the engineering discipline such as science, technology, engineering, mathematics, physics, statistics and computer science, etc.

Humanities knowledge: Master the knowledge related to cultures, people, societies and eras; skills related to critical thinking, writing aptitude, effective communication, talents to connect dots, and different realities adjustment; and mindset related to questioning and reflection, open mind, global vision, acknowledgement of difference of others, and one reality with plurality of angles.

Languages: Able to communicate interculturally with foreigners in foreign languages.

Artistic knowledge: Master the knowledge for creativity, innovation, communication, contemplation, and appreciation of culture.

Layer 2: Professional Abilities

Organizing and execution ability: Possess the methods and skills of job planning, organization, prioritizing, and archiving specific tasks or organizational goals.

Information management ability: Master the methods and tools for information search, access and analysis, and resources to judge information accuracy, reliability, and authenticity.

Research skills: Master the principles, processes, design, methods, and skills of scientific research.

Change management ability: Master the strategies, processes, methods, and skills of planning and organizing industry/corporate changes.

Engineering practices skills: Master the principles, norms, standards, and responsibilities of engineering practices.

Productivity control ability: Master the monitoring and control processes and procedures to improve operational efficiency and productivity.

Teamwork: Respect team members and maintain an atmosphere for team building and working with team members.

Effective communication: Possess effective communication skills such as sending and receiving clear messages, conducting presentations, discussions and negotiations, comprehending and compiling engineering reports and documents, etc.

Layer 3: Key Qualities

Lifelong learning: Commit to learning for whole life and integrate new knowledge and skills into work.

Technology awareness: Pay attention to the technology development and current issues in the engineering area continuously.

Craftsmanship: Continuously pay attention to details, pursue excellence, take pride in products/services made, and be responsible for the decisions and results made.

Self-motivation: Set high standards for self, monitor continuously and adjust behaviour from others' constructive suggestions.

Intercultural ability: Able to appreciate, respect and tolerate diverse cultures/ worldviews.

Entrepreneurial mindset: Able to rapidly sense opportunities, think and act in business manner, and adapt to a changing context for capturing benefits of uncertainty.

Systems thinking: Possess a holistic viewpoint on system in a larger context, including the system itself, the environment and all stakeholders affected by the system.

Creativity: Apply unprecedented methods or technologies to design solutions.

Layer 4: Morality and Ethics

Ethical awareness: Commit to sustaining the engineering industry's ethical behaviour and professional conduct, which includes a positive attitude, integrity, honesty, trust, result-oriented, productive work habits, a strong work ethic, ethical judgment, and balance.

Social awareness: Recognize the societal issues and responsibilities in engineering projects, and anticipate the perceptions and expectations of relevant stakeholders.

Compliance: Comply with the laws, regulations, codes, and other instruments to protect public rights in engineering projects.

Judgement and decision-making: Possess the methods and skills to evaluate, judge the values and risks of engineering projects and make quick and accurate decisions.

Safety awareness: Recognize the safety issues and responsibilities in engineering projects and take preventive measures to improve the safety of engineering personnel and the public.

National policy awareness: Recognize the national policies issues and directions to anticipate the strategy and responses.

Discussion of the Competency Model

Many considerations and issues influence the development process and the model regarding the above competency model. Hence, this section will discuss the following topics: The model development approach, competencies' identification approach, competency layer determination, and comparison with the published engineering competency models.

Approach of the Competency Model Development

Tate (1995) claimed two different schools of thought regarding the concept of competency: The American school emphasizes individual competencies reflecting the individual's capabilities for satisfactory job performance. The British school focuses on job performance so that the job can be done successfully if the individuals fulfil the competencies criteria of the job. Hence, these two interpretations of the competency concept affect the context and motives in developing their competency models.

Incorporated with the approaches proposed by Yang et al. (2006), the American-style competency models tend to adopt a top-down approach which reflects the competency elements aligning with the organizational strategic directions. By comparison, the British-style competency models prefer a bottom-up approach, illustrating the competency elements ensuring satisfactory performance. Furthermore, British-style competency models can be used as assessment or qualification guidelines to identify capable individuals.

Regarding the competency model in this study, I intended to identify the essential competencies for Hong Kong energy engineering practitioners to tackle the energy transition's challenges. As the energy transition is a global revolutionary process, there is no doubt that Hong Kong will also be influenced. Even though hydroelectric, nuclear, and wind energy technologies are well developed, other renewable energy sources, especially clean energy technologies such as hydrogen, photovoltaics, and battery storage, are still evolving. Hong Kong energy sector enterprises must closely monitor the industrial trend, adjust their organizational strategic objectives, and maintain a practical and meaningful competency model for energy engineering practitioners. Hence, I adopted a top-down approach to developing a competency model which was strategic and oriented to individual capabilities. Compared with the bottom-up approach, I believed this approach was a better developmental strategy for my study.

Identification of the Competency Items

Chapter 2 explained that Cardy and Selvarajan (2006) suggested four approaches to identifying individual-level competencies: job-based, future-based, person-based, and value-based. The competencies' natures and the organizational contexts of these approaches are different from each other. In this study, I anticipated that a competency model for energy engineers reflecting the context of Hong Kong could be developed. By considering the study's cultural context and technological attributes, I adopted the value-based and future-based approach to identify the competency elements for the model.

Regarding the value-based approach, Cardy and Selvarajan (2006) observed that organizations prefer to explore their core values and develop their value-based competencies since organizational core values are always steadier than strategies which are vulnerable to turbulent market environments. Dutta et al. (2021) also noted that ethical organizations are vital for their long-term viability; hence incorporating ethical competency within the organizational competency framework became critical. More organizations include ethical competencies in their organizational models to ensure long-term survival and success. It matches the Confucianism culture of Eastern countries. By adopting this approach, I expected that some individual-level competency elements reflecting Eastern culture could be uncovered in this study.

By comparison, the future-based approach is strategic direction oriented. The individual-level competencies identified by this approach aim at what jobs must be done to achieve the organizational strategic goals. This approach matches the future-oriented aspect of my study since the energy transition is still evolving in Hong Kong, and our energy sector is developing solutions to cope with its difficulties.

Determination of the Competency Layers' Structure

This model classified the competency items into four layers based on the level of implicitness, as proposed by Spencer and Spencer (1993). The iceberg competency model, illustrated in Figure 2.2, categorizes five types of competencies into three groups. Knowledge and skills are classified into the outermost category, representing the most visible characteristics of this group; the self-concept lies in the middle, while motives and traits are grouped in the innermost category, denoting the most implicit behaviour of this category.

While developing the competency layers, I observed several competencies I could not appropriately group into the existing three categories: judgement and decision-making, ethics and professional spirit, and social awareness. I believe these competencies' implicitness level is beyond motives and traits, and I need to define one more level representing their difference. Hence, in terms of the level of implicitness, I proposed four layers to accommodate all competency elements. The most visible layer is 'Engineering and academic knowledge', followed by 'Professional abilities and skills' and 'Key qualities', and the innermost or most implicit layer is 'Morality and ethics'. This innermost layer accommodates all ethical competency items, which involve judgments about the rightness or wrongness of individuals' competencies.

The explicit, visible, and trainable academic and engineering knowledge are located in the outermost competency layer, followed by the professional abilities demonstrating practical and sophisticated capabilities in the workplace, and then the key qualities closely related to the self-concept, career ambitions and characteristics of individuals. The most implicit competency elements are accommodated in the innermost layer of this competency model, such as ethics and professional spirit, social awareness, and compliance. These competency elements represent the individual's core values and morality. As a result, I believe that this model's competency elements and architecture are comprehensive, meaningful, and structural.

Comparison with the Published Engineering Competency Models

The 12 published engineering competency models analysed in Chapter 2 find various development approaches, purposes, architectural designs, and assessment criteria. In general, US organizations tend to establish American-style competency models, while European organizations prefer to develop competency models in the British manner. For Asian countries, however, competency models in either style are observed, and some countries construct both American-style and British-style competency models. This section will compare my competency model for Hong Kong energy engineers to these 12 models.

The Engineering Competency Model of the US Department of Labor exemplifies American-style competency models. Comparing it to my competency model revealed the following commonalities and differences: The purposes and development approaches of both models are comparable; they are both individual-focused and based on a top-down methodology, with clearly articulated definitions and descriptions of the competency items. Engineering practitioners and graduates might use the competency items in both models to guide their career progression, but neither model does not include assessment criteria. My competency model categorises competency items according to implicitness, which reflects the involvement level of ethical competencies. However, the US Engineering Competency Model adopted a tier-based occupation-oriented classification of competency items; the competency tiers extend from personal effectiveness to the academic, workplace, industrial, and occupation-specific dimensions. Even though this structure does not consider the extent of implicitness of the competency items, users can quickly identify competency items from various dimensions. These observations also remain consistent for the three other US competency models.

The UK-SPEC of the UK Engineering Council exemplifies the British-style competency models, another prominent competency model among these 12 published models. It defines three standards for registering three levels of trained engineering practitioners in the United Kingdom: Chartered Engineer, Incorporated Engineer, and Engineering Technician. The five competence areas of each standard are identical, but the competence contents and examples of evidence vary. My competency model is dissimilar to the UK-SPEC because it cannot be used as assessment criteria for qualification registration. In addition, since the five competence areas in the UK-SPEC represent five distinct functional areas, the implicitness of the competencies cannot be reflected. It is a further differentiation from my competency model. These insights can be extended to other competency models developed in the British style.

As the purposes and approaches for developing various competency models in Asian countries vary, it was necessary to compare each competency model with my competency model individually. Regarding the HKQF developed by the Hong Kong SAR government, the purpose is to enhance the competencies and competitiveness of the Hong Kong workforce to meet upcoming challenges. Consequently, the HKQF encompasses 22 sectors whose competency models are built using a bottom-up methodology. The accredited curricula and courses associated with the competency elements can be found on their website. In addition, the HKQF establishes a seven-tiered design reflecting the academic qualifications' architecture. This design is associated with another mission of the HKQF, which aims to interconnect the HKQF-recognized qualification with the Hong Kong academic qualification framework. In this respect, the HKQF is a competency framework that supplies workforces with accreditation. It links the HKQF-recognized qualification with the academic qualifications ladder, making it difficult to compare to my competency model.

Similar to the UK-SPEC, the purpose of the Standards of Capabilities Evaluation for Chinese Professional Engineers of CAST is to serve as a guideline for assessing the technical capabilities of qualified engineers, and another department inside CAST processes the assessment operation. In this standard, the competency items classification remains at five competence areas. Despite differences in the details of the competence areas between the UK-SPEC and this standard for Chinese professional engineers, the insights mentioned above from the British-style competency models remain applicable. In addition, the Chinese model is the only one among the 12 that classifies professional ethics as a separate competence area. Comparing this Chinese model to my competency model makes it attractive to note their high similarity. In the Chinese standard's competence area B – Engineering and Professional Ethics, the three competency requirements are described as follows:

- B1: Have a *strong sense of social responsibility and professional dedication*, be able to *correctly apply professional knowledge in work to ensure a harmonious development of the engineering projects*, nature, and society, and develop a concept of comprehensive, coordinated, and sustainable development.
- B2: Have the capability to consciously *comply with the laws and regulations* and technical specifications, and apply the knowledge of quality, safety, energy conservation, and environmental protection in engineering practices.
- B3: Have the *awareness of* occupational health and *safety*, energy conservation, environmental protection, and intellectual property protection, and be able to *apply professional knowledge in work to safeguard* the above factors.

Coincidently, the above-italicized descriptions match four of the five competency items defined in the morality and ethics layer of my competency model: ethics and professional spirit, social awareness, compliance, safety awareness, and judgement and decision-making. National policy awareness is the only missing competency item in the comparison; it not only reflects the distinct colonial history of Hong Kong but also indicates that the participants in this research are aware of this omission and desire to include it in the competency model.

Singapore established two distinct competency frameworks for its energy and power sector: the SFwEP and the PECF. The SFwEP, which the Ministry of Education developed, employs a bottom-up strategy to design many career paths, skills maps, and definitions of technical skills and competencies to assist Singaporeans in cultivating their capabilities for national development. Accordingly, competency descriptions, evaluation criteria, and competence levels for the 122 current employment roles are meticulously outlined. By contrast, the PECF, designed by the Singapore Energy Market Authority and eight governmental agencies, aims to ensure the reliability and security of Singapore's energy supply. As a result, the PECF’s career map, skills maps, and definitions of technical skills and competencies emphasize clean and renewable energy sources. Thus, the PECF follows a top-down development strategy.

Overall, the SFwEP and the PECF are well-planned, with the career paths, skills maps of all job positions in the pathways, and associated competencies of job positions in both frameworks being precisely designed and developed. In considerable detail, these two frameworks outline the necessary technologies, implementation methods and tools, and the accompanying knowledge and skills. In other words, the SFwEP constitutes a comprehensive, government-planned industrial and competency map for the current energy and power sector, while the PECF draws a future map for Singapore. Both of these competency frameworks are complementary to one another. In comparison to my individual-focused competency model, it is evident that both Singaporean frameworks are complex and substantial, such that the Singaporean government can manage the energy transition efficiently and effectively by using these two frameworks.

Nonetheless, I purposefully left the definition of necessary knowledge ambiguous in my competency model's engineering and academic knowledge layer; no technologies are named in the model. Instead, due to the rapid pace of technological progress, I remain open to this part so that education and training providers may offer the updated technologies at their own pace. Obviously, given my position, resources, and time, I could not develop a competency model equivalent to the Singaporean frameworks.

Limitations of the Study

After the competency model for Hong Kong energy engineers was developed and discussed, some limitations should be reported before concluding this study. These limitations are related to the COVID-19 pandemic, snowball sampling, sampling for the pilot study, and the issues related to the competency model that has just been developed.

COVID-19 and Snowball Sampling

The first and most important limitation is the sampling method adopted in the quantitative phase. In late March 2021, the quantitative phase was going to start. I planned to invite the members of nine local professional engineering bodies to participate in the survey research. Due to the lockdown and 'work from home' policies because of the COVID-19 pandemic, the original sampling strategy could not be carried out. Hence, snowball sampling was the only choice at the time. Although Venette (2013) has argued that snowball sampling is a decent approximation to random sampling once the initial round of survey participants is as random as possible, and this only requirement was met, this might have impacted the sample's representativeness. In addition, there was no control over the participants in the second and subsequent rounds. As a result, it is difficult to conclude that the quantitative samples were dispersed randomly, which is a significant regret in my research.

Sampling for Pilot Study

The second limitation concerns the sample of the pilot study. In the preliminary phase, after the questionnaire development is completed, a pilot study with a smaller sample should be conducted to test the feasibility of the sampling methods, questionnaire, and data collection procedures. The COVID-19 pandemic interfered with the pilot study of the survey instrument, as it was impractical to recruit extra participants for the pilot study. Hence, both experts involved in the questionnaire development were invited again to participate in the pilot study. Due to the overlapping identities of the experts in this study, it is impossible to rule out the potential of any bias in the data collected in the quantitative phase.

Bias in the Qualitative Data

The third limitation is the participants' desire to participate in the qualitative phase interviews. In the questionnaire, the last question asked the participants about their willingness to be interviewed in the qualitative phase. Participants who agreed to engage in semi-structured interviews might have different opinions than those who did not. Demographic characteristics might affect their willingness. Although there is no significant difference in the demographic characteristics between the quantitative and the qualitative samples, survey participants who were hesitant to discuss their perceptions with the researcher might have introduced another bias in the qualitative data.

Implications of the Study

The current turbulent business environments mandate that organizations closely monitor changes to survive and grow (Robbin and Judge, 2015). It is critical to identify, establish, and apply competitive organizational advantages to respond to environmental changes, and the advantages are underpinned by individual and institutional competencies (Baczynska et al., 2016; King et al., 2001). The Hong Kong energy sector is no exception to this circumstance. This study identified the competencies required by energy engineering practitioners in Hong Kong to build the competency model. These findings contribute theoretical and practical implications for local energy engineering practitioners, their organizations' human resources management, and the education and training institutions in Hong Kong.

Theoretical Implications

This study contributes a competency model with a new angle to Hong Kong energy engineers. This model establishes a distinct conceptual framework that is culturally relevant for energy engineering practitioners working in Hong Kong contexts and offers additional theoretical underpinning for emerging disciplines in energy sectors. The four-layers structure of this model represents the various level of implicitness of the competencies. In the core layer, most competencies are ethically related, including ethical awareness, social awareness and national policy awareness. This classification indicates the perspective of Eastern culture that none of the referenced competency models captures, except the competency model from CAST.

In methodological respects, this study enriches the literature on mixed methods research in the layer of competency modelling, which is dominated by a single research approach.

Existing competency models developed by governments and professional bodies mainly adopt job analysis frameworks to describe job requirements. However, these frameworks are usually job-oriented and outcome-based, emphasising the necessary knowledge and skills. Job analysis-based competency models are beneficial for assisting human resource personnel in preparing job descriptions. Still, they overlook the employees' key qualities, morality, and ethics, which are critical to the institutional competencies. The iceberg competency model developed by Spencer and Spencer in 1993 was to close this gap. This model was selected as a reference in this study because this well-known competency framework applies to the multi-level job contexts of energy engineers. This reference model categorises competencies by their tangibility and trainability. The authors are concerned about whether the competencies can be cultivated in school or revealed during recruitment interviews.

Moreover, the categorization technique employed in this study can be replicable; it can serve as a guideline for similar research on other engineering professionals and occupations to develop or maintain their competency models.

Practical Implications

This study establishes linkages among competency, energy engineering and human resources management and offers insights for local engineering practitioners of various fields in the energy industry. The competency model also provides some practical implications to stakeholders relevant to the Hong Kong energy sector, as explained in the following sections.

For Energy Engineering Practitioners

Existing engineering competency models are mostly job analysis-based; the competencies mentioned in the models usually describe the job requirements and responsibilities. Due to difficulties describing trainability and measurability, implicit competencies are not included in these models, nor are their requirements described. Energy engineering practitioners might have misconceptions that only by equipping them with these visible and measurable competencies could they perform their jobs excellently and make significant contributions to their organizations. Conversely, Nolan (1998) stated that high job performance is achieved by integrating knowledge, skills, attitudes, motives, and behaviours. Implicit competencies such as attitudes always play a determining role in driving high job performance, especially for practitioners at the management level. Hence, Hong Kong energy engineering practitioners can refer to the competency model of this study, which includes both locally perceived implicit and explicit competencies, as a reference for self-development.

For Energy Enterprises and Professional Bodies

Energy enterprises can refer to this competency model as a baseline to recruit engineers with the necessary abilities. However, overemphasis on competency models may ignore other implicit factors that underpin knowledge and skills (Ashworth and Saxton, 1990). Even though competency models provide a common platform for practitioners and human resources personnel to discuss workforce issues, these models should neither be the only consideration for recruitment and selection decisions (Cockerill et al., 1995) nor the only training and development instrument (Dalton, 1997). Applicants with specific abilities that are valuable to an organization might always be overlooked if the recruitment personnel only hire applicants that match a particular competency model.

Many human resources managers in large organizations, including energy enterprises, utilize competency models as their recruitment and selection guidelines. Still, they employ various recruiting techniques to evaluate applicants' competencies during interviews. These techniques could effectively provide insights into applicants' observable competencies. In turn, as intangible competencies located at the lower part of the iceberg are challenging to observe, human resources managers might apply other techniques to explore implicit competencies, such as the morality and ethics of candidates.

In addition, the competency model of this study illuminates the corporate training area. Energy enterprises can use this competency model as a curriculum structure reference for their corporate training programmes devoted to competencies development for employees with extensive work experience.

Developing expertise to become a specialist is always the primary purpose of professional bodies. Professional engineering bodies can use this competency model to develop their assessment criteria for their members to get accreditations. They can also develop training programmes for the competencies located in the middle layers for fresh graduates with limited work experience to explore.

For Educational and Training Institutions

The competency model of this study also offers insight into the academic arena and can deliver value to educational institutions in terms of competency dimensions. As the energy sector evolves, new energy technologies, such as clean hydrogen generation and battery storage technology for solar energy, are developing. Universities and research centres can contribute by upgrading these novel technologies in their curricula. Additionally, secondary school educators can prepare some STEM-related courses to arouse the interest of their students. On top of engineering knowledge, current employers expect university graduates to possess many non-engineering-related competencies, such as creativity and effective communication. Thus, educational institutions might need to adapt their curricula to meet market expectations, activities with artistic elements and multi-lingual participants can explore the students' potential. While technical subjects, such as engineering principles, occupy a significant portion of the engineering curriculum, specific managerial components should be included in these subjects. As previously stated, the competencies at the model's outer layers are more accessible to build than those at the inners. Universities’ curricula could focus on developing explicit competencies which are fundamental, tangible, and easy to teach. Some of this knowledge and skills are transferable, while others are professional-specific. Universities could design optional subjects for transferable knowledge and skills that students could choose as part of their career plans.

Moreover, universities could arrange credit accreditation for graduate students with certain engineering professional bodies. Training should be integrated into perspective employers' corporate training programmes for those competencies challenging to deliver at school. The competencies in the innermost layer are not easy to access and develop. However, educators in primary and secondary schools can contribute their efforts by arranging more ethical education when the students are young.

Recommendations for Future Research

Based on the outcomes of this study, a review of the literature, and my personal experiences as an instructor in a power company in Hong Kong, I would like to propose the following future research.

First, since my study only focused on establishing a competency model based on the sample recruited using snowball sampling, future research should utilize this competency model to verify the perceptions of high-performance energy engineering practitioners in Hong Kong. The validity of my competency model might be enhanced by verifying their judgements of the importance level of the competencies indicated in my competency model. Some competencies in my model could be refined if significant differences between two samples from different performance groups were found.

Second, another future research direction could be developing a competency repository for the Hong Kong energy sector, which would record competencies with appropriate definitions, behavioural indications, and assessment criteria for the Hong Kong energy sector. Although such a competency repository would still need to be modified for various fields in the energy sector, it might save some money since most of the competencies could be found in it.

Third, another potential research topic could be implementing this competency model in human resource activities. Hong Kong energy enterprises could utilize the competencies mentioned in this model to develop a competency-based performance management framework for engineers' recruitment, appraisal, and development. Furthermore, a competency-based HR application system might be built to establish and maintain individual competency profiles. The enterprise-wide competency profile could also be readily saved and accessed.

Lastly, referencing the Singapore frameworks supported by the POCCI model, my top-down approach competency model might be extended by constructing a bottom-up competency model to sketch the current industrial competency map of Hong Kong's energy industry. The stakeholders in Hong Kong's energy sector might use these two competency models to effectively address the energy transition's difficulties.

Conclusion

In conclusion, I contributed to understanding the competencies necessary for Hong Kong energy engineers to overcome the energy transition’s difficulties and grasp the potential faced by the energy sector. By adopting two approaches, quantitative research followed by qualitative research, I demonstrated different perspectives on the research topic, such that a clear and insightful framework was achieved. This study's outcome was a competency model for energy engineering practitioners in Hong Kong. This model could assist practitioners in career planning, energy enterprises in recruitment and selection, talent development and corporate training, and educational institutions in curriculum development. While this competency model is in a preliminary development stage, further evaluation and refinement are needed to better understand competency's multi-dimensional and dynamic aspects. I believe the present findings will be of great value to a wide range of energy engineering professionals in academia, industry, and consulting and will stimulate debate around the crucial competencies for practitioners and those related to local industrial needs.

Chapter 7: Research Reflections

Overview

This final chapter allows me to reflect on my experience of conducting this research. It covers the content of this thesis, highlighting what I have learnt during this research journey. Before starting this research, I believed I knew myself well and had good insight and awareness. Unfortunately, my observation is somewhat quite spot on. This chapter reviews the study, reflecting on what it meant to me personally and professionally.

Reflection on my Research

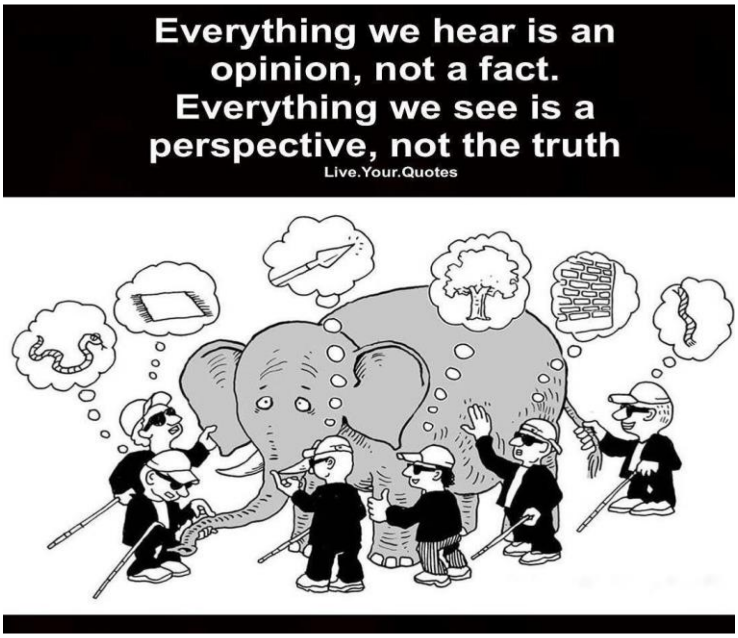
In the beginning, the selection of my research topic represented part of my personal and professional experiences and part of my role as a member of the Hong Kong community. I positioned myself as an insider and an outsider in this research, reflecting a unique perspective on the Hong Kong energy sector. My dual position in this research could be beneficial to the study. It could become a disadvantage if it had not been balanced; it had to be handled carefully to ensure that it contributed to the research rather than obstructing potential insights. In addition, preserving the participants' initial thoughts when transcribing the interviews was another challenge for me. I always interpreted their meanings without considering their perspectives and the context of the dialogue. I recognized that the outsider role helped me to figure out the participants' ideas because they had little expectation of my understanding of their sector, culture, and norms. They tended to tell me about their ideas in detail with justifications.

During my study, COVID-19 posed the most significant obstacle since it had a tremendous impact on lives worldwide. As of 5 July 2022, more than 550 million individuals have been infected, and more than 6,3 million have died. Quarantine, social distancing, online meetings, work from home, and even economic lockdown radically altered the afflicted countries' psychological, sociological, and financial situations. Unfortunately, I planned to undertake quantitative and qualitative research during this challenging time. Due to the semi-lockdown scenario in Hong Kong at the time, my target engineering organizations declined to assist me in disseminating my survey to their members. Although I tried to persuade them with tremendous effort, they did not alter their ultimate judgements. It had a significant effect on me since it derailed my sampling approach. Together with my anxieties over COVID-19, I became upset for a long time until I read the words of a friend who was also studying for a doctorate: ‘When God shuts a door, he opens a window, but it is up to you to find it,’ he said to encourage me. By consulting with my supervisor and researching various sampling methods, I realized that snowball sampling might be viable.

My listening ability proved to be highly useful in understanding the perceptions and interpretations of my interview participants: An enormous amount of new ideas on the research topic were extracted through careful listening and conversations. For instance, the relative importance between individuals' academic knowledge / professional skills and macro abilities such as environmental awareness and ethical responsibility, which puzzled me for a while, found a new interpretation in this research. I had no idea how important this new finding would be to the local energy sector and Hong Kong in general, but I believe I have found a new way of connecting my viewpoints with those of others.

Transcribing the interviews was the most time-consuming task of my research. To maximize my time, I arranged two interviews in a day, one in the morning and one in the afternoon, for 15 days. Once the interviews were completed and recorded each day, I tried to finish the transcriptions in the evening and after dinner because I had to interview another two participants the next day. I had to rearrange my interview schedule so that there were enough transcribing time slots between the interview slots. Before transcribing, several friends with research experience advised me to prepare two to three times the interview duration for transcribing. I ignored their advice and believed I could finish it much faster than that. Obviously, I was wrong, and I spent most of my time transcribing the repeated ‘uhms’, ‘ahs’, and ‘you know’ uttered in the interviews. Even though I am not a qualified transcriber, I still found it very helpful because it allowed me to focus on the participants' responses and grasp their ideas and interpretations. So, I recognized that the lengthy time spent transcribing benefited my comprehension of the interviews and deepened my understanding of their relevance to my research focus.

As a novice researcher, I read many books about research methodology and found that most research uses either quantitative or qualitative methods. I came across mixed methods research methodology throughout this study, which was a relatively new research idea. Mixed methods allowed me to use two complementary instruments to learn more about the research questions. I believe it should provide more perspectives than the situation mentioned in the parable of the blind men and an elephant: A group of blind men used their hands to sense different parts of a giant elephant's body. They affirmed their observations to define the elephant but suspected the others' honesty and then argued with each other.



(Source: Pinterest.com https://id.pinterest.com/pin/416864509249404571/)

My scientific background and various technological career paths shaped my positivist worldview, thoughts, and cognition, and I believe that everything in the world must be operated cause-and-effect like the earth must take 365.25 days to go around the sun. It was difficult to convince me to accept another completely different paradigm within an academic research framework.

Adopting a mixed methods research methodology was another challenge because two different research lenses were used to contrast the same research topic.

By learning about the vast literature relevant to the concepts of this research and attending training and workshops about research methodology, I recognized that the world is significant and that there are many different worldviews other than positivism. I opened myself to accept this finding, and I noticed that my concept of research methodology was gradually influenced. It was inconceivable for me to understand the concepts behind interpretivism and social constructivism. I was also surprised to see that I could accept these concepts, which were adopted successfully into my research.

In this research, I observed that the research design evolved from an initial concept of an explanatory sequential design, whose data integration required new ideas. The challenge for an inexperienced researcher like me was the trade-offs in research details, such as the sampling method, while defending the rigours of the research. Now, I would have an open mind about adopting appropriate research approach(es) for a study, provided that the approach(es) could achieve the purpose of the study.

Reflection on my Personal Development

In the 1980s, the structure of the Hong Kong curriculum was very close to the GCE Ordinary Level and Advanced Level of the UK. I remember when I was studying in secondary school and matriculation, my time was fully occupied with lectures, homework, assessments, and preparation for Ordinary Level and Advanced Level examinations. I had no time to reflect on what I had learnt from my studies, a societal phenomenon at that time. I strongly disagreed with it, and I am grateful for this opportunity to summarize the implications of the research experience on my personal development.

I started this research nine years ago. When I reflected on my overall progress, especially the first several years, I noticed that I was unprepared for this research. I was always puzzled and worried about whether my selected topic was feasible, which research methodology was appropriate, and where and how I could learn the philosophical underpinnings. At that time, I was unsure whether I was the only DProf student facing these questions, and I thought I had to solve the above difficulties by myself. Thus I did not consult with my supervisor, and he did not discuss it with me either. As a result, I wasted valuable study time. Later, due to ill health, he was absent from supervising me for an extended period. Upon reflection, I had to admit that I was too timid in facing challenges and therefore procrastinated and lost precious study time.

Over the past three years, my study has also been hindered by the fluctuating situation in Hong Kong. Unfortunately, 2019 and 2020 were the most challenging year I have ever encountered. Starting in June 2019, more and more protests and riots took place in Hong Kong. The rioters joined the demonstrations, threw petrol bombs, and used bows and arrows to shoot the police. They blocked the trunk roads, attacked the mass transit railway network, and hijacked the Polytechnic University and the Chinese University campuses to fight against the police. The rioters almost suspended Hong Kong, and fear, anxiety, and misery engulfed the whole town. I had never anticipated that all this violence could happen in Hong Kong. As the social events faded out in November 2019, COVID-19 broke out in China the next month. The pandemic caused Hong Kong to lock down intermittently, which caused many workers to become unemployed after February 2020. I was also a victim of the riots and the pandemic; around 90% of my teaching assignments were dropped, and I had to use my savings for my family's livelihood. My impact was not only financial, familial, and emotional but also impacted my research very seriously. Indeed, I could not imagine that I could complete it until an extension was granted and a new supervisor was assigned to me in October 2020.

There are two sides to everything. Although COVID-19 worsened my financial condition, it gave me more space and time to study. During the lockdown, I read a Chinese book on research methodology in which the author highlighted that the research supervisor should be the researchers' last formal teacher/mentor. I had no particular feelings while reading, but after meeting with my new supervisor, I ultimately agreed with the author. Our first Zoom meeting took place on October 12, 2020. My first impression was that she was an enthusiastic, diligent, and experienced research supervisor; she completely grasped my crucial circumstances but did not put me under extra stress. Instead, she requested me to give her my writing. She responded with much valuable advice, pointing out the flaws in my writings and providing detailed explanations passionately to show what I had to do to complete my research - every Monday at 7:30 a.m. UK time, we had a 45–60 minute Zoom conference to review my progress, answer my questions, and even motivate me if I got off track. After each meeting, I felt that my body had been shot with a powerful ' affirmative' vaccination, enabling me to overcome all hurdles. She sometimes shared with me her task list, which was densely interlaced with research projects, teaching, school administration responsibilities, and family and personal tasks. Her approach to managing this hectic schedule benefited me by enhancing my work productivity, properly utilizing my time, and balancing my work and life. I will remember and apply this excellent strategy in future, and I will share it with my children and students.

When I reflected on my progress in the Zoom meetings, I realized that I spent a great deal of time searching and reading the literature but deliberately avoiding writing. I believed that the reason was evident because I was not proficient at writing and lacked the confidence to apply abstract philosophical underpinnings to my research. Hence, in addition to the books I borrowed from libraries, I bought many books about mixed methods research methodology for reference. Through learning about various philosophical worldviews, I realized that the world is big, which made me feel humble and insignificant. People can construct their viewpoints and knowledge socially based on their background and experience. Hence, different individuals possess different points of view, and no single perspective is better than others, which helped me to respect others. This shift broadened my cognition and enriched my experience.

I also underestimated my mental overburdening; I became used to remembering everything in my mind, including the research design flow, the project activity details, and the relevant instruments and tools. In writing, when I moved from one chapter to the next, I became more conscious of the interconnections with the former chapters to make sense of the research logic. My supervisor suggested that I write down my ideas in a notebook. She proposed that I regularly write small passages rather than occasionally writing massive amounts. Printing and filing the writings also helped me visualize my thoughts, make amendments, and connect paragraphs.

The reflection on my personal development discussed in this section contributed to my academic assignment. Through teaching and discussion, I passed on what I had learned to my students and hoped they would share it with their colleagues, classmates, friends, and others, consciously or unconsciously. It is one of the missions of a professional educator and trainer. In any case, I will continue to develop myself after completing my doctoral programme and treat this as a part of my lifelong learning process.

Final Remarks

Through this research, I have contributed my knowledge, experience, and effort to Hong Kong society by tackling the challenges of the energy transition. This study has developed a competency model that collects and analyses data using the explanatory sequential mixed methods approach. This competency model is intended to be meaningful to the Hong Kong energy sector and interpretable by and applicable to local energy engineering practitioners. Users can refer to the essential competency elements identified in the model and successfully equip themselves to deal with the challenges.

This research accomplished its objectives: It studied the potential capabilities related to engineering disciplines from the published competency models and collected the necessary competencies perceived by the practitioners regarding the future challenges facing the Hong Kong energy sector. It collated, analysed, and extracted the essential competencies using statistical tools, then identified the rationales and justifications supporting them. Then, it consolidated the above findings and constructed a meaningful and practical competency model for practitioners' reference.

The stakeholders of this research project include employers of energy organizations, engineering practitioners, engineering graduates, education and training providers, and government and professional engineering bodies of Hong Kong. This research has generated new knowledge in understanding, defining, and developing an evidence-based competency model, which may substantially upgrade and strengthen the energy sector, especially energy engineering practitioners.

Reviewing this long research journey from the beginning of my doctorate programme, I believe I am approaching the terminus; the completion of this study trip witnessed my engagement in a highly challenging and motivating research experience. This research has brought me both achievement and challenges, physically, emotionally, and intellectually. This research topic has been a part of my life since I was a child; it was framed as my aspiration rather than a research project. I wish to investigate this topic as my doctorate research project to give back and contribute to Hong Kong society.

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List of Appendices

Appendix A: Ethical Approval Letter

Middlesex University London

Trans Disciplinary DProf REC

The Burroughs
Hendon
London NW4 4BT

Main Switchboard: 0208 411 5000

26/03/2021

APPLICATION NUMBER: 15833

Dear Wai Leung Chan and all collaborators/co-investigators

Re your application title: Mixed Methods - Hong Kong energy engineers competency model

Supervisor: Orthodoxia Kyriacou

Co-investigators/collaborators:

Thank you for submitting your application. I can confirm that your application has been given APPROVAL from the date of this letter by the Trans Disciplinary DProf REC.

The following documents have been reviewed and approved as part of this research ethics application:

Document Type	File Name	Date	Version
Data Protection Declaration	Data Protection Checklist and Declaration Form_V3	11/01/2021	3
Informed Consent Form	Consent Form_V2	11/01/2021	2
Participant Recruitment Information	Consent Form_V2	11/01/2021	2
Methods and data	Research study and rationale_V5	17/02/2021	5
Participant Recruitment Information	Invitation Email_V1	17/02/2021	1
Participant Recruitment Information	Participant Information Sheet_V4	17/02/2021	4
Informed Consent Form	Participant Information Sheet_V4	17/02/2021	4
Materials	Questionnaire_V1	20/02/2021	1
Resubmission Response to Feedback Summary	Resubmission Feedback Summary_V2	12/03/2021	2
Methods and data	Research study and rationale_V6	12/03/2021	6
Participant Recruitment Information	Participant Information Sheet_V5	12/03/2021	5
Informed Consent Form	Participant Information Sheet_V5	12/03/2021	5
Participant Recruitment Information	Invitation Email_V2	12/03/2021	2

Although your application has been approved, the reviewers of your application may have made some useful comments on your application. Please look at your online application again to check whether the reviewers have added any comments for you to look at.

Also, please note the following:

1. Please ensure that you contact your supervisor/research ethics committee (REC) if any changes are made to the research project which could affect your ethics approval. There is an Amendment sub-form on MORE that can be completed and submitted to your REC for further review.

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2. You must notify your supervisor/REC if there is a breach in data protection management or any issues that arise that may lead to a health and safety concern or conflict of interests.

3. If you require more time to complete your research, i.e., beyond the date specified in your application, please complete the Extension sub-form on MORE and submit it your REC for review.

4. Please quote the application number in any correspondence.

5. It is important that you retain this document as evidence of research ethics approval, as it may be required for submission to external bodies (e.g., NHS, grant awarding bodies) or as part of your research report, dissemination (e.g., journal articles) and data management plan.

6. Also, please forward any other information that would be helpful in enhancing our application form and procedures - please contact MOREsupport@mdx.ac.uk to provide feedback.

Good luck with your research.

Yours sincerely

Chair Dr Kate Maguire

Trans Disciplinary DProf REC

Appendix B: Invitation Email (Bilingual)

Online Survey Invitation E-mail

Dear Engineer,

My name is Wai Leung CHAN. I am a student studying Doctorate in Professional Studies Programme at Middlesex University of UK, and I am conducting a research as part of my doctoral degree requirements. My research is entitled, Exploring a competency model for Hong Kong energy engineers: A mixed method study. This research has been approved by the Transdisciplinary Doctorate in Professional Studies Research Ethics Committee of the university.

I am writing to invite you to participate in this research. The purpose of the research is to explore the essential competences for Hong Kong energy engineers under the context of global and regional threats and opportunities (e.g. the Covid-19 pandemic, post Covid-19 evolution, global warming, energy technology revolution, industry 4.0 popularization, economic rise of China, the "One Belt, One Road" initiative and the development of the Guangdong-Hong Kong-Macao Greater Bay Area). The corresponding competency model is the deliverable of this research, which will help Hong Kong energy industry / energy engineers to recognize the essential capabilities to overcome challenges and seize opportunities ahead.

This research consists of two parts. In part one, you will be asked to spend about 20 minutes in completing an online survey. In part two, you will be invited for an individual online interview which will last less than 60 minutes. During the online interview, the researcher will ask you for the arguments of your answers in part one, the dialogue will be recorded and transcribed for further analysis. Your participation in both parts are crucial to this research. After completing the data collection, the research team integrates and analyzes the data from both parts to construct a competency model for Hong Kong energy engineering practitioners. Research details please refer to the attached Participant Information Sheet.

Please be assured that your data will be kept strictly confidential. An independent research team of this research will collect your data and then analyze after integrating the data from all respondents. All research data will be destroyed permanently within five years after the completion of this research. Your participation in this research is completely voluntary. You can withdraw from the research at any time without worrying about punishment or any negative consequences.

After reading this email and the attached information sheet, I very much hope that you can participate in this research. If you have informed consent and accept my invitation, you can click on **this link** to start the first part of this research. If you have any enquiries about this research, please send email to wc396@live.mdx.ac.uk or call +852 91682462 to contact me. Thanks for participating in this research!

Wai Leung CHAN
Researcher

"探索香港能源工程師之勝任力模型" 研究 邀請函

尊敬的工程師,

本人陳偉樑，就讀於英國米德爾塞克斯大學(Middlesex University) — 專業研究博士課程(Doctor of Professional Studies Programme) 的一名研究生，現正進行一項關於香港能源工程師勝任力的研究，項目名稱為 "探索香港能源工程師之勝任力模型：混合方法研究" 。此項研究已獲得大學專業研究倫理委員會的批准。

本人現誠邀 閣下參與是項研究，研究目的旨在探索香港能源工程師在全球和地區性威脅與機遇下(如: 新冠肺炎疫情，後疫情演變，全球氣候暖化，能源技術革命，能源綠色化及低碳化，工業 4.0 普及化，國家經濟崛起， "一帶一路" 建設及粵港澳大灣區發展等) 必需裝備的勝任力。相應的勝任力模型是這項研究的成果，它將幫助香港能源行業 / 香港能源工程師認清克服挑戰及抓緊機會所需的必要勝任力。

這項研究包括兩個部分，第一部分是線上問卷調查，第二部分是個人線上訪談。在第一部分中， 閣下只需大約 20 分鐘的時間來填寫線上問卷，分享對每個問題中列出的每種勝任力重要性的看法。而在第二部分， 閣下將被邀請進行 60 分鐘內的個人線上訪談，在線上訪談中，研究人員將詢問閣下在第一部分問卷答案的論據，訪談對話會被錄音及轉錄，作為日後分析之用。閣下的兩部分意見對是項研究尤為寶貴。完成數據收集後，研究小組把兩部分之數據整合併分析以建立能源工程師勝任力模型。

懇請放心， 閣下所提供的資料將會絕對保密，數據將由此項研究的研究小組獨立收集，並由研究小組綜合其他被訪者的回應後一併分析，而所有數據會於此項研究完成後五年內銷毀。參與這項研究是完全自願的。閣下可以隨時退出研究，而不必擔心受到懲罰或任何負面後果。

我很希望 閣下能參與這項研究，如 閣下閱讀這電子郵件和隨附的信息表後，知情同意下並接受邀請，可點擊此問卷調查鏈接進行第一部分研究。如 閣下對此項研究有任何查詢，請發送電子郵件到 wc396@live.mdx.ac.uk 或致電+852 91682462 與本人聯絡。感謝參與這項研究！

研究員：陳偉樑

Appendix C: Online Questionnaire (English)

Middlesex University London

Online survey of "Competence Model for Hong Kong Energy Engineers" research

First of all, thank you very much for participating in this online survey!

This questionnaire consists of 4 parts and a total of 36 questions. In general, participants will take about 20 minutes to complete this questionnaire and share their views on the importance of each competence mentioned in each question. If you encounter any difficulties/problems in answering this questionnaire, please send an email to wc396@live.mdx.ac.uk or call +852 91682462 to contact the research team. Many thanks!

Part 1: Basic information

The following questions are about your background information. This personal information will be kept strictly confidential and will only be used for the statistical analysis of this research. Please answer according to your actual situation, thank you for your cooperation.

1. Your gender is:
   - Male
   - Female
   - Others
   - Prefer not to reply

2. Your age group is:
   - Under 21
   - 21 – 30
   - 31 – 40
   - 41 – 50
   - 51 – 60
   - 61 – 70
   - Over 70
   - Prefer not to reply

3. Your highest educational qualification obtained is:
    - Associate degree / Higher diploma / High certificate
    - Bachelor degree
    - Master degree / Postgraduate diploma / Advanced diploma
    - Doctor degree
    - Post-doctor
    - Others
    - Prefer not to reply

4. Your current employment status is:
    - Unemployed / Looking for a job
    - Part-time employed
    - Full time employment
    - Self-employed
    - Retired
    - Others

5. Your working experience in engineering industry is:
    - Less than 5 years
    - 5 – 8 years
    - 9 – 12 years
    - 13 – 16 years
    - 17 – 20 years
    - More than 20 years

6. Which field(s) in the Hong Kong energy industry do your engineering working experience belong? (You can select more than 1 answer)
    - Petroleum products related, such as: car gasoline, diesel, aviation gasoline, etc.
    - Gas fuel related, such as: towngas, LPS, etc.
    - Power supply related, such as: power generation, transmission, distribution, etc.
    - Power equipment related, such as: main switch, distribution box, power line, etc.
    - Electrical equipment related, such as: elevators, water pumps, lighting equipment, etc.
    - Electrical value-added equipment/service related, such as: UPS, smart meters, energy saving, etc.
    - New energy related, such as: solar, wind, hydro, nuclear energy, etc.
    - Others

7. In your engineering work experience, how many people at most in your organization are directly or indirectly affected by your decisions?
   - 9 or less
   - 10 - 99
   - 100 - 999
   - 1000 - 9999
   - 10000 or above

Part 2: Questionnaire

In the following questions, please rely on your intuition to rate the importance of the competence. [The following questions are randomly ordered by Qualtrics]

In recent years, Hong Kong traditional energy industry is facing global and regional threats and opportunities, such as the Covid-19 pandemic, post-epidemic evolution, global warming, energy technology revolution, Industry 4.0 popularization, economic rise of China, the “Belt and Road” initiative and the development of the Guangdong-Hong Kong-Macao Greater Bay Area. However, energy engineers are the mainstay of Hong Kong energy industry. Whether the energy engineers can upgrade their essential competences determines the success in tiding over the difficulties and seizing the opportunities ahead.

In order to recognize the necessary competence required by Hong Kong energy engineers, please base on your perception to rate the importance of the following competency descriptions.
(1 means "Not important at all", 7 means "Crucial")

8. "Proficient in the academic knowledge pertinent to the engineering discipline such as physics, mathematics, statistics and computer science, etc."

	1	2	3	4	5	6	7	
Not important at all	○	○	○	○	○	○	○	Crucial

9. "Master the professional knowledge, skills and tools to solve engineering problems."

	1	2	3	4	5	6	7	
Not important at all	○	○	○	○	○	○	○	Crucial

10. "Master the principles, norms, standards and responsibilities of engineering practices."

	1	2	3	4	5	6	7	
Not important at all	○	○	○	○	○	○	○	Crucial

11. "Pay attention to the technology development and current issues in the engineering area continuously."

	1	2	3	4	5	6	7	
Not important at all	○	○	○	○	○	○	○	Crucial

12. "Set high standards for self, monitor continuously and adjust behaviour from others' constructive suggestions."

	1	2	3	4	5	6	7	
Not important at all	○	○	○	○	○	○	○	Crucial

13. "Manage time and resources properly, prioritize tasks to achieve personal and career goals."

	1	2	3	4	5	6	7	
Not important at all	○	○	○	○	○	○	○	Crucial

14. "Commit lifelong learning and integrate new knowledge and skills into work."

	1	2	3	4	5	6	7	
Not important at all	○	○	○	○	○	○	○	Crucial

15. "Possess effective communication skills such as sending and receiving clear messages, conducting presentations, discussions and negotiations, comprehending and compiling engineering reports and documents, etc."

	1	2	3	4	5	6	7	
Not important at all	○	○	○	○	○	○	○	Crucial

16. "Respect team members and maintain an atmosphere for team building and team work."

	1	2	3	4	5	6	7	
Not important at all	○	○	○	○	○	○	○	Crucial

---

17. "Commit to upholding the ethics and professional conduct of engineering industry."

	1	2	3	4	5	6	7	
Not important at all	○	○	○	○	○	○	○	Crucial

---

18. "Continuously pay attention to details, pursue excellence, take pride in products/services made, and be responsible for the decisions and results made."

	1	2	3	4	5	6	7	
Not important at all	○	○	○	○	○	○	○	Crucial

---

19. "Apply unprecedented methods or technologies to design solutions."

	1	2	3	4	5	6	7	
Not important at all	○	○	○	○	○	○	○	Crucial

---

20. "Recognize the societal issues and responsibilities in engineering projects, and anticipate the perceptions and expectations of relevant stakeholders."

	1	2	3	4	5	6	7	
Not important at all	○	○	○	○	○	○	○	Crucial

---

21. "Recognize the environmental and sustainability issues and responsibilities in engineering projects, and take precautions to enhance the environment."

	1	2	3	4	5	6	7	
Not important at all	○	○	○	○	○	○	○	Crucial

---

22. "Recognize the safety issues and responsibilities in engineering projects, and take preventive measures to improve the safety of engineering personnel and the public."

	1	2	3	4	5	6	7	
Not important at all	○	○	○	○	○	○	○	Crucial

---

23. "Master the principles, processes, skills and responsibilities in engineering projects management."

	1	2	3	4	5	6	7	
Not important at all	○	○	○	○	○	○	○	Crucial

---

24. "Possess the methods and skills to evaluate, judge the values and risks of engineering projects and make quick & accurate decisions."

	1	2	3	4	5	6	7	
Not important at all	○	○	○	○	○	○	○	Crucial

---

25. "Possess the vision and insight in engineering industry development forecasts and corresponding corporate strategy suggestions."

	1	2	3	4	5	6	7	
Not important at all	○	○	○	○	○	○	○	Crucial

---

26. "Master the strategies, processes, methods and skills of planning and organizing industry/corporate changes."

	1	2	3	4	5	6	7	
Not important at all	○	○	○	○	○	○	○	Crucial

---

27. "Possess the methods and skills to provide subordinates guidance, direction and expectations to improve work performance."

	1	2	3	4	5	6	7	
Not important at all	○	○	○	○	○	○	○	Crucial

---

28. "Master the monitoring and control processes and procedures to improve operational efficiency and productivity."

	1	2	3	4	5	6	7	
Not important at all	○	○	○	○	○	○	○	Crucial

---

29. "Possess the methods and skills of job planning, organization and prioritizing."

	1	2	3	4	5	6	7	
Not important at all	○	○	○	○	○	○	○	Crucial

---

30. "Master the methods and tools for information search, access and analysis, and resources for judgement of information accuracy, reliability and authenticity."

	1	2	3	4	5	6	7	
Not important at all	○	○	○	○	○	○	○	Crucial

---

31. "Comply with the laws, regulations, codes and other instruments to protect public rights in engineering projects."

	1	2	3	4	5	6	7	
Not important at all	○	○	○	○	○	○	○	Crucial

---

32. "Master the principles, processes, design, methods and skills of scientific research."

	1	2	3	4	5	6	7	
Not important at all	○	○	○	○	○	○	○	Crucial

---

33. "Able to communicate interculturally with foreigners in foreign languages."

	1	2	3	4	5	6	7	
Not important at all	○	○	○	○	○	○	○	Crucial

---

34. "Able to appreciate, respect and tolerate diverse cultures/worldviews."

	1	2	3	4	5	6	7	
Not important at all	○	○	○	○	○	○	○	Crucial

---

35. "Able to study global, regional and inter-cultural issues."

	1	2	3	4	5	6	7	
Not important at all	○	○	○	○	○	○	○	Crucial

---

36. In the following 12 items, please select 5 "critical" competencies for Hong Kong energy engineers, and input 1 to 5 in the corresponding box for ranking. **(1 is the most important, 5 is the least important)**

- [ ] Academic knowledge
- [ ] Continuous development & adaptability
- [ ] Engineering skills & practices
- [ ] Environmental, societal & safety awareness
- [ ] Global competence
- [ ] Innovation & creativity
- [ ] Leadership & management
- [ ] Legal & regulatory compliance
- [ ] Professionalism & ethical responsibilities
- [ ] Research skills
- [ ] Self management skills
- [ ] Teamwork & communication skills

Part 3: Consent to participate in the second part of this research (confidential)

Thank you very much for your contribution in this survey!

If you are willing to participate in the second part of this research – individual online interview, please fill in your personal information below. After the online survey is completed, the research team will contact you. Most importantly, your personal contact information is top-secret information and is only used for contact purpose in this research. The research team will never disclose your name and contact information to any third parties, please feel free to provide them.

Personal Contact Information:

First Name:

Last Name:

Mobile phone:

Email address:

Part 4: Participants recommendation to the research

If you endorse the purpose of this research – to help Hong Kong energy industry / energy engineers overcome future challenges, please notify this research to other engineers you know, and invite them to participate in this research. Methods are as follows:

1. Later, after you press the "->" button at the lower right corner of this page, the system will go to the invitation page of this research.

2. Please copy the research invitation link, forward it to the engineers you know, and invite them to participate in this research. Thank you very much for your support and help!

Thank you again for your participation in this survey and have a nice day!

Appendix D: Online Questionnaire (Chinese)

Middlesex University London

「香港能源工程師勝任力模型」研究網上調查

首先，非常感謝您參與這項網上調查！

此問卷由 4 個部分組成，共 36 個問題。 一般而言，參與者需要大約 20 分鐘來完成此問卷，問題關於參與者對多種勝任力重要性的個人看法。 如果您在回答此問卷時遇到任何困難或問題，請發電郵至 wc396@live.mdx.ac.uk 或致電 +852 91682462 聯繫研究團隊。 謝謝！

第一部分：基本資料

以下是關於您個人的背景資料，這些資料將僅供本研究統計分析之用，不會對外公開，請您依照實際情況放心作答，謝謝您的配合。

1. 您的性別是:
   - 男性
   - 女性
   - 其他
   - 不想回答

2. 您的年齡層是:
   - 21 歲以下
   - 21 – 30
   - 31 – 40
   - 41 – 50
   - 51 – 60
   - 61 – 70
   - 超過 70 歲
   - 不想回答

3. 您的最高學歷是:
   - 大專
   - 大學學位
   - 碩士學位
   - 博士學位

- ○ 博士後
- ○ 其他
- ○ 不想回答

4. 您目前的就業狀況是:
   - ○ 失業 / 待業
   - ○ 兼職受僱
   - ○ 全職受僱
   - ○ 自僱
   - ○ 退休
   - ○ 其他

5. 您在工程行業的工作經驗是:
   - ○ 5 年以下
   - ○ 5 – 8 年
   - ○ 9 – 12 年
   - ○ 13 – 16 年
   - ○ 17 – 20 年
   - ○ 超過 20 年

6. 您的工程工作經驗屬於能源行業的哪個領域? (可以選擇多個答案)
   - ○ 石油產品相關，如：車用汽油、柴油、航空汽油等。
   - ○ 燃氣燃料相關，如：煤氣、LPS 等。
   - ○ 電源相關，如：發電、輸電、配電等。
   - ○ 電力設備相關，如：總開關、配電箱、電源線等。
   - ○ 電氣設備相關，如：電梯、水泵、照明設備等。
   - ○ 電氣增值設備/服務相關，如：UPS、智能電錶、節能等。
   - ○ 新能源相關，如：太陽能、風能、水力、核能等。
   - ○ 其他

7. 在您的工程工作經驗中，您的機構中最多有多少職員直接或間接地受到您的決策的影響？
   - ○ 9 人或以下。
   - ○ 10 – 99 人
   - ○ 100 – 999 人
   - ○ 1000 – 9999 人
   - ○ 10000 人或以上

第二部分： 調查問卷

以下問題，請依靠您的認知來評價勝任力的重要性。［問題由 Qualtrics 隨機排序］

近年來，香港傳統能源產業面臨全球和區域性威脅和機遇，如 COVID-19 大流行、後疫情演變、全球暖化、能源技術革命、工業 4.0 普及、中國經濟崛起、“一帶一路”倡議與粵港澳大灣區建設。然而，能源工程師是香港能源業的中流砥柱。能源工程師能否提升自己的勝任力，決定了他們能否克服以上困難，抓緊機遇。

為了辨認香港能源工程師所需的勝任力，請根據您的認知來評估以下勝任力描述的重要性。**（1 表示“完全不重要”，7 表示“至關重要”）**

8. "精通工程學科相關的學術知識（如：物理，數學，統計學和電腦科學等）。"

	1	2	3	4	5	6	7	
完全不重要	○	○	○	○	○	○	○	**至關重要**

9. "掌握解決工程問題的專業知識，技能和工具。"

	1	2	3	4	5	6	7	
完全不重要	○	○	○	○	○	○	○	**至關重要**

10. "掌握工程實施的原則，規範，標準和職責。"

	1	2	3	4	5	6	7	
完全不重要	○	○	○	○	○	○	○	**至關重要**

11. "持續關注當前工程領域的技術發展和新興問題。"

	1	2	3	4	5	6	7	
完全不重要	○	○	○	○	○	○	○	**至關重要**

12. "為自己設定高標準，持續監控並根據他人的建設性建議調整自己的行為。"

	1	2	3	4	5	6	7	
完全不重要	○	○	○	○	○	○	○	**至關重要**

13. "妥善管理時間和資源，確定課題的優先次序，以實現個人和職業目標。"

1 2 3 4 5 6 7

完全不重要 ○ ○ ○ ○ ○ ○ ○ 至關重要

14. "進行終身學習，並整合新知識和技能於工作中。"

1 2 3 4 5 6 7

完全不重要 ○ ○ ○ ○ ○ ○ ○ 至關重要

15. "具備有效的溝通技巧 (如: 發送和接收明確的訊息，進行演示、討論和談判，理解和撰寫工程領域的報告和文檔等)。"

1 2 3 4 5 6 7

完全不重要 ○ ○ ○ ○ ○ ○ ○ 至關重要

16. "尊重團隊成員，並保持團隊建設和合作的氛圍。"

1 2 3 4 5 6 7

完全不重要 ○ ○ ○ ○ ○ ○ ○ 至關重要

17. "致力維護工程行業的道德倫理和專業操守。"

1 2 3 4 5 6 7

完全不重要 ○ ○ ○ ○ ○ ○ ○ 至關重要

18. "持續重視細節，追求卓越，以產品/服務為傲，並對所做的決定和結果負責。"

1 2 3 4 5 6 7

完全不重要 ○ ○ ○ ○ ○ ○ ○ 至關重要

19. "運用嶄新的技術或方法來設計解決方案。"

1 2 3 4 5 6 7

完全不重要 ○ ○ ○ ○ ○ ○ ○ 至關重要

20. "意識到工程項目中的社會問題和責任，並預期相關持份者的看法和期望。"

	1	2	3	4	5	6	7	
完全不重要	○	○	○	○	○	○	○	至關重要

21. "意識到工程項目中的環境和可持續性問題和責任，並採取預防措施以改善環境。"

	1	2	3	4	5	6	7	
完全不重要	○	○	○	○	○	○	○	至關重要

22. "意識到工程項目中的安全問題和責任，並採取安全措施以提升工程人員及公眾的安全。"

	1	2	3	4	5	6	7	
完全不重要	○	○	○	○	○	○	○	至關重要

23. "掌握工程項目管理的原則，流程，技能和職責。"

	1	2	3	4	5	6	7	
完全不重要	○	○	○	○	○	○	○	至關重要

24. "具備工程項目價值和風險的評估，判斷以及果斷做出準確決策的方法和技能。"

	1	2	3	4	5	6	7	
完全不重要	○	○	○	○	○	○	○	至關重要

25. "具備工程行業發展預測和相應企業戰略建議的視野和見解。"

	1	2	3	4	5	6	7	
完全不重要	○	○	○	○	○	○	○	至關重要

26. "掌握策劃和組織行業/企業變革的策略，流程，方法和技能。"

	1	2	3	4	5	6	7	
完全不重要	○	○	○	○	○	○	○	至關重要

27. "具備為下屬提供指導，方向和期望的方法和技巧，以提高工作績效。"

1 2 3 4 5 6 7

完全不重要 ○ ○ ○ ○ ○ ○ ○ 至關重要

---

28. "掌握監測和控制流程和程式，以提高運營效率和生產力。"

1 2 3 4 5 6 7

完全不重要 ○ ○ ○ ○ ○ ○ ○ 至關重要

---

29. "具備工作計畫，組織和優先排序的方法和技能。"

1 2 3 4 5 6 7

完全不重要 ○ ○ ○ ○ ○ ○ ○ 至關重要

---

30. "掌握資訊搜索，存取和分析的方法和工具，以及判斷資訊準確性，可靠性和真實性的資源。"

1 2 3 4 5 6 7

完全不重要 ○ ○ ○ ○ ○ ○ ○ 至關重要

---

31. "遵守法律、法規、守則和其他指引，以保護工程項目中的公眾權利。"

1 2 3 4 5 6 7

完全不重要 ○ ○ ○ ○ ○ ○ ○ 至關重要

---

32. "掌握科學研究的原則，流程，設計，方法和技能。"

1 2 3 4 5 6 7

完全不重要 ○ ○ ○ ○ ○ ○ ○ 至關重要

---

33. "具備以外語與外國人士進行跨文化溝通的能力。"

1 2 3 4 5 6 7

完全不重要 ○ ○ ○ ○ ○ ○ ○ 至關重要

---

34. "具備欣賞，尊重並包容多元文化/世界觀的能力。"

	1	2	3	4	5	6	7	
完全不重要	○	○	○	○	○	○	○	**至關重要**

---

35. "具備研究全球性，區域性和跨文化問題的能力。"

	1	2	3	4	5	6	7	
完全不重要	○	○	○	○	○	○	○	**至關重要**

---

36. 在下列 12 個勝任力中，請選擇對香港能源工程師最重要的五個的項目，並按照其重要性，在對應框中輸入 1 到 5 進行排名。**(1:最重要，5:最不重要)**

- □ 學術知識
- □ 持續發展與適應能力
- □ 工程技術與實踐
- □ 環境，社會和安全意識
- □ 全球勝任力
- □ 創新與創造力
- □ 領導與管理
- □ 法律法規意識
- □ 專業精神和道德責任
- □ 科研能力
- □ 自我管理能力
- □ 團隊合作和溝通技巧

第三部分：同意參加本研究的第二階段(機密)

非常感謝您對本次調查的貢獻！

如果您願意參加本研究的第二階段 - 個人線上訪談，請在下面填寫您的個人資訊。第一部分網上調查完成後，研究團隊會與您聯繫。

您的個人資訊是機密的，僅用於研究目的。 研究團隊絕不會將您的姓名和聯繫資訊透露給其他人員。在整個研究過程中，您的隱私權和匿名權將得到保證。

個人聯繫資訊：

姓名: [ ]

手機號碼: [ ]

電郵地址: [ ]

第四部分：調查參與者推薦

如果您喜歡本次調查的體驗，並認同本研究的目標 - 促進香港能源行業 / 能源工程師應對未來的挑戰，請通知其他你認識的工程師來參與這項研究，方法如下:

1. 稍後，您點擊本頁面右下角的"->"按鈕後，系統將進入此研究的邀請頁面。
2. 請複制研究邀請鏈接，轉發給您認識的工程師，邀請他們參與此研究。 非常感謝您的支持和幫助！

再次感謝您參與本次調查，祝您生活愉快！

Appendix E: Informed Consent Form (Bilingual)

Middlesex University London

Participant Identification Number 參與者識別號碼：

CONSENT FORM 研究知情同意書

Title of Project 項目名稱： Exploring a Competency Model for Hong Kong Energy Engineers- A Mixed Methods Study 探索香港能源工程師之勝任力模型-混合方法研究

Name of Researcher 研究員姓名： Wai Leung CHAN 陳偉樑

請草簽

1. I confirm that I have read and understand the information sheet dated ....for the above study and have had the opportunity to ask questions.

   我確認在 2021 年____月____日已閱讀並理解本研究的資訊表，並有機會提出問題。 [1]

2. I understand that my participation is voluntary and that I am free to withdraw at any time, without giving any reason and without penalty.

   我是自願參與本研究的。在沒有任何理由和懲罰下，我可以隨時退出本研究。 [2]

3. I agree that this form that bears my name and signature may be seen by a designated auditor.

   我同意指定審計師可以查看這張印有我的名字和簽名的表格。 [3]

4. I agree that my non-identifiable research data may be stored in National Archives and be used anonymously by others for future research. I am assured that the confidentiality of my data will be upheld through the removal of any personal identifiers.

   我同意我提供的無法身份識別的研究資料可以存儲在國家檔案館中，並可被其他人士匿名地用於未來的研究。通過刪除任何個人識別字，我的資料的機密性得以保證。 [4]

5. I understand that my interview may be taped and subsequently transcribed.

   我知道我的訪問對話可能會被錄音和轉錄的。 [5]

6. I agree to take part in the above study.

   我同意參加上述研究。 [6]

Name of participant 參加者姓名 ________ Date 日期 ________ Signature 簽名 ________

Researcher 研究員 ________ Date 日期 ________ Signature 簽名 ________

1 copy for participant; 1 copy for researcher 參與者和研究人員各保留一份

Appendix F: Interview Guide (Bilingual)

Interview Guide

Introduction

Thank you very much for your participation in this interview today. Our goal of this interview is to understand your perceptions and opinions about the competences required by the energy engineering practitioners in Hong Kong in order to tackle the challenges and grasp the opportunities ahead. I will ask you a series of questions about this topic. All information you provided will be kept strictly confidential and no identifying information will be reported. We are interested in your personal views therefore I appreciate your honest and candid answers. There are no right or wrong answers to these questions as I am seeking your perspective based on your knowledge and experience. If you are not sure or do not wish to answer, please let me know and we will proceed to the next question. Are you ready to get started?

簡介

XXX先生 / 小姐，非常感謝您今天參與這次採訪。 我們這次對話的目的是瞭解您對香港能源工程師 應對面前的挑戰和把握未來的機會 所需要的勝任力的看法和意見。稍後，我將會向您提出有關這個主題的一些問題，這些問題是沒有正確或錯誤的答案，我們只是對您的個人觀點感興趣，因此，請根據您的知識和經驗坦率的回答便可以了。您提供的所有資訊均將嚴格保密，並且不會披露任何您的個人資訊的。如果您不確定或不希望回答的話，請告訴我，我們將跳過這個問題，繼續下一個問題的。 你準備好開始了嗎？

Interview Questions

This interview follows a semi-structured interview format meaning that I have organized my questions around your working background, your perceptions on the challenges and opportunities faced by Hong Kong energy industry, the necessary competences for the above-mentioned issues and your arguments of your survey responses. While I will ensure that we explore each theme, we have the flexibility to pursue additional thoughts or questions depending on where the conversation leads us. For this reason, I may ask further questions for clarity or probe you for greater detail. I will take some notes as we speak

Page 1 of 3

and I will also tape this session to ensure transcription accuracy. Is this acceptable to you?

訪問內容

這次採訪是採用半結構化的方式進行，問題將會圍繞您的工作背景，對香港能源行業面臨的挑戰和機遇的看法，所需要的勝任力的意見和觀點，以及您上次答覆問卷調查的論據。 此外，我可能會問其他問題以求澄清，或引導您尋求其他想法。 在對話時，我將會做一些筆記，並把本次對話的內容錄音，以確保轉錄內容的準確性。 你明白嗎？ 你有其他意見嗎？

A. Working background 工作背景 (10 minutes)

1. Can you tell me about your working experience in energy engineering? 可否告訴我　您在能源工程方面的工作經驗嗎？
   Probes:
   - Years of working experience 年資
   - Field(s) of energy industry 能源行業領域
   - Job nature and responsibilities 工作性質和職責
   - Span of decision/no. of subordinates 決策範圍 / 下屬人數

2. In your opinion, which competences are required for you to achieve this job? 您認為需要具備什麼勝任力才能完成這項工作？

B. Challenges and opportunities faced by Hong Kong energy sector 香港能源行業面臨的挑戰和機遇 (15 minutes)

3. In your opinion, which challenges are faced by Hong Kong energy sector? To what extent do these challenges impact the industry? And why? 您認為香港能源行業面臨哪些挑戰？ 這些挑戰在多大程度上影響了能源行業？為什麼呢？
   Probes:
   - Covid-19 pandemic 新冠肺炎疫情
   - Post epidemic evolution 後疫情進程
   - Global warming 全球暖化
   - Energy technology revolution 能源技術革命
   - Industry 4.0 popularization 工業4.0普及化
   - Economic rise of China 中國經濟崛起
   - “Belt and Road” initiative “一帶一路” 倡議
   - Greater Bay Area development 大灣區發展
   - Others 其他

4. In your opinion, which opportunities are faced by Hong Kong energy sector? To what extent do these opportunities benefit the industry? And why? 您認為香港能源行業面臨哪些機遇？ 這些機遇在多大程度上影響了能源行業？為什麼呢？

C. Competences to response the challenges and opportunities ahead 應對未來挑戰和機遇的勝任力 (25 minutes)

5. In order to tackle the above-mentioned challenges, in your opinion, which competences should you equip yourself? 為了應對上述挑戰，您認為您應該具備哪些勝任力？

6. In order to grasp the above-mentioned opportunities, in your opinion, which competences should you equip yourself? 為了把握上述機會，您認為自己應該具備哪些勝任力？

7. Do you have any other ideas to response the above-mentioned challenges and opportunities? 除了上述勝任力，您還有其他想法來應對上述挑戰和機遇嗎？
   Probes:
   - Government 政府
   - Industry itself 行業本身
   - Consumers 消費者
   - Others

8. [Inform the rank order in the survey to the interviewee] Can you tell me why you rank these five critical competences for Hong Kong energy engineers in this way? [將調查的等級順序告知受訪者] 可否告訴我 為什麼您以這種方式對香港能源工程師的這五個關鍵能力進行排名嗎？

D. Wrap up 總結 (10 minutes)

9. Is there anything I have not asked you about that you think is important? 有沒有什麼一些您認為重要的想法 但我沒有問過您呢？

10. Anything else that you want to add to this interview? 有沒有什麼其他內容 您想加到這次採訪中？

Thank you for your participation in this interview. We appreciate the time you took to talk with us. Do you have any questions about the interview or the study that I can answer? 謝謝您參與這次採訪，非常感激您抽出寶貴時間與我們交談。 您對我們的採訪或研究有任何疑問嗎？

Appendix G: Participant Information Sheet

MIDDLESEX UNIVERSITY

Participant Information Sheet (PIS)
More Than Minimal Risk or High Risk Projects

Participant ID Code:……………………………………………

SECTION 1

1. Project/Study title
The title of this study is "Exploring a competency model for energy engineers in Hong Kong: A mixed methods study".

2. Invitation paragraph
You are being invited to take part in a research study. Before you decide it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it with others if you wish. Ask us if there is anything that is not clear or if you would like more information. Take time to decide whether or not you wish to take part.

Thank you for reading this.

3. What is the purpose of the study?
The purpose of the study is to explore the essential competences for Hong Kong energy engineers under the context of global and regional threats and opportunities (e.g. the Covid-19 pandemic, post Covid-19 evolution, global warming, energy technology revolution, industry 4.0 popularization, economic rise of China, the "One Belt, One Road" initiative and the development of the Guangdong-Hong Kong-Macao Greater Bay Area). The corresponding competency model is the deliverable of this study, which will help Hong Kong energy industry / Hong Kong energy engineers to recognize the essential capabilities to overcome challenges and seize opportunities ahead.

The following definitions of terms are used to clearly define this study:

Competency: An area of knowledge or skill that is critical for producing key outputs. Competencies are internal capabilities that people bring to their jobs; capabilities which may be expressed in a broad, even infinite, array of on-the-job behaviour.

Competency model: A competency model is an organizing framework that lists competencies required for effective performance in a specific job, job family, and organization. Individual competencies are organized into competency models to enable people in an organization or profession to understand, discuss, and apply the competencies to workforce performance.

Hong Kong energy industry: As Hong Kong has no natural energy resources, most energy is imported from outside. So, the Hong Kong energy industry refers the industries related to the following fields:

- Petroleum products related, such as: car gasoline, diesel, aviation gasoline, etc.
- Gas fuel related, such as: towngas, LPG, etc.
- Power supply related, such as: power generation, transmission, distribution, etc.
- Power equipment related, such as: main switch, distribution box, power line, etc.
- Electrical equipment related, such as: elevators, water pumps, lighting equipment, etc.
- Electrical value-added equipment/service related, such as: UPS, smart meters, energy saving, etc.
- New energy related, such as: solar, wind, hydro, nuclear energy, etc.

Hong Kong energy engineers: It refers to Hong Kong energy industry practitioners (at present or in the past) who obtained a local accredited/recognized degree or equivalent in engineering discipline.

4. Why have I been chosen?

The participants' recruitment criteria are to invite Hong Kong energy engineers who have working experience in Hong Kong energy industry and are willing to share their insights and opinions in achieving the purpose of this study. It is important that we assess as many participants as possible, and you have indicated that you are interested in taking part in this study.

5. Do I have to take part?

It is up to you to decide whether or not to take part. If you do decide to take part you will be given this information sheet to keep and be asked to sign a consent form. If you decide to take part you are still free to withdraw at any time and without giving a reason. If you do decide to withdraw from the study then please inform the researcher as soon as possible, and they will facilitate your withdrawal. If, for any reason, you wish to withdraw your data please contact the researcher within a month of your participation. After this date it may not be possible to withdraw your individual data as the results may have already been published. However, as all data are anonymised, your individual data will not be identifiable in any way.

6. What will I have to do?

You are expected to take part in the following activities:

- There are two parts in this study. Both part one and two will be conducted online so as to minimize the Covid-19 risk. Your participation in both parts is crucial to this research.
- In part one, you will spend approximately 20 minutes in the online survey, please select a convenient location and time slot to respond to the online survey by using your computer/mobile phone. Before you start the online survey, you will be asked to read and accept the consent form of this study. The online survey will ask you to share your perceptions on the importance of each competence listed in each question. Please make sure your answers are completed as accurate as you can.
- In part two, you will be invited to join an individual online interview which will last around 60 minutes. Only you and the researcher will participate in this online interview. The researcher will make an appointment with you in advance, you can select a convenient location and time slot for online interview. During the online interview, the researcher will ask you the arguments of your answers in part one, the dialogue will be audio recorded and transcribed for further analysis.
- Your participation in both parts are absolutely voluntary, you can withdraw from this study anytime without any negative consequences.

Please note that in order to ensure quality assurance and equity this project may be selected for audit by a designated member of the committee. This means that the designated member can request to see signed consent forms. However, if this is the case your signed consent form will only be accessed by the designated auditor or member of the audit team.

7. Will I have to provide any bodily samples (i.e. blood/saliva/urine)?

No.

8. What are the possible disadvantages and risks of taking part?

There is no known risk in participating in this project.

Appropriate risk assessments for all procedures have been conducted, and will be followed throughout the duration of the study.

9. What are the possible benefits of taking part?

We hope that participating in the study will help you. However, this cannot be guaranteed. The information we get from this study may help Hong Kong energy industry / Hong Kong energy engineers to recognize the essential competencies necessary to overcome challenges and seize opportunities ahead.

10. Will my taking part in this study be kept confidential?

The research team has put a number of procedures in place to protect the confidentiality of participants. You will be allocated a participant code that will always be used to identify any data you provide. Your name or other personal details will not be associated with your data, for example, the consent form that you

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sign will be kept separate from your data. All paper records will be stored in a locked filing cabinet, accessible only to the research team, and all electronic data will be stored on a password protected computer. All information you provide will be treated in accordance with the UK Data Protection Act.

In addition, the Middlesex University Privacy Policy provides you more information about protection of your confidentiality. Details please refer to Section 2.

11. What will happen to the results of the research study?
The results of the research study will be used as part of a postgraduate dissertation. The results may also be presented at conferences or in journal articles. However, the data will only be used by members of the research team and at no point will your personal information or data be revealed.

12. Who has reviewed the study?
The study has received full ethical clearance from the Research ethics committee who reviewed the study. The committee is the Transdisciplinary DProf Research Ethics Committee.

13. Contact for further information
If you require further information, have any questions or would like to withdraw your data then please contact:

Researcher: Mr. Wai Leung CHAN
Email address: wc396@live.mdx.ac.uk

Supervisor: Dr. Orthodoxia Kyriacou, BA(Hons) MA, PGCHE, PGDip, FAIA, SFHEA
Associate Professor in Transdisciplinary DProf Developments
Middlesex University
Address: Hendon Campus, Middlesex University, The Burroughs, London. NW4 4BT
Work number: +44(0)20 8411 5580
Email address: o.kyriacou@mdx.ac.uk

Thank you for agreeing to take part in this study. You (the participant) should keep this "Participant Information with Consent" sheet since it contains important information and the research teams contact details

SECTION 2

Middlesex University Privacy Notice for Research Participants

The General Data Protection Regulation (GDPR) protects the rights of individuals by setting out certain rules as to what organisation can and cannot do with information about people. A key element to this is the principle to process individuals' data lawfully and fairly. This means we need to provide information on how we process personal data.

The University takes its obligation under the GDPR very seriously and will always ensure personal data is collected, handled, stored and shared in a secure manner. The University's Data Protection Policy can be accessed here: https://www.mdx.ac.uk/__data/assets/pdf_file/0023/471326/Data-Protection-Policy-GPS4-v2.4.pdf.

The following statements will outline what personal data we collect, how we use it and who we share it with. It will also provide guidance on your individual rights and how to make a complaint to the Information Commissioner's Officer (ICO), the regulator for data protection in the UK.

Why are we collecting your personal data?

As a university we undertake research as part of our function and in our capacity as a teaching and research institution to advance education and learning. The specific purpose for data collection on this occasion is to help Hong Kong energy industry / Hong Kong energy engineers to recognize the essential competencies necessary to overcome challenges and seize opportunities ahead.

The legal basis for processing your personal data under GDPR on this occasion is Article 6(1a) consent of the data subject.

Transferring data outside Europe

In the majority of instances your data will be processed by Middlesex University researchers only or in collaboration with researchers at other UK or European institutions so will stay inside the EU and be protected by the requirements of the GDPR.

In any instances in which your data might be used as part of a collaboration with researchers based outside the EU all the necessary safeguards that are required under the GDPR for transferring data outside of the EU will be put in place. You will be informed if this is relevant for the specific study you are a participant of.

Your rights under data protection

Under the GDPR and the DPA you have the following rights:

- to obtain access to, and copies of, the personal data that we hold about you;
- to require that we cease processing your personal data if the processing is causing you damage or distress;
- to require us to correct the personal data we hold about you if it is incorrect;

- to require us to erase your personal data;
- to require us to restrict our data processing activities;
- to receive from us the personal data we hold about you which you have provided to us, in a reasonable format specified by you, including for the purpose of you transmitting that personal data to another data controller;
- to object, on grounds relating to your particular situation, to any of our particular processing activities where you feel this has a disproportionate impact on your rights.

Where Personal Information is processed as part of a research project, the extent to which these rights apply varies under the GDPR and the DPA. In particular, your rights to access, change, or move your information may be limited, as we need to manage your information in specific ways in order for the research to be reliable and accurate. If you withdraw from the study, we may not be able to remove the information that we have already obtained. To safeguard your rights, we will use the minimum personally-identifiable information possible. The Participant Information Sheet will detail up to what point in the study data can be withdrawn.

If you submit a data protection rights request to the University, you will be informed of the decision within one month. If it is considered necessary to refuse to comply with any of your data protection rights, you also have the right to complain about our decision to the UK supervisory authority for data protection, the Information Commissioner's Office.

None of the above precludes your right to withdraw consent from participating in the research study at any time.

Collecting and using personal data

Your data will be collected by online survey and online interviewing. Both data are recorded in digital format. All data including personal data, protected by strong password and encryption, will be stored in Microsoft OneDrive. Only the researcher, supervisory team and examination team can access your data. In order to ensure the data security and confidentiality, your data will not be accessed by using public WIFI network and sharable computers. The researcher will only access the data by a dedicated computer, which installed anti-virus software with daily virus pattern update. This dedicated computer will be used in private premises with firewall protection. All data will be deleted permanently within five years after the final submission of the research writing, and the Microsoft OneDrive account, holding all research data, will also be closed permanently as well.

Data sharing

Your information will usually be shared within the research team conducting the project you are participating in, mainly so that they can identify you as a participant and contact you about the research project.

Responsible members of the University may also be given access to personal data used in a research project for monitoring purposes and/or to carry out an audit of the study to ensure that the research is complying with applicable regulations. Individuals from regulatory authorities (people who check that we are carrying out the study correctly) may require access to your records. All of these people have a duty to keep your information, as a research participant, strictly confidential.

If we are working with other organisations and information is shared about you, we will inform you in the Participant Information Sheet. Information shared will be on a 'need to know' basis relative to achieving the research project's objectives, and with all appropriate safeguards in place to ensure the security of your information.

Storage and security

The University takes a robust approach to protecting the information it holds with dedicated storage areas for research data with controlled access.

Alongside these technical measures there are comprehensive and effective policies and processes in place to ensure that users and administrators of University information are aware of their obligations and responsibilities for the data they have access to. By default, people are only granted access to the information they require to perform their duties. Training is provided to new staff joining the University and existing staff have training and expert advice available if needed.

Retention

Under the GDPR and DPA personal data collected for research purposes can be kept indefinitely, providing there is no impact to you outside the parameters of the study you have consented to take part in.

Having stated the above, the length of time for which we keep your data will depend on a number of factors including the importance of the data, the funding requirements, the nature of the study, and the requirements of the publisher. Details will be given in the information sheet for each project.

Contact us

The Principal Investigator leading this research is Mr. Wai Leung CHAN

Contact number: +852 9168 2462

Email address: wc396@live.mdx.ac.uk

The University's official contact details are:

Data Protection Officer
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NW4 4BT
Tel: +44 (0)20 8411 5555
Email: dpaofficer@mdx.ac.uk