Identifying the Needs of Electric Power Industry through Online Job Ads: A Mixed-methods Approach

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Abstract

With policies and projects charting the net zero future of the electric power system, new jobs are created to meet the increasing demand for electrical engineers in integrating renewable energy resources. Despite universities' efforts to prepare students for the workforce, the industry still faces a talent shortage, resulting from a gap between the fast-evolving industry expectations and the quickly outdated university curricula. The lack of systematic methods to understand authentic industry needs is one of the root causes of the gap. This paper proposes a holistic process for identifying the knowledge and skills in demand in the electric power industry by analyzing public data - job advertisements (job ads). The job ads are scraped from major online job boards and screened with a data selection framework. A mixed-method approach is applied to analyze the data, involving both quantitative and qualitative analysis. The results of this study provide a benchmark for tertiary engineering educators on what to include in their curricula to better adapt the courses and training provided and equip students with up-to-date knowledge and skills for the fast-changing industry. This approach can also be applied to other disciplines to identify the demand of the evolving job markets to produce job-ready graduates in the relevant areas.

1 Introduction

The Australian Government has committed to an ambitious new target of reducing greenhouse gas emissions to 43% below the 2005 level by 2030 and achieving net zero by 2050 [1]. Decarbonizing the electricity sector has become one of the most important and most efficient pathways to facilitate the Australian economy's transition to net zero [2]. Australian Energy Market Operator (AEMO) has planned a rapid transformation for the National Electricity Market (NEM), where the energy generation and consumption profile would change profoundly given the expanding renewable energy integration [3]. This is anticipated to have a significant impact on the workforce in the electric power system [4, 5], leading to the creation of new jobs for electrical engineers in the area of renewable energy integration, the construction of necessary infrastructure, as well as the design, planning and operation of the transformed power system. To this end, electrical engineers need to be trained appropriately at the university level to acquire an extensive knowledge base and technical skills to achieve the goal of workforce development.

However, the Australian electric power industry has seen a talent shortage despite the universities' efforts to equip soon-to-be graduates with the knowledge and skills for the workplace [6]. Due to the lack of an efficient and adaptable process of curriculum renewal, the associated content being taught at the university level become quickly outdated, leaving a gap between the fast-changing industry expectation and the university curriculum [7-9]. Engineering educators currently face the challenge of redesigning curricula that effectively address the demands of the industry. Essentially, they need to benchmark the curriculum framework against the set of knowledge and skills that are currently sought-after in the energy sector. One of the solutions which potentially addresses this problem is to provide academics with a systematic way to uncover the authentic need of the electric power industry through public data (e.g., job ads) [10, 11].

This paper aims to provide an effective approach to analyzing the job ads data and present the electric power industry's prominent demand. The following research questions are addressed in this paper:

- RQ1: How to effectively collect online job ads and exploit the data for identifying the industry needs?
- RQ2: What are the knowledge base and skillsets required in the contemporary power system industry according to the job ads?

The structure of this paper is described as follows: Section 2 (Literature review) summarizes and evaluates existing job market using job ads analysis, highlighting gaps seen in studies in other fields instead of the power system industry. Section 3 (Method) details the data collection and processing procedures, as well as the criteria used to select the data for analysis. Section 4 (Data analysis and discussion) presents the results of the study, including a comprehensive analysis of the applicants' educational background and working experience, technical knowledge, and soft skills. Section 5 (Conclusion and recommendations) summarizes the main findings of the study and provides recommendations for future research, along with highlighting the implications of the research for the field. The findings are expected to guide tertiary engineering educators [1] on what needs to be incorporated into the curriculum framework, so that power system engineering students can be equipped with up-to-date knowledge and skills that better prepare them for the industry.

2 Literature review

In the literature, job ads analysis is considered an empirical technique for extracting skills and identifying industry demands. Studies have been conducted across various industries and regions.

The market appetite of Requirement Engineers (RE) is explored across three countries Netherlands, Canada and China, in the year 2015, 2017 and 2019 respectively, where job ads analysis is applied [12-14]. All three studies adopt a similar empirical research method that collects a wide range of RE position ads, selects a relevant data set, and then apply coding, analysis and synthesis to the qualitative data. In the data selection process, scanning job ads in all three studies were manual and depended on the researchers' subject criterion. The 2015 Nethlans study describes the data selection method as a four-step inclusion-or-exclusion criteria, which inspects all areas of the job ads to ensure that the job is a RE job [12]. The 2017 Canadian study adopted a two-round selection workflow of the collected job ads, where the first round of selection is by job title and overview, the second round by job responsibility, and lastly removing duplications [13]. The 2019 Chinese study highlights a pilot data selection on a 160 job ads sample, where author 1 and author 2 both select the relevant jobs from the 160 job ads respectively and compare the results, based on a 90%+ consensus and the selection criteria is verbally agreed between the authors, which has increased the credibility of the data selection [14].

[12-14] analyzed tasks and skills in groups according to the data, and rankings of skills are drawn out from the job ads, interpreted and compared in detail. Bar charts are frequently used to present the top listed skills and RE competency. Interestingly, the author of [12] and [14] compared the ranking of the technical skills and soft skills required by the RE jobs with the previous studies, and a change in skill ranking is presented and discussed. For example, the literature [14] found that the RE experience was ranked first and has increased over 60% compared to [13], where the RE experience was ranked second. In addition, educational qualifications, tasks and skills, job titles, and company profiles are investigated. However, the literature [12-14] has seen common drawbacks: 1) the implications to education are mentioned based on the top required skills briefly, with no detailed discussion on which skills have or

[1] In Australia, tertiary education refers to post-secondary education; tertiary institutions are universities, technical and further education (TAFE) and other vocational colleges [11].

haven't been included in the curriculum and where they should sit in education; and 2) the comparison across time and region focused only on soft skills, instead of technical skills.

Apart from RE jobs, job ads analysis has been applied to other engineering disciplines. Aiming at shaping the biomedical engineering graduates in the UK with curriculums that represent the needs of the industry, instead of using an industry advisory committee for high education curriculum design, [15] explored an alternative approach to see the industry needs through the job ads analysis, using qualitative analysis software. Results reveal the relevant technical skills hierarchy and rated importance of generic skills. One highlight of this study is that the technical skills are divided into a hierarchy – top-level skills, sub-level skills and specific skills. Skills are statistically analyzed by job category, e.g., engineer, manager, scientist, software tester, specialist, etc. Interestingly, the required level of proficiency is specifically examined by coding the adjectives used to describe them, which is very unique among all the literature reviewed. Specifically, this research focused on "biomedical engineering" as a whole, so the data is solely collected using keyword search, no data selection is needed. Furthermore, a total of 36 job ads are under investigation in this research, which is a relatively small sample size. [16] studies civil engineering jobs in the Turkish construction sector, in light of the Turkish construction industry's global growth. The study has a specified focus on early-career civil engineer graduates (i.e., no more than 3 years of experience). A wide variety of job titles are found, and a total of 427 job ads are identified for research. Qualifications are statistically analyzed in 5 areas: technical skills, software skills, language skills and interpersonal skills. Compared to the rest of the literature, this study identifies further vague soft skills required by civil engineers in construction, such as adaptability to flexible working hours and taking responsibility and innovation. However, the author has mentioned that the data selection is manual, but no criteria for selection framework is mentioned; it is solely dependent on the authors' knowledge and experience. These two works found that there is a significant difference between education and industry, however, limited suggestions were made to replenish this gap.

[17] conducted job ads analysis for AI Engineers in the Netherlands, where the appetite for AI engineers has exploded but the definition of AI engineer is less well established than other jobs in this field, such as data analysis or software development. The study retrieved and characterized 367 job ad results from a large job ads database over 2 years. In data analysis, AI engineers are categorized into 5 groups: "business understanding, data engineering, modelling, software development and operations engineering". The results ranked the software packages, technical knowledge and soft skills as top mentions in job ads. Innovatively, this study constructed an equational notation for the job ads keyword search criteria: (developer || engineer) & (AI || ML || DL), the full form of the abbreviations, "artificial intelligence", "machine learning", "deep learning" are also used. In the end, the implication to education is generalized, with no detailed suggestion of what knowledge and skills need to be included in the curriculum.

While most of the research manually conducted the qualitative coding to the text of job ads, a series of Morocco studies has made great efforts to automate the job ads analysis process by using text mining and big data technologies. [18-20] analyzed job ads for the cybersecurity job market, the Automotive job market and off-shore sector in Morocco. Keyword searches are used for attribute extraction. The highlights of the three research can be stated as follows. [18] compared the skills extracted with the cybersecurity-specific curriculum, and found that the highly-requested skills are not emphasized in the curriculum, while the traditional skills taught regularly are less in demand. [19] not only detected skills required by the automotive industry but also creatively used a random forest algorithm to predict the salary of the job offers, where the existing job requirements and salary data are used for training the model. [20] presented a flow chart of the methodology used in the study - from scraping data using a web crawler, removing duplication, classification, information extraction, and job title matching. In all the

three studies, job ads are selected based on the authors' experiences and understanding. No selection framework or criteria for this data selection or keyword search is specifically mentioned. While these three studies highlight the use of big data technology and natural language processing to automate the skill extraction and data analysis process, it might not be the most desirable method for qualitative data analysis, specifically when the deeper meaning of the connection in the words used in job ads needs to be interpreted based on some technical understanding.

Job ads analysis is also used to examine non-engineering jobs. [21] focused on entry-level public relations, aimed to link the educational competencies and industry requirements. analyzed 1000 jobs and uncovered the skills that entry-level public relations jobs most frequently request. [22] examined the qualifications and skills required for a professional position using data collected from job ads, and provided suggestions to the professional education program based on the skills and experiences identified. Both [21, 22] have described their data selection criteria in some sections, including keywords, tasks or departments for inclusion. It is worth mentioning that [21] conducted a survey prior to the data collection, asking the HR professionals who have been involved in posting entry-level PR job ads about what job titles have been used, then collected 1000 job posts according to the list of names collected. In terms of the implications to education, [21] suggested including social media in a stand-alone course or including it in various courses to prepare the students for the workforce. [22] also suggested inclusion of digital content into librarian-related degrees based on the research results. Soft skills require more careful and extensive study in positions that demand them, unlike engineering jobs where technical skills are fundamental and form the core of engineering education. Therefore, technical skills should be a primary focus for engineering jobs.

Table I. Summary of literature on job ads analysis.

Ref	Year	Position / Industry	Country	Job ads studied	Data selection	Data processing
[12]	2015	Research Engineer	Netherlands	101	Manual, selection criteria provided	Manual, no description
[13]	2017	Research Engineer	Canada	109	Manual, selection criteria provided	Manual, no description
[14]	2019	Research Engineer	China	535	Manual, verbally agreed between authors	Manual, qualitative coding
[15]	2016	Biomedical Engineer	UK	36	No data selection	Manual
[16]	2015	Civil Engineer	Turkish	427	Manual, no discretion	Manual
[17]	2022	AI Engineer	Netherland	367	Use a formula for job title keyword search	Manual
[18]	2019	Cybersecurity	Morocco	409	Keyword search	Text search
[19]	2018	Automotive	Morocco	8027	Keyword search	Text search
[20]	2018	Offshore sector	Morocco	28,000	Big data algorithm	Big data algorithm
[21]	2020	Public Relations	The US	1000	Manual, selection criteria provided	Manual, no description
[22]	2009	Digital librarian	The US	363	Manual, selection criteria provided	Manual, qualitative coding

Table 1 provides a summary of the job ads analysis method seen in the literature. Overall, the common traits seen in the literature include:

- Use of ample data set,
- Use of coding for qualitative data,
- Job/skills grouped by themes, job categories, or level of jobs,
- Focus on soft skills, and
- Implication to education.

However, the common deficiency can also be concluded after the literature review:

- lack of a systematic data selection procedural framework to select job ads relevant to the research, and
- lack of the mapping of skills extracted and the university curriculum to identify the gap, hence make suggestions on what might be included in power engineering curriculum.

3 Method

To answer the RQs raised in Section 1, the following method is proposed, as illustrated in the flow chart Figure 3.1. First, job ads are scraped from online job boards to create a pool of data for the study. Then, specific job ads are selected based on the scope of study using a selection framework, which will be described in Section 3.2. Next, a combination of qualitative and quantitative analysis is applied to the selected data set, leading to answering RQ2. Overall, the analytical process involves three steps:

1) Data collection
2) Data selection
3) Coding and Analysis

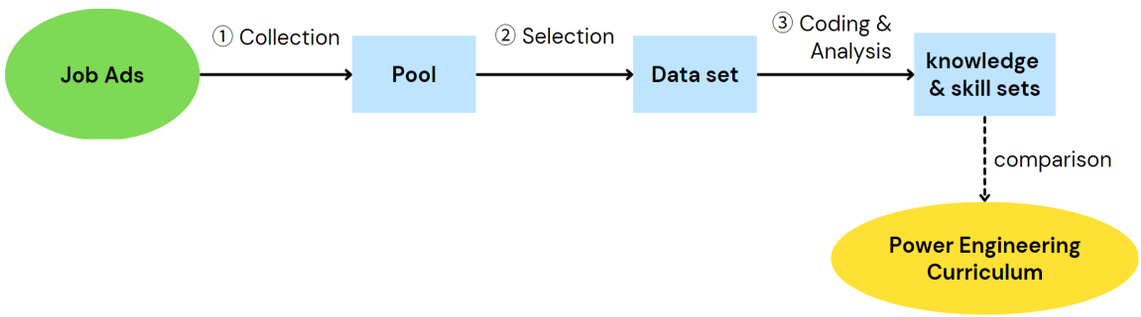

Figure 3.1. Job ads analysis method flow chart.

3.1 Data Collection

To understand the up-to-date needs of the electric power system industry, job ad data are collected from three major job boards in Australia - LinkedIn, Seek, and Indeed. The main reasons for choosing these online job boards are:

1) They are the top three ranked websites by third-party HR service [23],
2) Commonly recommended by employers and university career programs, and

3) Substantial duplications are found when searching into a fourth online job board at each time of data collection, indicating that the job ads collected from the three websites can be considered sufficient to represent the current job market demand.

Keyword searches are used to create the pool of potentially relevant job ad data, as all three platforms cover the jobs in demand across different industries. The keywords used to search for job ads include: Electrical Engineer, Power System Engineer, and Electrical Power Engineer. In terms of the data processing tool, Nvivo Ncapture is chosen to scrape the text of job ads, for the convenience of extracting clean text from websites, and for the smooth importation to the qualitative analysis tool. The data collection was conducted three times in December 2021, February 2022 and September 2022 to scrape job ads from the nominated job portal to avoid considerable duplications among the collected job ads. It is worth noting that the collection times were chosen based on the major intakes of graduates, which are associated with the university schedule. The collection process described above resulted in a total of 179 job ads collected. At a preliminary stage, the observation of a substantial pool of the job ads being collected can be made as below:

- Employer companies of power system engineers are found in various types of businesses. The main employers include engineering consultancy (e.g., Jacobs, GHD), utility company (e.g., Transgrid, AEMO), instrument manufacturer (e.g., Simens, ABB), energy generator and retailer (e.g., origin, AGL).
- Several titles are observed when describing the engineering position within the scope of this study. Conventional titles such as power system engineer, electrical engineer, and grid connection engineer are seen across all types of companies. Other titles of positions are also found describing power system engineering positions, such as system engineer, infrastructure (planning) engineer, modelling engineer, project delivery engineer, and even software production engineer. The title “consultant” is also commonly used, especially by consultancies.

Because the chosen online job boards are not limited to the electric power industry, and the results returned from keyword searches consist of a wide range of titles, it is paramount to look into the job descriptions and select desired positions according to the scope of the study. Consequently, a selection framework is proposed and described in Section 3.2.

3.2 Selection Framework

Before discussing the selection of job ads, the scope of study needs to be cleared. The power system engineer in this paper refers to electrical engineers who work mainly within the electric power system industry, where the power system involves the electrical facilities and services that supply, transfer, control, and protect electric power [11].

To ensure the position advertised falls within the scope of this study, the selection framework needs to ensure that the jobs chosen met the following requirements:

1) The nature of the job is technical engineering or design. Roles that focus on project management or client engagement are excluded.
2) The position is in the field of electrical engineering. Although renewable energy resources are the area of interest, the design and engineering of the renewable energy generation technologies, such as the design of solar panels, hydrogen fuel cells, etc. do not fall within the scope of this study.
3) The engineering work focuses on the large-scale electric power system - the supply, transfer, control and protection of the electric energy, in other words, the electrical grid. The electrical systems of buildings, railway systems, or electric vehicles (EVs) are out of the scope of this study.

Based on the rules mentioned above, manual selection is applied to the job ads pool, using the selection framework illustrated in Figure 3.1.

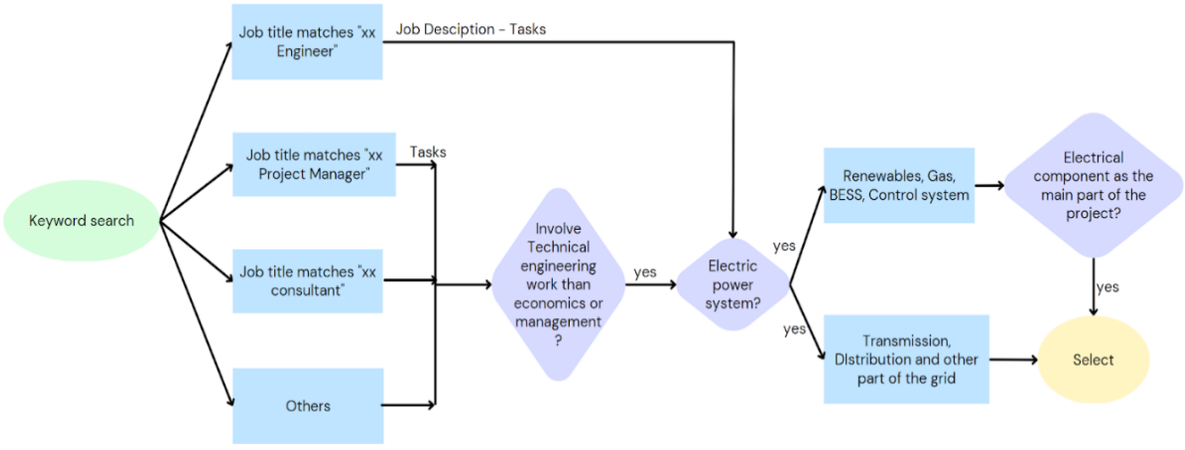

Figure 3.2. Job ads selection framework.

As described in Section 3.1, the job titles that came back from the keyword search can be generally categorized into four categories - “xx Engineer”, “xx Project Manager”, “xx consultants”, and others. Based on this categorization, the first step is to ensure the nature of work emphasis is engineering and this decision needs to be made for all positions whose titles do not specify “engineer”. After filtering out business or management-focused positions, the second decision is to narrow down the scope of work to the electric power system. Thirdly, if the scope of work falls within the power transmission and distribution network, i.e., the electrical grid, then the job is selected into the study dataset. If the responsibilities of work are articulated around renewable energy, gas turbine, battery energy storage system (BESS), or control system, one further step is needed to filter out positions that focus on the chemical, mechanical, process or computer system instead of the electrical component. To obtain a panoramic view of the electric power job market, advertisements at all levels, from entry-level to more senior positions, are collected and examined thoroughly. As the job postings are not selected based on the level of position, this information is not specified in the selection framework.

3.3 Data Processing

Figure 3.3 demonstrates an example of the job ads scraped from LinkedIn. The content can be divided into four parts - introduction, tasks, requirements, and benefits. The introduction section provides a brief explanation of the employer company and the role, the sector where the new hire will be working and some major projects. This section is usually the opening of a job ad, starting with “about us”, and “about the role”. The tasks section is usually presented in bullet points, outlining the tasks that the position will be undertaking; this section is usually framed as "what you will do", "your responsibility", "your impact", "you will" or "job description". The requirements section lists the requirements for the applicants, including requirements on their educational background (i.e., qualification), certification, working experience and skills. This section is usually worded as "what you will bring", "about you", "what we need from you", "the successful applicant", and "essential". The benefits section presents the support and development that can be provided to the employees culturally, professionally, and economically.

Moreover, in job ads, as a form of practical writing, some common characteristics can be seen:

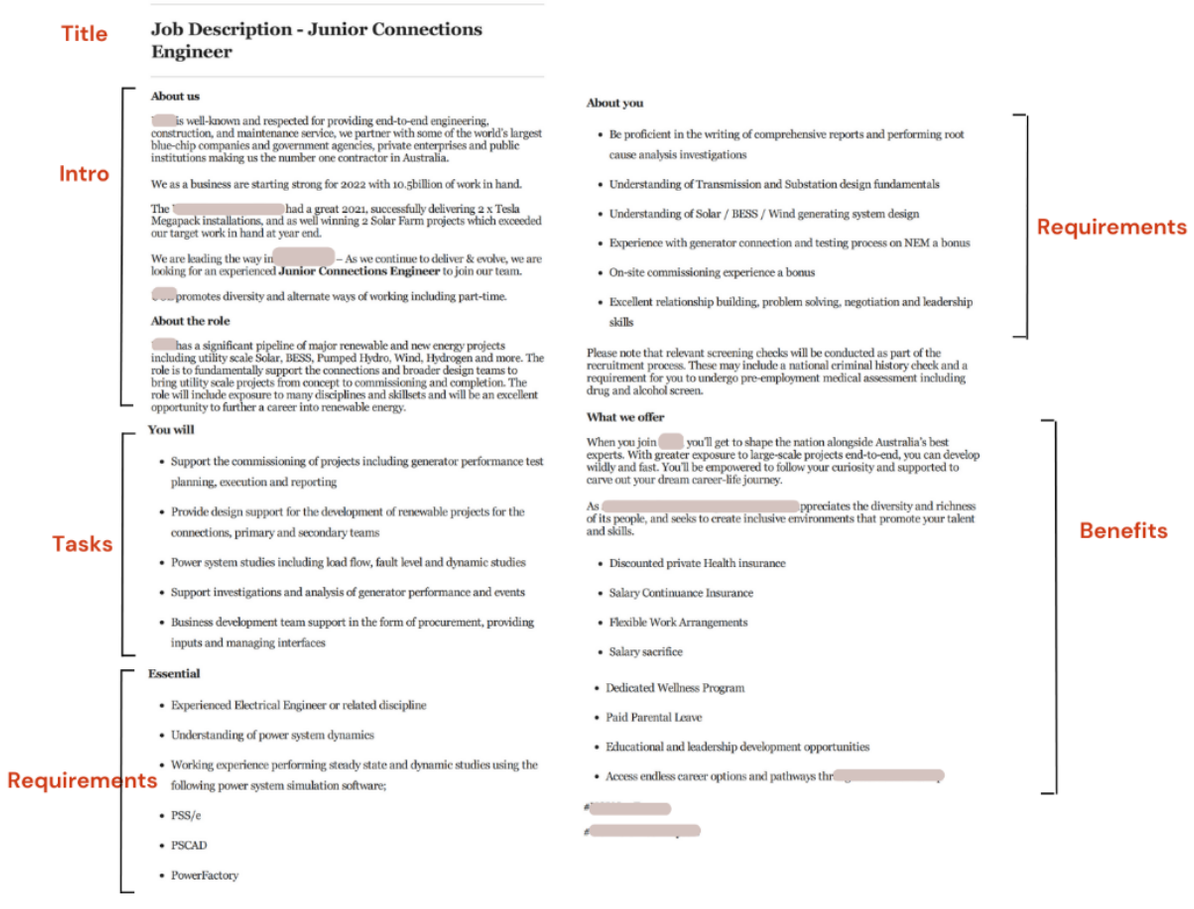

Figure 3.3. Sample Job Ads.

- The knowledge and skills under study are mainly seen in the section 'Tasks' and 'Requirements'.
- When describing the tasks, job ads usually emphasize tasks involving technical skills first, followed by soft skills.
- When listing requirements, the requirement for education (degree, certificate etc.) and experience will be listed first, if applicable.
- Knowledge and skills usually overlap between the 'tasks' section and 'requirements' section, where different wordings are used.

The following coding and analysis focus on the two sections 'tasks' and 'requirements. Due to the software's incapability in processing natural language, the data are processed manually. The selected job ads are analyzed using the qualitative data analysis tool NVivo. NVivo is chosen for its capability of analyzing qualitative data, especially unstructured data which are heavy in text [24]. The qualitative analysis theory of Merilyn [25], a method using NVivo described in [24] is adopted. The data processing procedure of this paper is illustrated in Figure 3.4.

In this paper, the term "code" refers to knowledge and skills extracted from the text, for example, "knowledge of solar farm". Additionally, "coding" refers to the process to extract the knowledge and skills information from the text, as shown in the dotted box in Figure 3.4. A new code was created when a new knowledge/skill is identified. If an excerpt is similar to what has already been coded, for example, "knowledge of PV generation", it would be added to an existing code ("knowledge of solar farm"). In this particular case, an excerpt (e.g., "grid connection of solar farm") can be coded into multiple codes ("grid connection studies" and

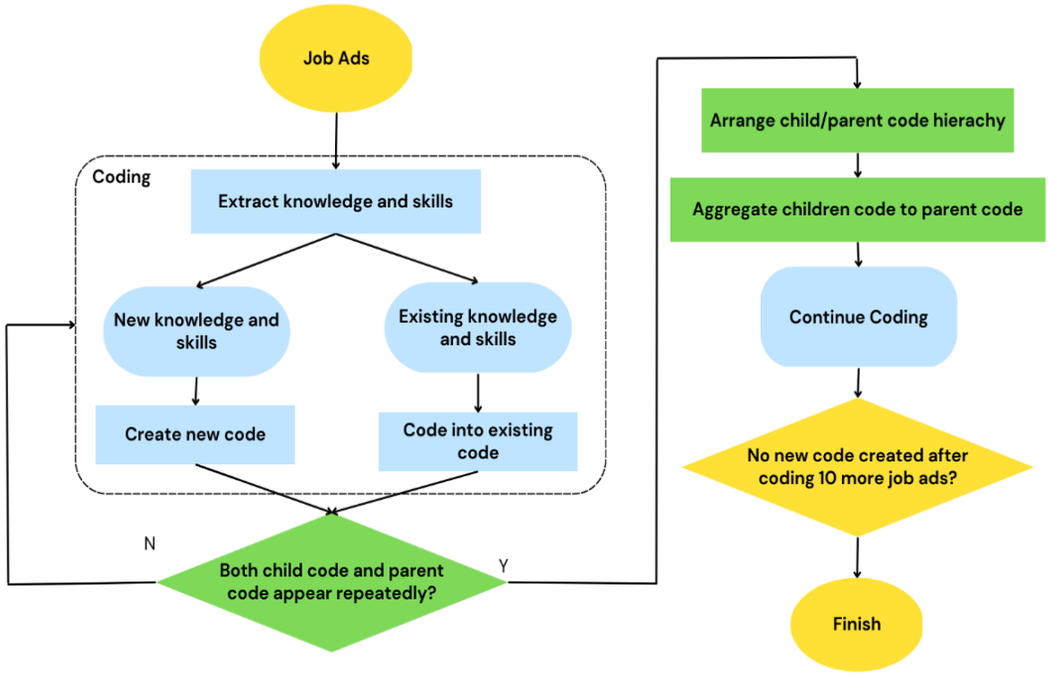

Figure 3.4. Data processing flow chart.

“knowledge of solar farm”) since it implies more than one type of knowledge and skills. During the coding process, we conduct an ongoing analysis to identify the subsidiary relationship between codes and create a hierarchy accordingly, as highlighted in green in the figure above. This type of hierarchy is defined as parent - child hierarchy. One instance of such a hierarchy is a parent node labeled "knowledge of renewable energy generation" that has child nodes named "knowledge of solar farm" and "knowledge of wind farm". Grounded theory has identified that saturation is unavoidable in qualitative analysis. Although its definition is subject to debate [26], this paper defines saturation as the point at which coding will terminate when no new codes are generated after coding ten additional job ads.A total of 89 job ads are coded before reaching saturation.

4 Data Analysis and Discussion

In Figure 4.1, a word cloud is used to visualize the overall outcome of the coding in an unorganized but impactful manner. As it is shown, the code extracted from job ads falls into a general category shown in the list below:

- Education and Experience
- Technical Knowledge
  - Technical skills
  - Software skills
- Soft Skills

The results for each category are presented in the following sections.

Figure 4.1. Coding results visualization – word cloud.

4.1 Education and Experience

59 out of 89 job ads coded have mentioned requirements for education, out of which, 42% of the job required a minimum tertiary certificate. 58% specified that a successful candidate with a degree at bachelor's level would be sufficient, 8% mentioned that a higher degree at the postgraduate level would be preferable. In conclusion, while a bachelor's degree would guarantee the candidate meets all the jobs' requirements on education, a tertiary education certificate would open more than half of the opportunity for power system engineers (61% overall), and higher education would provide you with an edge in some positions. This result matches our common expectations for an engineering position.

Interestingly, 7% of power system engineering jobs are open to more disciplines of engineering than electrical engineering, however, the technical skill required of these jobs are very specific, and all of these jobs have requirements for work experience, both in the length (e.g., 3 years, 5 years) and area of work.

4.2 Technical Knowledge

Because job ads are written in a way that contains both generalized descriptions of knowledge and skill sets and specific knowledge and skills associated with certain roles in the power system industry, this study separates them into two big categories - general technical knowledge (GTK), and role-specific technical knowledge (RSTK). The hierarchy chart of technical knowledge extracted from job ads is shown in Figure 4.2.

Exploring the ranking of RSTK, the orange part of the hierarchy chart, gives insight into the most sought-after positions and the tasks involved.

Among all the job ads, the most in-demand RSTK is about power generation and transmission technology. Where some job ads use the term "power generation and transmission" as a general concept, it can be seen from the subcategory that this is related to the work of design and construction of power generation-transmission infrastructure, including substations and transmission lines. This indicates the high demand for knowledge and experience in network development. As AEMO 2022 ISP has pointed out, significant opportunities are

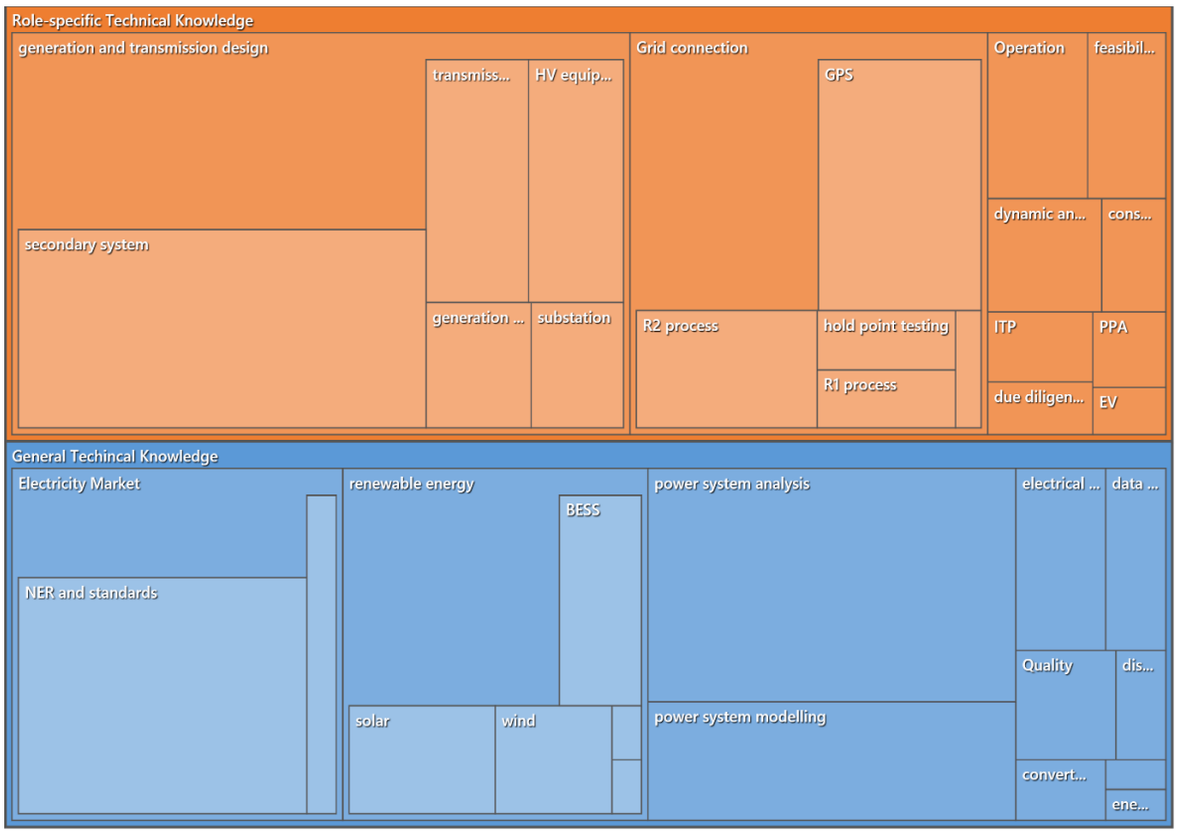

Figure 4.2. Technical knowledge for power system engineer hierarchy chart.

foreseen in the infrastructure investment, estimated approximately $12.8 billion network investment in today's value while the infrastructure is expected to add $28 billion in value [3]. 12 major network projects have been planned and actionable, due to deliver by 2030 within the NEM; these major projects would require design for significant transmission lines and substations. To this end, the demand for knowledge in substation design, secondary system, transmission and distribution design, and HV equipment is higher in the overall ranking.

Noticeably, a relatively new job category in power system engineering has ranked second in the job ads - grid connection. In recent job ads, this high-demand position mainly focuses on assessing new generators, often a renewable generation or storage system, and connecting them to the grid. This trend in the job market closely follows Australia's commitment to emission reduction [1] and the urgency to integrate more renewable energy generation into the grid.

To connect a new generator to the NEM, generator registration and connection requests need to be submitted to (Australian Electricity Market Commission) AEMC [27]. For inverter-based generators, such as renewable energy and BESS, it is also important to minimize their negative impact on the electricity grid stability and electrical quality, thus, the generation connection needs to show compliance with the AEMC rule on system strength [28]. The work of grid connection engineers is to assess the performance of new generators through modelling and simulation [29], help new generators comply with NER and finally enable connecting them to the grid.

As all generators need to follow the connection and testing process as defined by NER, subcategories for this RSTK are highly overlapping, including Generator Performance Study (GPS), R1 & R2 process and testing. Other RSTK down the list include operation (12%), feasibility study (9%), dynamic analysis (7%), etc.

Another category of technical knowledge that is required across several roles are grouped into GTK. The most coded GTK, which also topped the overall chart, is the knowledge of the electricity market, with 56% of the job ads under study mentioning it. The knowledge of the energy market includes a few children nodes - knowledge of the National Electricity Market (NEM), National Electricity Rule (NER) including the Australian and/or international standards, rules of network service providers (NSPs), and the policies of the transitioning energy market. As discussed above, both the transmission and distribution design and the grid connection would require the engineer to understand the electricity market operation, comply with relative standards and rules, and consider the industry trends in their design. Undoubtedly, knowledge of electricity markets is a crucial tool for electrical engineers working in the power system industry. This knowledge, along with efforts to incorporate it into the curriculum, has been observed in both literature and pioneering practices worldwide.

[30] presented an example of creating a curriculum on Urban Energy Systems and Energy Economics (UESEE), where energy markets are incorporated into the curriculum, and according to the student survey, close to 90% of students expressed their wish of incorporating the knowledge of energy market (both local and global), and energy policy into the curriculum and more than half of the respondents reckoned that student should be taught at least to an intermediate level. [31] added a smart-grid-oriented project into the curriculum, where important topics such as the smart grid, electricity market operation, and demand side response are planted. This practice took an important step forward in bridging the gap between university education and industry content.

The second most demanded knowledge is power system analysis (49%). Power system analysis has a long history ever since the electrical power system emerged in the late 19th century [32], and engineers develop mathematical models and methods to analyze the behavior of electrical power system. As the electricity demand increased, the demand for electrical engineers with the ability to perform power system analysis also rose. The content of power system analysis also involves studies from steady-state analysis to transient analysis, system stability, etc. Although the method, algorithm, and tools for these analyses have evolved to a very advanced level, the main focus seen from job ads remains with the essentials, among which, fault analysis is the most mentioned specific task. Educators and researchers around the globe have long been seeking to improve the curriculum of power system analysis [33, 34], although the goal is mostly to improve the quality of teaching.

Because the nature of power system analysis involves the modelling of power system components, the result that power system modelling is another highly coded skill (28%) is explainable.

The third top-coded GTK is renewable energy, where 42% of the position requires some knowledge of renewable energy. This is not surprising as renewables have taken the center of discussion for their potential in tackling climate change, and the development of academic programs around these interdisciplinary projects started as early as 1990s [35]. The fulfilment of Australia's commitment to a 43% reduction in carbon emissions by 2030 and net-zero goals by 2050 relies heavily on the development of renewable energy. ISP has estimated a staggering nine-fold utility-scale VRE available by 2050, and nearly five times distributed PV[3]. Additionally, a new technology, the battery energy storage system (BESS), is gaining significance. The first grid-scale battery storage system, the Hornsdale Power Reserve, was built and commissioned in South Australia in 2017 [36]. Currently, 11 grid-scale BESS are operating in the NEM and more than 30 projects are under construction, aggregating to approximately 11GW capacity [37, 38]. The use of BESS in power grids has been a popular topic of research in the academic community. Numerous studies have been conducted to investigate its operation, optimization, provision of ancillary services, and potential of grid-forming in the stationary energy market [39, 40]. However, the topic is not well covered in educational curriculums, due to the complexity and leading-edge nature of this technology.

Other GTK down the list include electrical drawing, data analysis, quality construction, etc. Often these knowledge and skills build on the foundation established through education and are further developed through industrial experiences.

With the rapid advancement of workplace technology, digitalization has become increasingly prevalent in the industry, hence, software skills are no doubt a vital demand for employees. 68% of job ads have expected specific software skills from candidates. Figure 4.3 illustrats the software skills required by power system engineer positions via pie charts.

The top three required software are PSSE (24%), PSCAD (24%) and DigSILENT PowerFactory (21%). These are used to conduct RMS or EMT simulation of a power system, and they are highly associated with the grid connection engineers' position. This is due to the fact that the system studies have to abide by NER, and AEMO has issued power system modelling guidelines for the convenience of applicants to provide correct and specific information for registry [41]. PSS/E is the most mentioned simulator in job ads, its popularity has been recognized widely by the industry as well as academic research [42]. The integration of PSS/E into the electrical engineering curriculum has been done as early as 1990s for students to perform power flow analysis [43], while the use of PSCAD in the classroom was also seen in the literature [44].

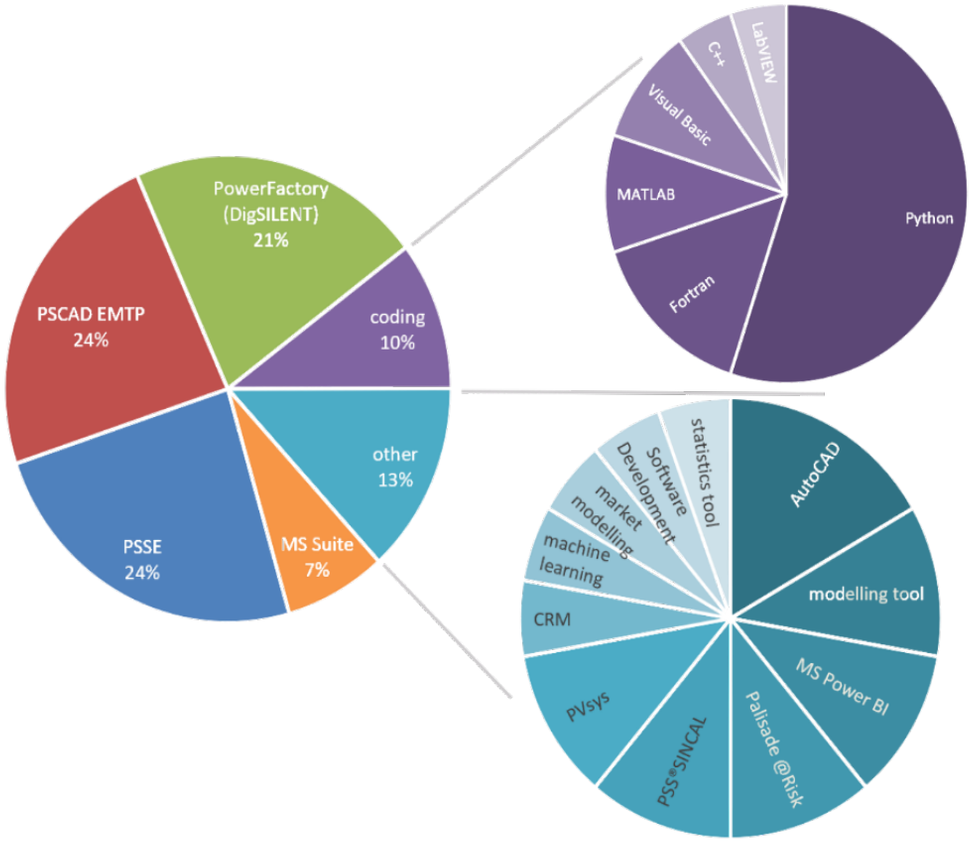

Figure 4.3 Software skills for power system engineer jobs.

Except for specific software, proficiency in Microsoft (MS) office software suite is widely required. Noticeably, more job ads do not mention MS office as this has already been considered a common skill in the digital era, and only a small number of jobs emphasized MS software.

10% of the software skills consist of programing. Among these, Python is the most popular language required in the industry, followed by Fortran, MATLAB and other languages. Unlike the software development roles, the requirement of programing for electrical engineers mainly focuses on automating, reporting, plotting, calculation and data analysis, instead of developing

any interface or application. Thus, Python, with strong compact ability across this area, is most required. Fortran is second on the list mainly due to its efficiency in math calculation, which made it suitable to simulate large physical systems, and the existence of legacy code in the industry practice.

In short, while policy and investment fuse the growth of the electric power industry, the workforce, however, is facing growing skills shortages [5, 6]. On the other hand, academics have seen the need to renew the power system engineering curriculum and attempts to integrate up-to-date knowledge into the curriculum are reflected in the literature [30, 31, 34, 39, 40, 42-44].

4.3 Soft Skills

The resulting ranking of soft skills extracted from the job ads is shown in Figure 4.4. The soft skills that employers emphasize most are communication skills, teamwork skills and analytical skills. This highly matches the results of other research that adopt a similar job ads analysis method but for different engineering positions, such as requirement engineers [14], software engineers [45], civil engineers [16] and biomedical engineers [15]. This is because the soft skills are not subject-specific, and the requirement is similar due to the jobs' engineering nature. On the other hand, the high similarity has proven that the coding sample is sufficient to show the correct result and saturated.

Interestingly, around 33% of the job ads mentioned stakeholder management. By reviewing the positions that entail this particular skill, it was discovered that they are sourced from a diverse range of entities within the energy market value chain, including operators, NSPs, generator owners, consultancies, and Original Equipment Manufacturers (OEMs). In the context of a power system project, these entities are deemed as stakeholders to each other and must collaborate effectively to ensure the successful execution of the project.

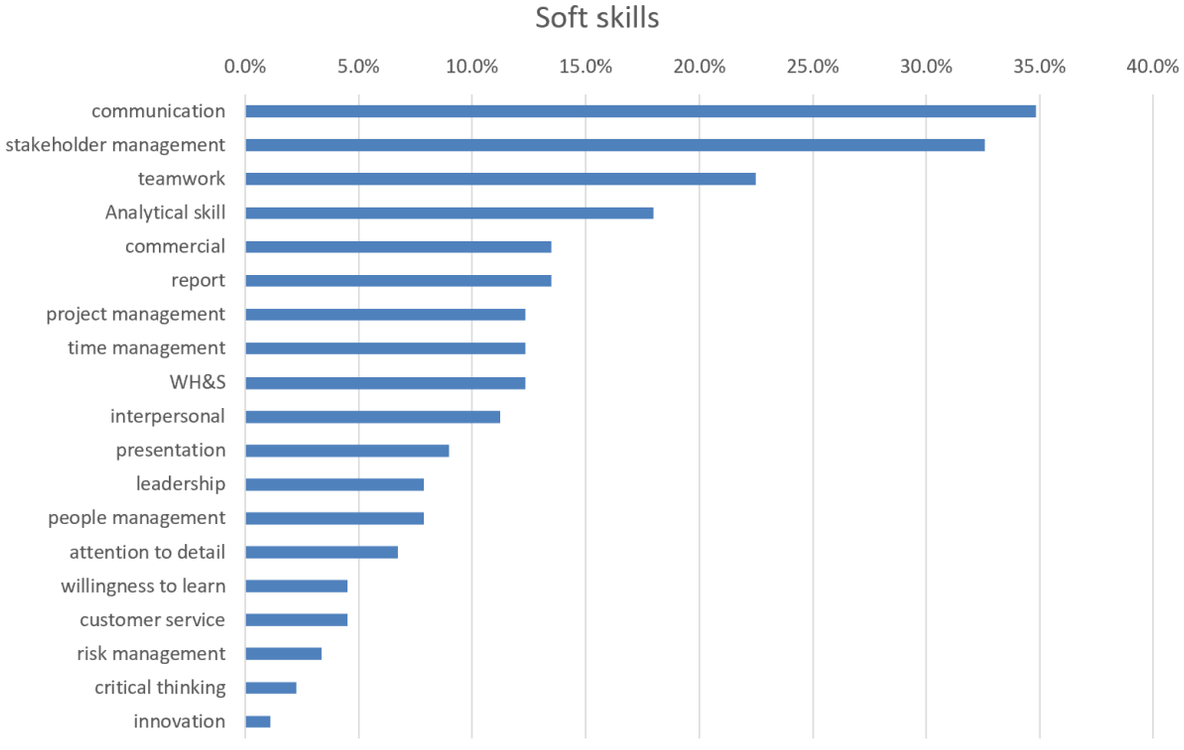

Figure 4.4. Soft skills required for power system engineers.

5 Conclusion and Recommendations

This paper sets in the context of the rapid transition of the electric power system. The study presented in this paper identified that academics lack a systematic way to benchmark the course content against the knowledge and skills required by the present industry. To this end, this paper proposed a structured approach to extract data from job ads to outline the knowledge and skills most demanded by power system engineer employers. A mixed-method approach is applied to investigate the gap between the industry and the university curriculum in a practical manner. As the gap exists not only in the energy sector but in a growing range of other disciplines, the proposed approach can be easily adopted by other disciplines, to facilitate the linkage between the university curriculum and the industry at scale, to underpin the modern engineering practice. The findings of this paper might also benefit the industry. By presenting the knowledge and skills that their graduates potentially lack, employers can develop more effective and targeted training to help their early career professionals master their craft and to help their employees to upskill.

In order to fully utilize the findings of this research, academics and educators can utilize the list of the most valued skills to enhance their curriculum and customize their programs to meet the current needs of the industry. Future work is required to investigate the knowledge and skills taught in the current power engineering curriculum and compare them with industry expectations.

6 Reference

[1] Australian Government Department of Climate Change, Energy, the Environment and Water (16 June 2022). *Australia NDC 2022 Update to UNFCCC*. [Online] Available: https://unfccc.int/sites/default/files/NDC/2022-06/NDC%202022%20Update%20Letter%20to%20UNFCCC.pdf

[2] J. Aubrey. "ROADMAP TO NET-ZERO: AUSTRALIA CAN BE POWERED BY RENEWABLE ENERGY BY 2030." cleanenergycouncil.org.au. https://www.cleanenergycouncil.org.au/news/roadmap-to-net-zero-australia-can-be-powered-by-renewable-energy-by-2030#:~:text=NewsArticle-,Roadmap%20to%20net-zero:%20Australia%20can%20be%20powered,by%20renewable%20energy%20by%202030&text=Ahead%20of%20the%20Federal%20Government's,by%20renewable%20energy%20by%202030 (accessed 26 Oct 2022).

[3] AEMO, "2022 Integrated System Plan for the National Electricity Market," 2022. [Online]. Available: https://aemo.com.au/-/media/files/major-publications/isp/2022/2022-documents/2022-integrated-system-plan-isp.pdf?la=en

[4] C. Council, "Renewable energy jobs: Future growth in Australia," 2016.

[5] C. Briggs, J. Rutovitz, E. Dominish, and K. Nagrath, "Renewable energy jobs in Australia: stage one," ed: Institute for Sustainable Futures, University of Technology Sydney, 2020.

[6] J. Rutovitz *et al.*, "E3 opportunity assessment: developing the future energy workforce: final report 2021," 2021.

[7] H. Chai, J. Ravishankar, S. Krishnan, and M. Priestley, "Work-in-Progress: A Holistic Approach to Bridging the Gap between Power Engineering Education and Electric Power Industry," in *2022 IEEE Global Engineering Education Conference (EDUCON)*, 28-31 March 2022 2022, pp. 2044-2048, doi: 10.1109/EDUCON52537.2022.9766552. [Online]. Available: https://ieeexplore.ieee.org/document/9766552/

[8] D. Peftitsis and A. Mavroudi, "Students Perceptions on Teaching Design of Power Electronics Using Student-Response Systems: Thematic Content Analysis of Interviews," *IEEE Access,* vol. 10, pp. 64059-64071, 2022.

[9] H. Chai, J. Ravishankar, K. Meng, and M. Priestley, "Improved Power Engineering Curriculum: Analysis in a Year 3 Course in Electrical Engineering," presented at the 2021 IEEE Global Engineering Education Conference (EDUCON), 2021.

[10] L. M. Tan and F. Laswad, "Professional skills required of accountants: what do job advertisements tell us?," *Accounting Education,* vol. 27, no. 4, pp. 403-432, 2018.

[11] N. G. Brooks, T. H. Greer, and S. A. Morris, "Information systems security job advertisement analysis: Skills review and implications for information systems curriculum," *Journal of Education for Business,* vol. 93, no. 5, pp. 213-221, 2018.

[12] M. Daneva, C. Wang, and P. Hoener, "What the job market wants from requirements engineers? An empirical analysis of online job ads from the Netherlands," in *2017 ACM/IEEE international symposium on empirical software engineering and measurement (ESEM)*, 2017: IEEE, pp. 448-453.

[13] C. Wang, P. Cui, M. Daneva, and M. Kassab, "Understanding what industry wants from requirements engineers: An exploration of RE jobs in Canada," in *Proceedings of the 12th ACM/IEEE International Symposium on Empirical Software Engineering and Measurement*, 2018, pp. 1-10.

[14] C. Wang, Y. Tang, P. Liang, M. Daneva, and M. van Sinderen, "What industry wants from requirements engineers in China? An exploratory and comparative study on RE job ads," in *Proceedings of the 14th ACM/IEEE International Symposium on Empirical Software Engineering and Measurement (ESEM)*, 2020, pp. 1-11.

[15] A. Ward, B. Baruah, A. Gbadebo, and N. Jackson, "What do job adverts tell Higher Education about the 'shape'of Biomedical Engineering graduates?," in *International Conference on Advancements of Medicine and Health Care through Technology; 12th-15th October 2016, Cluj-Napoca, Romania*, 2017: Springer, pp. 43-48.

[16] I. H. Gerek and I. E. Efeoglu, "What qualifications and skills are important for civil engineers? A job advertisement analysis," in *Proceedings of the MakeLearn and TIIM: oint International Conference*, 2015, pp. 689-695.

[17] M. Meesters, P. Heck, and A. Serebrenik, "What Is an AI Engineer? An Empirical Analysis of Job Ads in The Netherlands," in *International Conference on AI Engineering: Software Engineering for AI*, 2022: IEEE Computer Society.

[18] I. Rahhal, I. Makdoun, G. Mezzour, I. Khaouja, K. Carley, and I. Kassou, "Analyzing cybersecurity job market needs in Morocco by mining job ads," in *2019 IEEE Global Engineering Education Conference (EDUCON)*, 2019: IEEE, pp. 535-543.

[19] I. Makdoun, G. Mezzour, K. M. Carley, and I. Kassou, "Analyzing the needs of the automotive job market in Morocco," in *2018 13th International Conference on Computer Science & Education (ICCSE)*, 2018: IEEE, pp. 1-6.

[20] I. Khaouja, I. Rahhal, M. Elouali, G. Mezzour, I. Kassou, and K. M. Carley, "Analyzing the needs of the offshore sector in Morocco by mining job ads," in *2018 IEEE Global Engineering Education Conference (EDUCON)*, 2018: IEEE, pp. 1380-1388.

[21] S. Meganck, J. Smith, and J. P. D. Guidry, "The skills required for entry-level public relations: An analysis of skills required in 1,000 PR job ads," *Public Relations Review,* vol. 46, no. 5, p. 101973, 2020/12/01/ 2020, doi: https://doi.org/10.1016/j.pubrev.2020.101973.

[22] Y. Choi and E. Rasmussen, "What qualifications and skills are important for digital librarian positions in academic libraries? A job advertisement analysis," *The journal of academic librarianship,* vol. 35, no. 5, pp. 457-467, 2009.

[23] K. Ahsan, M. Ho, and S. Khan, "Recruiting project managers: A comparative analysis of competencies and recruitment signals from job advertisements," *Project Management Journal,* vol. 44, no. 5, pp. 36-54, 2013.

[24] E. Welsh, "Dealing with data: Using NVivo in the qualitative data analysis process," in *Forum qualitative sozialforschung/Forum: qualitative social research*, 2002, vol. 3, no. 2.

[25] M. Annells, "Grounded theory method: Philosophical perspectives, paradigm of inquiry, and postmodernism," *Qualitative health research,* vol. 6, no. 3, pp. 379-393, 1996.

[26] M. O'reilly and N. Parker, "'Unsatisfactory Saturation': a critical exploration of the notion of saturated sample sizes in qualitative research," *Qualitative research,* vol. 13, no. 2, pp. 190-197, 2013.

[27] AEMC, "Generator Registrations and Connections," Australian Energy Market Commission, Online 2020. [Online]. Available: https://www.aemc.gov.au/rule-changes/generator-registrations-and-connections

[28] AEMC, "A new approach to stabilise the grid to better connect and dispatch low-cost, low-carbon energy," Australian Energy Market Commission, Online. [Online]. Available: https://www.aemc.gov.au/news-centre/media-releases/new-approach-stabilise-grid-better-connect-and-dispatch-low-cost-low-carbon-energy

[29] H. Chai, M. Priestley, X. Tang, and J. Ravishankar, "Implementation of Microgrid Virtual Laboratory in a Design Course in Electrical Engineering," presented at the 2020 IEEE International Conference on Teaching, Assessment, and Learning for Engineering (TALE), 2020.

[30] H. Mälkki and J. V. Paatero, "Curriculum planning in energy engineering education," *Journal of Cleaner Production,* vol. 106, pp. 292-299, 2015/11/01/ 2015, doi: https://doi.org/10.1016/j.jclepro.2014.08.109.

[31] Q. Hu, F. Li, and C. f. Chen, "A Smart Home Test Bed for Undergraduate Education to Bridge the Curriculum Gap From Traditional Power Systems to Modernized Smart Grids," *IEEE Transactions on Education,* vol. 58, no. 1, pp. 32-38, 2015, doi: 10.1109/TE.2014.2321529.

[32] "Electric power system." Wikipedia. https://en.wikipedia.org/wiki/Electric_power_system (accessed 3-Jan-2023.

[33] E. B. Makram and A. Girgis, "A new method in teaching power system harmonics in the undergraduate power curriculum," *IEEE transactions on power systems,* vol. 5, no. 4, pp. 1407-1412, 1990.

[34] S. Bahadoorsingh, R. Dyer, and C. Sharma, "Integrating serious games into the engineering curriculum-a game-based learning approach to power systems analysis," *International Journal of Computational Vision and Robotics,* vol. 6, no. 3, pp. 276-289, 2016.

[35] T. C. Kandpal and L. Broman, "Renewable energy education: A global status review," *Renewable and Sustainable Energy Reviews,* vol. 34, pp. 300-324, 2014/06/01/ 2014, doi: https://doi.org/10.1016/j.rser.2014.02.039.

[36] AEMO, "Energy Explained: Big Batteries," 2021. [Online]. Available: https://aemo.com.au/en/learn/energy-explained/energy-101/energy-explained-big-batteries

[37] ARENA, "Battery storage." [Online]. Available: https://arena.gov.au/renewable-energy/battery-storage/

[38] C. E. Council, "Clean Energy Australia Report 2022," Online, 2022. [Online]. Available: https://assets.cleanenergycouncil.org.au/documents/resources/reports/clean-energy-australia/clean-energy-australia-report-2022.pdf

[39] Y. Yang, S. Bremner, C. Menictas, and M. Kay, "Battery energy storage system size determination in renewable energy systems: A review," *Renewable and Sustainable Energy Reviews,* vol. 91, pp. 109-125, 2018.

[40] H. C. Hesse, M. Schimpe, D. Kucevic, and A. Jossen, "Lithium-ion battery storage for the grid—A review of stationary battery storage system design tailored for applications in modern power grids," *Energies,* vol. 10, no. 12, p. 2107, 2017.

[41] AEMO, "Power System Model Guidelines," 2018. [Online]. Available: https://aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/System-Security-Market-Frameworks-Review/2018/Power_Systems_Model_Guidelines_PUBLISHED.pdf

[42] A. M. Mohamad, N. Hashim, N. Hamzah, N. F. N. Ismail, and M. F. A. Latip, "Transient stability analysis on Sarawak's Grid using Power System Simulator for Engineering (PSS/E)," in *2011 IEEE Symposium on Industrial Electronics and Applications*, 25-28 Sept. 2011 2011, pp. 521-526, doi: 10.1109/ISIEA.2011.6108766.

[43] J. Cote and J. Aspnes, "Integrating laboratory and computer exercises into electric power engineering education," in *Technology-Based Re-Engineering Engineering Education Proceedings of Frontiers in Education FIE'96 26th Annual Conference*, 1996, vol. 1: IEEE, pp. 16-19.

[44] F. Chalkiadakis, "Classroom Studies In Power Flow And Transmission Lines By Means Of Pscad/Emtdc," in *2007 Annual Conference & Exposition*, 2007, pp. 12.364. 1-12.364. 9.

[45] G. Matturro, F. Raschetti, and C. Fontán, "A Systematic Mapping Study on Soft Skills in Software Engineering," *J. Univers. Comput. Sci.,* vol. 25, no. 1, pp. 16-41, 2019.