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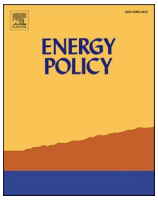
2024

Energy Policy 191 (2024) 114163

Contents lists available at ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol



Challenges in increasing Women's participation in the energy transition in ASEAN and G7 countries: A qualitative approach based on the three tenets of justice

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ARTICLE INFO

Keywords:
Women's participation
Just energy transition
Inclusive energy transition
ASEAN
G7
Tenets of justice

ABSTRACT

Ensuring an inclusive and just transition towards a low-carbon economy has become increasingly important. This paper emphasises the challenges in increasing the extent of women's participation in the energy transition in ASEAN and G7 countries. In this paper, two research questions are addressed: First, what are the challenges and barriers women face in ASEAN and G7 countries in participating in the energy transition? Second, what are the policies that can be implemented in ASEAN and G7 countries to ensure that the energy transition is both just and inclusive? Using VOSviewer, we found a gap in the literature, particularly in terms of women's perspectives in the context of the energy transition in ASEAN and G7 countries. To bridge this gap, we collected data by conducting interviews with women working in the energy sector in ASEAN and G7 countries. Moreover, we employed scientific literature to strengthen the analysis. These data were qualitatively analysed by applying Jenkins' three tenets of justice in the energy transition. The challenges we identified refer to raising awareness, access to opportunities, cultural background, women's psychological beliefs and physical considerations. Our discussion extends to policy implications, including drivers to policy change, enabling policies and the role of the private sector, non-governmental organisations (NGOs), academia and communities in increasing women's participation in the energy transition.

1. Introduction

We live in an era of energy transition, where countries worldwide are making efforts to move away from fossil fuels towards a low-carbon economy. Sovacool et al. (2017) emphasise the importance of social inclusivity in transitioning from fossil fuels to renewable energy sources. An inclusive energy transition entails creating an energy system that is affordable, accessible, secure, dependable and equitable for all (Weijnen et al., 2021). Therefore, achieving an inclusive energy transition should involve all stakeholders, including women, as integral members of society.

The idea of a just transition centres on inclusiveness, ensuring that no one is left behind. However, there remains a notable gap in addressing the impact of energy usage on women in rural areas, particularly those residing in island countries. This is an important issue in the context of sustainable development goals (SDGs) 3, 5 and 7, which encompass health sector, gender equality and clean energy access, respectively, according to the United Nations (UN) (Ali et al., 2021; Chakraborty et al., 2014; Dutta and Banerjee, 2014; Gordon et al., 2014; Perez-Padilla et al., 2010; Viegi et al., 2004). Household air pollution resulting from the use of solid fuels and kerosene leads to 3.2 million premature deaths per year (World Health Organisation [WHO], 2022).

Research demonstrates that involving women in the energy transition process is crucial (Allen et al., 2019; Maji et al., 2021; Standal et al., 2020; Wiese, 2020; Yasmin and Grundmann, 2020). Women actively participate in the energy transition and are affected by the energy transition process. Some studies have focused on the impact of the energy transition on women in terms of access to clean energy and the consequences of environmental damage (Maji et al., 2021; Yasmin and Grundmann, 2020).

Ensuring a just energy transition that leaves no one behind is imperative for every country. Within the evolving conceptual framework of the energy transition, Jenkins et al. (2016) introduce the three tenets of justice: recognition, procedural and distributional justice. This

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https://doi.org/10.1016/j.enpol.2024.114163
Received 22 September 2023; Received in revised form 25 April 2024; Accepted 30 April 2024
Available online 18 May 2024

paper focuses on ASEAN and G7 countries to collect evidence concerning these justice aspects for women in the energy transition workforce and women as energy consumers (specifically, transitioning from dirty to clean cooking practices). In the context of the energy transition, distributional justice refers to justice in terms of the fair distribution of economic benefits and losses, regardless of race, gender or other factors. Procedural justice relates to a fair and transparent policymaking process, ensuring that women have an equal right to participate in decision-making, allowing their voices to be heard. Recognition justice highlights those who are left behind and ignored during the process of energy transition.

This paper aims to understand how ASEAN and G7 countries can develop their policies to address the challenges in the energy transition within the context of women's participation. The objectives of this paper are twofold: first, to critically analyse the challenges of involving women in the energy transition process in both ASEAN and G7 nations using this framework, and second, to provide policy recommendations to governments for achieving a just and inclusive energy transition within their respective countries.

According to the World Bank Database (2020), the majority of ASEAN countries are grouped as lower-income countries. This group includes Indonesia, Cambodia, Lao PDR, Myanmar, the Philippines and Vietnam. The ASEAN Centre for Energy (ACE) (2022) reports that over 43% of the total ASEAN energy demand relies on fossil fuels, with fossil fuels (primarily coal) accounting for more than 60% of the electricity mix. By contrast, G7 members have a proven track record of fostering innovation, developing technologies and successfully commercialising them through supportive policies within stable economies. The leadership of the G7 in decarbonising its energy sector benefits its members by developing new knowledge, technologies and jobs. Energy transition is a global issue where mutual learning will accelerate the transition on a global scale.

Sumarno et al. (2023) address the question of '*the level of women's participation in energy transition in ASEAN and G7 countries*'. They apply strategic basic research, grounded in theoretical exploration to gain new knowledge, yielding results that could provide valuable insights for policymaking (Thomas, 2021). Employing the same dataset and methods, we address the two pivotal questions in this paper. First, what are the challenges that women face in ASEAN and G7 countries when participating in the energy transition? Second, what policies could be implemented in ASEAN and G7 countries to ensure the energy transition is just and inclusive? To date, our research has primarily relied on literature reviews related to women in the energy transition. However, there is very limited literature on women's perspectives in the energy transition in ASEAN and G7 countries. Therefore, to address this literature gap, we collect data directly from women who work and live in these countries. This gap analysis is further detailed in Section 2.

There is a pressing need for more policy actions and research in this area, particularly in ASEAN and G7 countries. Therefore, the contributions of this article are threefold. First, this paper will significantly contribute to the existing literature on women's participation in the energy transition in ASEAN and G7 countries. It examines both those who participate as industry employees and as energy users in these regions. Most of the literature on women's issues in the energy sector relates to energy poverty and access, where women are exposed as energy consumers. Second, limited literature exists on aspects of justice regarding women's participation in the energy transition process. This paper will seek to address this gap. Third, this paper will connect theory to practice by formulating energy transition policies that explicitly centre on women. It bridges justice and inclusivity in the energy transition from women's perspectives, considering both upstream and downstream beneficiaries.

This paper consists of five sections. Section 2 examines the literature gap analysis and the existing literature on women's perspectives in the energy transition. This is to provide an understanding of the current narrative in this field. Section 3 outlines the methods that we selected to analyse and address the issues in this article. Section 4 applies the three tenets of the justice framework to critically analyse the challenges of increasing women's participation in the energy transition in ASEAN and G7 countries, along with the policy implications. Furthermore, this section discusses the results of the collected data, which includes both primary and secondary data. Finally, Section 5 presents our conclusions and policy recommendations related to SDG 5 and SDG 7 to the respective governments.

2. Literature review

2.1. Gender gap and energy transition literature

To confirm the availability of gender content in energy transition-related research, we utilised VOSviewer, a software that generates maps between related content (see Appendix A for VOSviewer processing steps). The maps generated by VOSviewer are shown in Figs. 1–3. The thickness of the lines indicates the degree of correlation between the keywords, with thicker lines signifying stronger correlations. The lines' hue is based on the colour of the keywords (Van Eck and Waltman, 2019). The similarity of the node's colour between the keywords signifies the correlation. High similarity indicates a strong correlation (Van Eck and Waltman, 2019).

The analysis of keywords offers a comprehensive perspective on the prevailing research patterns depicted in scholarly publications. These keywords serve as indicators of the authors' areas of interest and the main themes explored in their work. In this section, we demonstrate the construction of a co-occurrence network using the VOSviewer software. To generate the network/map in this section, we follow the procedures outlined by Van Eck and Waltman (2019). We establish the links of the network based on the strength of associations between terms. The numerical value represents how frequently two analysed terms occur together in papers—the higher the frequency, the stronger the link. The nodes of the network represent terms identified by VOSviewer, considering their appearance in papers with a 12 × threshold. Through clustering, we group the terms (items) into four distinct clusters, with each term exclusively belonging to a single cluster. Based on this procedure, 102 terms are organised into four clusters, resulting in 3087 relationships for further analysis.

The network of keywords extracted from the author and indexed under the themes of 'gender' and 'just energy transition' is shown in Fig. 1. Keywords such as 'women', 'gender' and 'just transition' form a cohesive cluster (indicated by the same colour), implying close relationships and frequent co-occurrence among these keywords. However, notably, the 'gender' and 'women' nodes are smaller than other nodes within the same cluster, suggesting that they are less frequent than other keywords. Interestingly, the 'gender' nodes have a direct link to energy policy, while the nodes associated with the keyword 'women' lack a direct connection to energy policy nodes.

To examine patterns related to the intersection of gender and just energy transition in each country, we conducted further analysis (Fig. 2). The nodes in this figure serve as the country of origin of the authors. The bigger the nodes, the stronger the level of discussion within the country and the more research that is conducted regarding the topic. Collaboration between authors from different countries is represented by the line between the nodes. The density of these lines reflects the level of collaboration between authors from the related countries. For our analysis, we set a threshold of 10, resulting in 25 countries meeting the criteria. Notably, countries sharing the same colour belong to the same cluster. For instance, the United Kingdom, Australia, South Africa and Sweden belong to one cluster. The relationship between countries is also a vital factor that determines the collaboration between authors.

To gain a deeper understanding of gaps in the existing literature, we conducted a network analysis focusing on the co-citation of this topic. Fig. 3 shows a network visualisation map of this co-citation analysis, centred on the topic of 'just transition'. Our unit of analysis is the cited

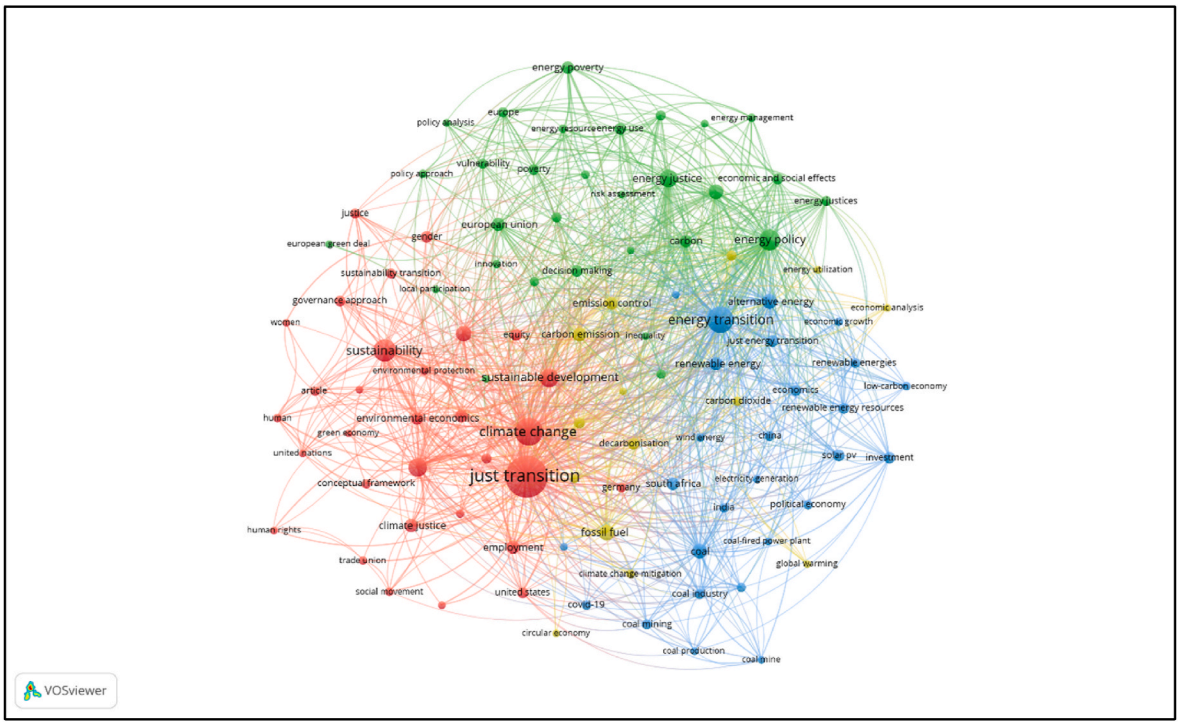

Fig. 1. Existing literature with related content of gender, energy and just energy transition generated from VOSviewer. Notes: A network visualisation map was selected based on author and index keywords. Keywords with minimum occurrences of 12 times were shown on the map.
Source: Developed by Authors (2023).

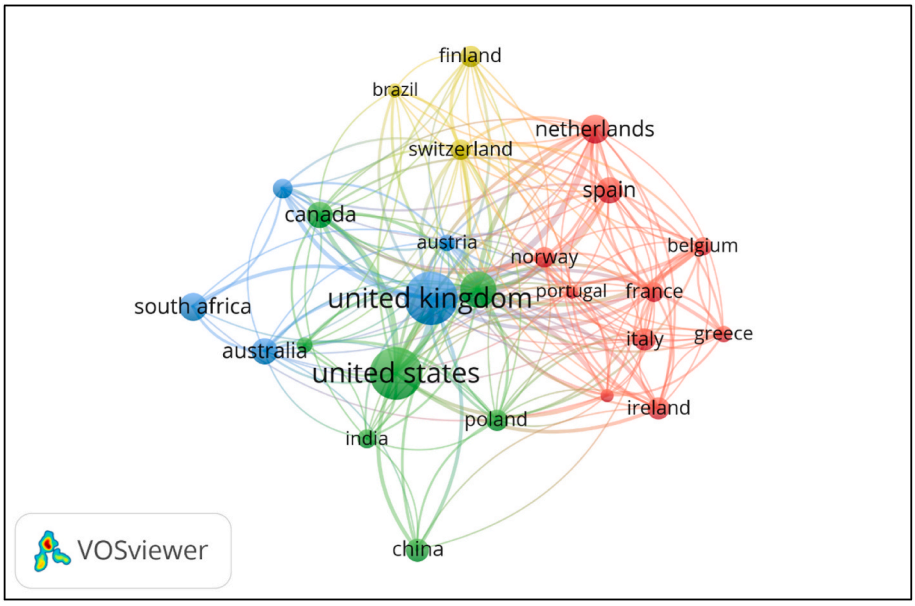

Fig. 2. Country co-authorship network visualisation of gender and just transition topics.
Source: Developed by Authors (2023).

authors. We visualised authors with a minimum of 100 citations. The map included 18 authors who were selected based on the procedure. In this network, each node represents an individual author, while the line indicates that two authors have been cited together in the same document. The node's size reflects the frequency with which an author's work has been cited. The similarity of the authors' study fields can be observed based on the distance between two nodes.

The network analyses show that there has been a limited amount of literature produced concerning gender (women) in energy transition in ASEAN and G7 countries.

2.2. Existing literature on gender and energy transitions

Research indicates that men hold significant roles in the centralised power sector and national energy decision-making processes (Allen et al., 2019; Pearl-Martinez and Stephens, 2016a; Resurrección et al., 2017). Over the past decade, many international organisations have conducted research on women's equality within the energy sector,

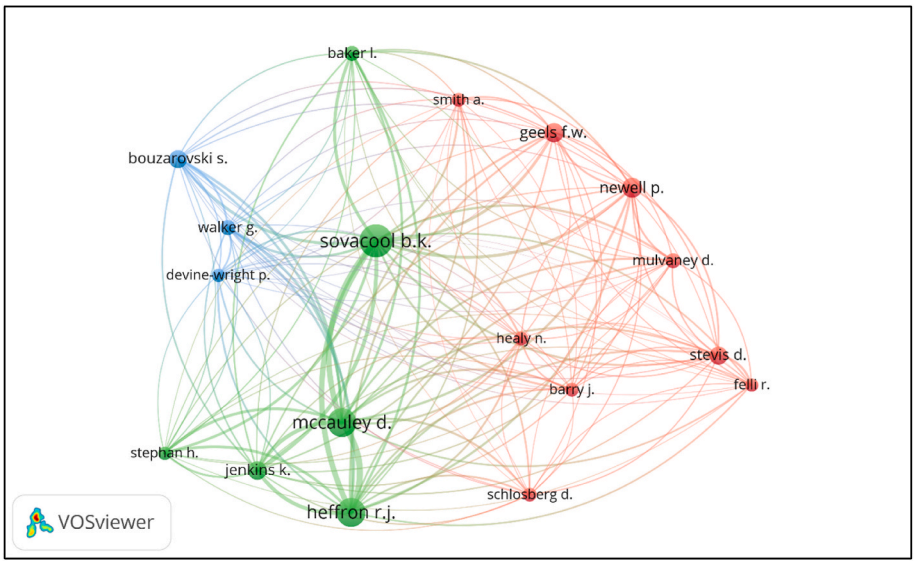

Fig. 3. Network visualisation of co-citation analysis.
Source: Developed by Authors (2023).

particularly since the UN emphasised the importance of SDGs 5 and 7. Their reports state that women in leadership roles help to improve the energy sector in a country. Additionally, women as end users and those residing in rural areas play a significant role in energy transition policy development.

Many experts highlight the energy and climate nexus, particularly given that the energy sector is a major emitter of greenhouse gases, especially from fossil fuels (Alam et al., 2016; Huang et al., 2017; Khondaker et al., 2016; Lamb et al., 2021; Neagu and Teodoru, 2019). Women bear the brunt of the impact of these emissions, which significantly contribute to climate change (Moniruzzaman and Day, 2020; Rao et al., 2019). Therefore, transitioning to cleaner energy can improve women's livelihoods. For example, decarbonising the energy supply can create valuable chances for fostering more socially equitable approaches to living (Ding et al., 2014; Maji et al., 2021; Wilson, 2018). According to Bell et al. (2020), diverse perspectives within the energy sector, including those of women, offer a foundation for deepening our understanding of why we must redouble our efforts to create a sustainable energy culture while leaving unsustainable practices behind. They highlight that women's viewpoints are a crucial aspect of establishing a just energy system. There is a risk of failure within renewable energy projects if there is a lack of women's involvement (Cecelski, 2000). Energy corporations with more gender-diverse employees and a commitment to women's economic empowerment tend to exhibit better financial performance (Johnson et al., 2019; Pearl-Martinez and Stephens, 2016a,b).

According to McKinsey and Company report (2022), women accounted for 39% of global employment in 2020. Moreover, data from the International Renewable Energy Agency (2020) reveals that there were 3.7 million women employed in the renewable energy sector worldwide in 2019, constituting approximately 32% of all jobs created in this field. IRENA also highlights that women in science, technology, engineering and mathematics (STEM) are underrepresented compared to their non-STEM counterparts within the renewable energy sector. Several barriers have been identified by Baruah (2017) and Standal et al. (2020), including challenges related to perceptions of women's roles, cultural and social norms and prevailing hiring practices.

Energy transition hinges on innovation and the active participation of a diverse society (Iwińska and Bukowska, 2022; Konadu et al., 2022; Tesfaye and Wainikka, 2022; Żuk and Żuk, 2022). In the energy transition, inclusivity is not optional—it is essential. For over two decades, the necessity of involving women in the energy sector has been emphasised (Cecelski, 2000). According to Cecelski, listening to women's input and addressing their needs can help renewable energy producers unlock substantial market opportunities. This also applies to energy policymakers, who will be able to harness a potent force for renewable energy development. However, when energy researchers exclude women from their research and analyses, they risk overlooking a significant portion of energy consumption and production. Lastly, donors who fail to support gender-sensitive energy assistance miss their most important target populations.

This paper also highlights the perspectives of women as consumers. In ASEAN countries, where cultural traditions remain strong, understanding women's viewpoints as consumers becomes essential, as they can drive the transition towards renewable energy (Johnson et al., 2019; Pascale et al., 2016; Seah et al., 2021). According to Akash et al. (2018), a country's progress in energy transition is often determined by the significant role played by cultural factors such as literacy, poverty, economic diversity and trust in leadership (both industries and governments). There are various ways of linking energy and women, for example, energy technology development can impact cultures and traditions and vice versa. To achieve this, governments must implement appropriate policies that support technology adoption (Ding et al., 2014).

Efforts aimed at mainstreaming gender perspectives in energy policies, initiatives, programmes and projects are on the rise. Following the worldwide UN campaign for universal access to sustainable energy alongside the post-2015 SDGs agenda, these efforts have brought increased attention to this area (Clancy and Roehr, 2003).

2.3. *Existing gender-responsive energy policy*

Currently, neither ASEAN nor the G7 have established a gender-responsive energy policy. However, both regions have attempted to enforce gender equality across all sectors. The following section will provide more details about the efforts to implement gender-responsive policies within ASEAN and the G7.

2.3.1. *ASEAN gender-mainstreaming policy efforts*

Since the 1980s, ASEAN has actively endorsed women's engagement in politics and economic activities through implementing various initiatives and issuing formal statements such as the 1988 ASEAN Declaration on Women's Advancement. In 2017, ASEAN reaffirmed its commitment to gender equality through the ASEAN Declaration on the

Gender-Responsive Implementation of the ASEAN Community Vision 2025 and Sustainable Development Goals. The organisation has also established the ASEAN Gender-Mainstreaming Strategic Framework 2021–2025 and the ASEAN Comprehensive Recovery Framework. These initiatives aim to promote women's full and equal involvement in policymaking and create integrated policy frameworks that are 'pro-poor, inclusive, gender- and climate-responsive'.

While there is no national or regional gender-responsive energy policy and regulations within ASEAN, several laws and regulations at the national level in Indonesia, the Philippines, Thailand and Vietnam are not gender-blind, continuing efforts towards mainstreaming (ASEAN Centre for Energy [ACE], 2022a,b). Additionally, some ASEAN countries have adopted the convention on the elimination of all forms of discrimination against women (CEDAW). However, despite regional declarations and frameworks emphasising gender responsiveness, the participation of women in renewable energy policy remains absent (ACE, 2022a,b) (see Table 1).

Recently, ACE developed a roadmap for the ASEAN Member States to formulate a gender-responsive renewable energy policy and accelerate renewable energy deployment in the region. This roadmap ensures a just and inclusive energy transition.

2.3.2. G7 gender-mainstreaming policy efforts

Gender equality has formed a core agenda of the G7 for some time and has been included as a key goal in the leaders' declaration since 2012. In 2016, the G7 explicitly stated that mainstreaming gender equality is one of its objectives (Berger et al., 2020).

Within the G7, a coalition of civil society organisations formed the Women 7 (W7) to advocate for gender equality and women's rights to government bodies. In 2017, the G7 established the G7 Roadmap for a Gender-Responsive Economic Environment, which comprehensively addresses all aspects of women's inclusion in the economy, such as women's income, pensions and retirement savings (Berger et al., 2020; Group of 7 [G7], 2018). This roadmap also promotes awareness of STEM education opportunities for women and provides insights into the challenges of balancing work and family life (G7, 2017).

Under the Canadian Presidency in 2018, the Gender Equality Advisory Council (GEAC) was established to collaborate closely with the W7. Their goal was to develop recommendations on how the G7 could ensure that women are at the heart of its policymaking (G7, 2017). In 2021, the GEAC recommended promoting more opportunities for women in the modern economy; adopting a gender-responsive approach to climate financing, investments and policies; and ensuring that women can benefit from the 'green revolution'. They also recommend achieving gender parity in STEM education and careers (UNWomen, 2021). Following the UK Presidency's recommendations on gender equality in all areas, the United Kingdom established a set of recommendations for governments and companies to ensure that gender considerations form part of the just energy transition to net zero. For energy companies, this meant providing training that supports both men and women in transitioning from 'traditional energy' jobs to cleaner energy jobs. Gender-sensitive working practices and social norms within work environments were also highlighted, along with the need to set quotas or targets for women's representation in these companies (UKaid and Work and Opportunities for Women, 2021).

Table 1
List of gender policies and regulations in ASEAN.

ASEAN Member States	National Gender Policy and Regulations
Brunei Darussalam	N/A
Cambodia	N/A
Indonesia	• The National Gender-Mainstreaming Policy: Presidential Instruction No. 9/2000 •Gender Analysis Pathway 1998 •The Gender Equity & Equality Index and Gender-Mainstreaming Institutionalisation Indicators to measure the progress of Gender Equality in Development •National Strategy to Accelerate Gender Mainstreaming through Gender-Responsive Planning and Budgeting (2009) •National Action Plan for the Elimination of Violence Against Women •Inclusion of gender-mainstreaming policy in 38 programmes of the National Development Programme (2000–2004) •Law No. 12 of 2003 on General Election
Lao PDR	•Law on Women's Development and Protection •10-year Women's Development Strategy (2016–2025)
Malaysia	•Laws and Policy on Gender Equality •5 Year Malaysia Plan (2011–2015)/(2016–2020)/(2021–2025) •Laws and Policy on Gender Equality
Myanmar	N/A
The Philippines	•Gender Equality and Women's Empowerment Plan •Republic Act No. 9710 an Act Providing for the Magna Carta of Women
Singapore	N/A
Thailand	Gender Equality Act (2015)
Vietnam	•Gender Equality Law (2006) •The National Strategy on Gender Equality 2011–2020

Source: Modified from ASEAN Centre for Energy (2022).

2.4. Three tenets of justice: Women's participation in the energy transition in ASEAN and G7

The field of energy transition encompasses various research areas, including the application of the concept of energy justice (McCauley et al., 2019; Moniruzzaman and Day, 2020; Mundaca et al., 2018). This concept sheds light on the social impacts of energy policies. According to Jenkins et al. (2016), justice can be categorised into three tenets: distributional justice, recognition and procedural justice (see Table 2).

Fig. 4 shows the challenges of increasing women's participation in energy transition in ASEAN and G7 countries based on the tenet of justice perspectives, developed by Sumarno et al. (2023).

The explanation of the figure is detailed in the following sections.

2.4.1. Recognition justice

The principle of recognition justice involves acknowledging and respecting all individuals who are part of a project and other stakeholders who are affected by any project's activities and/or decisions. Recognition justice should also consider the diverse cultures, values and situations of those affected (Whyte, 2011). This concept applies to both public (society/community) and private (companies) settings. It is important to respect, appreciate and recognise people for who they are. Recognition, or its absence, plays a fundamental role in distributive

Table 2
Three tenets of justice in the context of Women's participation in the energy transition in ASEAN and G7 countries.

Tenets	Evaluative	Normative	Context
Distributional	Where is the injustice?	How should we solve them?	This emphasises principles designed to address the distribution of economic benefits and burdens among individuals in society.
Recognition	Who is ignored?	How should we recognise them?	The fundamental concept of recognition is that an individual or a group should be acknowledged in an appropriate manner.
Procedural	Is there a fair process?	Which new processes?	The fairness of the decision-making process, or in other words, procedural justice, focuses on the quality of the process of making a fair distributive decision.

Source: Sumarno et al. (2023).

Fig. 4. Tenet of justice analysis.
Source: Modified and adapted from Sumarno et al. (2023).

justice and is a critical component in and of itself (Schlosberg, 2007).

In the context of energy justice, recognition justice focuses on acknowledging those affected by energy developments and activities, including indigenous communities. However, this paper specifically focuses on women's recognition in the energy transition process within ASEAN and G7 countries, exploring how women are recognised and valued for their ideas and views on energy development within the industry and research communities.

There has been significant research focusing on women's recognition within the energy transition. Feenstra (2002) underlined the importance of recognising women's contributions in the energy sector, especially during the transition from fossil fuels to a low-carbon economy. In her recent publication, she emphasised that women should actively participate in formulating energy policies, as women are both energy consumers and integral participants in the energy supply chain. A study by Rojas and Prebble (2020) revealed that 38 out of 192 energy frameworks identify women as key stakeholders in energy sector governance and decision-making at both local and national levels. They play diverse roles in designing, adapting and using new energy technologies (Feenstra, 2020).

Regarding women's participation, Sumarno et al. (2023) found that the energy transition progression in ASEAN countries is influenced by several factors: the level of public awareness of energy transition, opportunities for women to participate in the energy transition and women's psychological beliefs (which in this context is women's perception of inferiority). Additionally, they found that ASEAN and G7

countries still face common challenges, including a lack of visibility for women in the renewable energy sector. Increasing awareness of women's contributions in this field is crucial to dispel the false belief that women should be confined to desk roles while men excel at technical work (engineering, field development, etc.).

Ensuring that women are recognised and actively involved in developing renewable energy in G7 and ASEAN countries should be a top priority for both governments and industries (USAID and Resource to Advance Leds Implementation (RALI), 2019). The absence of women in leadership or influential positions within renewable energy projects can potentially lead to project failures. For instance, the Indonesian geothermal energy project in the province of East Nusa Tenggara, Wae Sano, has caused social issues due to the exclusion of indigenous communities, including women representatives, from the project design.

2.4.2. Distributional justice

Distributional justice within the energy sector scrutinises the significant impacts of energy projects. According to Lamont and Favor (2017), distributive justice encompasses various dimensions, including factors like income, wealth, opportunities, jobs, welfare and utility. It also considers the nature of the recipients of distribution (whether individuals or groups) and the basis upon which the distribution should be made (such as equality, maximisation, according to individual characteristics or according to free transactions). This concept emphasises the principles that are designed to address the distribution of economic benefits and burdens among individuals throughout society (Lamont and Favor, 2017).

Discussion surrounding the just energy transition invariably raises questions of distributional justice, specifically how the benefits of renewable energy development are shared among stakeholders and whether anyone is negatively affected during the transition. Sumarno et al. (2023) explore the distribution of benefits and the impact of transitioning from fossil fuels to clean energy on women.

Research by Atakhanova and Howie (2022) found that despite the increasing participation rates of women involved in the energy transition in Kazakhstan, it is still dominated by men. Women comprise only a small and diminishing percentage of the workforce and are often confined to low-paying occupations. It remains questionable whether energy transition brings equal benefits to women and addresses their priorities (Özerol and Harris, 2020).

From an industrial perspective, women's income in the energy sector lags behind that of men (IEA, 2022a). According to Sumarno et al. (2023), this is due to women tending to undervalue their skills and expertise in the energy sector, regardless of whether they have the same level of expertise as men. They found that women in ASEAN and G7 countries have limited access to opportunities for employment in the energy sector. The source of energy consumed impacts women as users significantly, affecting their health and productivity. Women in ASEAN countries residing in rural areas often still rely on biomass (wood) or charcoal for cooking. These types of cooking fuel affect their health as they emit CO_2. Moreover, collecting wood for fuel is time-consuming and labour-intensive for women (Sumarno et al., 2023).

The development of renewable energy has become increasingly significant for women's and society's well-being. Consider the off-grid renewable energy deployment in East Lombok, Indonesia, which has helped rural women in their home-industry businesses, leading to improved welfare (Asian Development Bank, 2021). With the deployment of off-grid renewable energy, women are no longer burdened by spending their time collecting wood for cooking. Instead, they can focus on more productive endeavours, such as helping their children at school or becoming entrepreneurs. Overall, renewable energy deployment can have positive effects on women's livelihoods and contribute to a stronger economy.

2.4.3. Procedural justice

In a broader context, research by Britton and Williams (2000) underscores the systematic challenges faced by women in securing promotions to managerial positions. This remains true in the current context. Procedural justice is an important aspect of a just energy transition, ensuring equitable decision-making processes and inclusivity. In the energy sector, procedural justice also pertains to access to information about energy issues, meaningful participation in energy-related decision-making and access to legal mechanisms for seeking redress or contesting decision-making processes (Gillard et al., 2017). Energy researchers and policymakers must prioritise gender and identity considerations, recognising their impact on access to resources, exposure to pollutants and opportunities for participation in energy resource management, policy formation and scientific work (Ryan, 2014).

While distributional justice primarily concerns outcomes and decisions related to cost and benefits distributions, procedural justice focuses on the quality of making fair distributive decisions within the energy sector (Abdelzadeh et al., 2015; Grimes, n.d.).

Despite increasing awareness of the importance of women in combating climate change and accelerating the energy transition, their participation and involvement as decision-makers in this field remain limited (Feenstra, 2020). Extensive research has examined the role of women's leadership in the context of the energy transition (Allen et al., 2019; Weijnen et al., 2021; Winther et al., 2018). As early as 2000, women constituted the minority at the decision-making level within the energy sector, with minimal involvement in energy projects (Feenstra, 2002). As the energy transition agenda continues to evolve, governments should initiate discussions with women and invite them to participate in formulating energy transition policies. From an instrumentalist perspective, women are seen as key stakeholders who should be involved at all levels of the decision-making process, leveraging their knowledge and experience as energy users to foster a more open and accountable process (Rojas and Prebble, 2020).

Sumarno et al. (2023) found that both ASEAN and the G7 consider the decisions made by renewable energy employers to be influenced by regional cultures and beliefs. While there are an appropriate number of women experts in the renewable sector within some ASEAN countries, they rarely occupy leadership or senior management positions. The International Energy Agency (2022b) has documented the share of women in leadership and management roles across renewable energy sectors globally (Fig. 5). Surprisingly, despite a higher proportion of women in senior leadership in the renewable energy sector, the actual number of women in this sector within ASEAN remains significantly lower than in G7 countries.

Greater gender diversity in corporate leadership positions allows companies to benefit from diverse perspectives and innovative decision-making, ultimately improving overall performance (Belghiti-Mahut et al., 2016). To accelerate the transformation within the energy system and enhance the implementation of energy justice principles, women must be included in leadership roles within the sector (Allen et al., 2019). Women, in general, serve as energy managers within households and are therefore disproportionately affected by indoor air pollution resulting from cooking and other household activities (Sovacool, 2012). Innovation in energy technology plays a pivotal role in tackling climate change and accelerating the energy transition. The involvement of energy users can drive technology development in this sector (Gamser, 1988). Research by Bell et al. (2005), Bosley and Bosley (1988), Ek (2005), Gross (2007) and Wolsink (2012) has studied social acceptance of renewable energy development and innovation. Hence, women in senior leadership positions can drive innovation by influencing communities to embrace any renewable energy developments in their areas.

3. Methods

This paper represents a semi-empirical study, emphasising evidence that is derived from experiences. It also applies strategic basic research by exploring the existing literature on the subject (Thomas, 2021). This

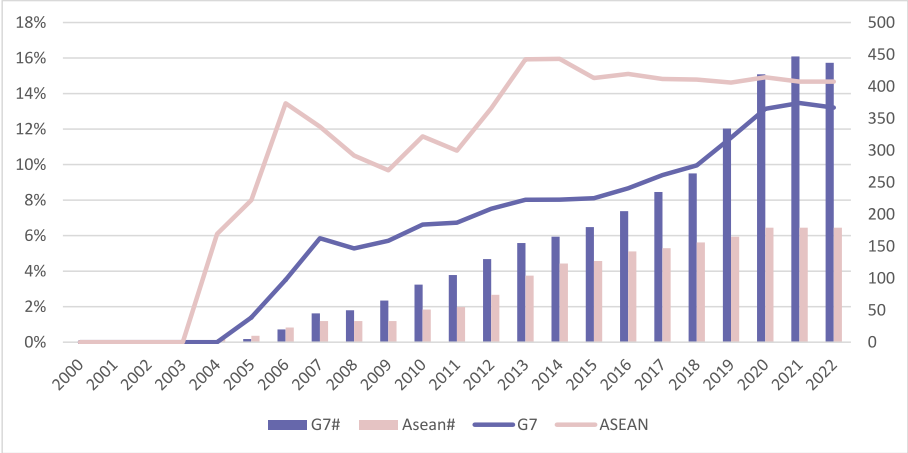

Fig. 5. Share of women at senior managerial levels in the renewable energy sector in G7 and ASEAN countries (2000–2022).
Source: Developed by Authors based on the International Energy Agency (2022b) database.

study investigates the existing studies within the G7 and ASEAN countries through exploratory intensive literature reviews, encompassing both academic research studies and international reports. The literature review was conducted via Scopus, using the keywords: TITLE-ABS-KEY 'gender AND energy' OR 'just energy transition' OR 'just transition'. We sorted the literature manually by excluding journals unrelated to the topic of gender and energy. Based on this procedure, 778 articles were collected. We saved this literature database in the form of RIS-type files. Bibliometric analysis was subsequently performed using VOSviewer 1.6.18 for Windows software.

Furthermore, this paper applies the three tenets of justice proposed by Jenkins et al. (2016) to identify and analyse the challenges associated with women's participation in the energy sector.

3.1. Data collection

This research paper employs exploratory and intensive literature reviews. To collect data, we conducted semi-structured interviews with identified stakeholders, who were carefully selected to be representative of this research and to strengthen our analysis. We believe that they can provide a deeper understanding of the social phenomenon surrounding women's participation in the energy transition and the impact of this transition on women. Our investigation is contextualised within ASEAN and G7 countries. In obtaining their perspectives on women's participation in the energy transition, we focus on the following aspects: (1) the role of women in the energy transition, (2) the gender gap and gender gap mitigation policies in place within organisations, (3) national gender equality policies and (4) women as consumers and leaders within the energy sector.

Our sample consists of a purposive non-probability sample. Following the sampling process outlined by Davies and Hughes (2014), we identified prospective interviewees at the outset and initiated the selection process from this list. The selection includes representatives from various sectors, including intergovernmental institutions, consultancy, academics and industry. This diverse group ensures a holistic perspective on the gender equality dimension within energy transitions.

The purpose of our research interviews is to explore awareness, views, experiences and beliefs related to this area. For instance, we inquire about their observations and experiences in their workplaces as female employees. Our interviews are guided by a set of questions (see Table 3). The flexibility of this approach, especially in comparison to structured interviews, also enables the discovery or elaboration of information that is critical to participants but may have previously been overlooked by the research team (Gill et al., 2008). Some questions regarding women's inclusion in the energy transition are addressed, utilising the three elements of just metrics discussed in the previous section (see Appendix B for the list of interviewees and Appendix C for the thematic analysis of the interview transcripts).

3.2. Key informant interviews

To strengthen our analysis, interviews were conducted with key informants, who hold mid-to senior-level positions in the energy sector. To select the interview sample, we applied purposive sampling of women in the energy sector across the ASEAN and G7 countries. We have seven key informants (n = 7), all women, and we focused on their personal experiences. Our research participants included academics (n = 2), C-level executives in start-up companies (n = 1), senior positions in industry (n = 1), applied researchers (n = 2) and researchers at NGOs (n = 1). Based on our data set, the data saturation occurred within the first six participants.

The interviewees currently work in the energy sector in Norway, the United Kingdom, Germany, the Netherlands, Malaysia and Indonesia and have an average of 10 years of experience in leadership and research. Interviews were conducted online via teleconference software (n = 7) between October 2021 and January 2022. Two interviewers were present for more than half of the interviews to minimise biased interpretation, address differences and validate replies. The main author completed the analysis. The interviews encompassed both open- and closed-ended questions to obtain descriptive and qualitative data. Key informants had to consider the objective and their workplace values when answering all questions. Our research questions determined the form of the interview.

4. Results and discussion

To drive innovative and inclusive solutions for global energy transitions, the energy sector must prioritise gender diversity. Currently, the energy sector ranks among the least gender-diverse sectors of the economy. This sector must shift towards greater gender diversity by enlisting the talents of all individuals to provide a secure, affordable and sustainable energy future for all.

This paper identifies the key challenges faced by women regarding participation in the energy transition as a starting point for the development of a strategic gender policy framework.

This section discusses the barriers and challenges encountered when involving women in the energy transition process across both regions and analyses them using the three tenets of justice.

Table 3
Interview questions mapping onto Three Tenets of Justice.

Three Tenets of Justice	Questions	Purpose of Questions
Recognition Justice	Current role in the company – are you working in the field? Could you tell us a little bit more about your experience in your company or organisation? Is it male-dominated? Do male colleagues listen to you or other female colleagues when opinions or thoughts are shared? Have you had any experiences that you consider inappropriate during meetings or in any assignments—for example, where female perspectives were ignored?	To understand the role of participants and to gauge their familiarity with the context of the company/ organisation values; to understand the gender balance within the company; and finally, to gather evidence based on their experiences, if any.
Distributional Justice	From your observations of the energy transition in your country, do you think both female and male engineers/ geologists receive the same benefits? This could include aspects like annual leave, opportunities to take part in important events and salary.	To understand the distribution of the benefits between women and men within the company and the challenges/barriers that hinder equal benefits for women and men.
Procedural Justice	Does your organisation/ company have any policies that support gender equality? Could you please share your thoughts on this matter? (For example, human resource policies on gender, targets for the proportion of women at different levels, policies against gender discrimination, handbooks and training modules)	To understand whether the company/organisation acknowledges the importance of having a gender equality policy in place and the challenges/ barriers in formulating and implementing this policy.
Recognition Justice	How important do you consider women's involvement in the energy transition overall?	To obtain perspectives from the participants on the importance of women's participation in the energy transition and the aspects that affect women's involvement in it.
Procedural Justice	Could you elaborate on women's role in the energy transition in your region? Can you expand further on how your country supports females in the energy sector and includes women in formulating policy around energy transition?	To gain insights from both regions on women's role in energy transition and the challenges/barriers being faced by women in these regions.
Recognition Justice	Have you experienced having to cook with a fossil fuel stove (gas stove, kerosene, biomass etc.)? How important is clean cooking for you? If you have experienced both, can you elaborate on the differences?	To obtain participants' perspectives on clean cooking and how it differs from fossil fuel stoves and to understand the aspects that deter women from transitioning from fossil fuel cooking stoves to clean cooking stoves.
Recognition Justice	As someone living in a developed economy, how do you perceive the chances of emerging economies like Thailand, Indonesia, Vietnam and Malaysia involving women in policymaking processes or technology development within the energy sector?	To obtain participants' perspectives on how emerging economies could involve more women in the energy transition.
n/a	Do you have any other thoughts that you want to share related to the role of gender in the energy transition in general?	To capture any other information that is not covered in other questions.

Source: Developed by Authors (2023).

4.1. Gender barriers/challenges in the energy transition in ASEAN and G7

The following findings stem from the results obtained during our interviews (see Fig. 6).

4.1.1. Lack of gender awareness

This paper reveals that in G7 countries, there are currently no significant efforts within the renewable energy industry in terms of promoting the role of women in the energy transition. While some renewable energy companies have attempted to hire more women than men, their intentions with regard to promoting women's role in the energy transition remain unclear. International organisations and NGOs are understood to play a role in raising awareness, but their impact is not felt significantly within the industrial sector. Many people are unaware that the energy transition extends beyond climate change and the environmental sector, also encompassing other critical sectors, including the mining sector. Unfortunately, both men and women face challenges in this aspect. Not only do fewer people choose this path but also fewer women actively participate. Botha (2016) found that there are still challenges faced by women in mining, and many still face sexual harassment during fieldwork. Likewise, in the ASEAN region, there remains a lack of gender awareness within the energy sector, particularly concerning accelerating energy transition in the region.

Gender awareness in G7 and ASEAN countries around energy transition, and what it entails, must be given serious attention. According to Pearl-Martinez and Stephens (2016b), increasing the number of women in the energy sector will broaden social awareness of their inclusion in energy transition efforts. Hence, raising awareness about the significance of women's participation in the energy transition and deliberately and intentionally including women across all energy sectors must be undertaken simultaneously.

Currently, ASEAN lacks a gender-responsive renewable energy policy, presenting an opportunity to develop such a policy by studying existing gender-responsive energy policies from different countries. By contrast, the United Kingdom already has a gender-responsive energy policy in place, making amendments to the current policy more complicated. ASEAN should leverage this opportunity to learn from the G7 economies, understand how they have implemented their policies successfully and identify what could be adapted within the ASEAN context.

4.1.2. Access to opportunities for women in renewable energy sector

The availability of STEM and renewable energy courses offered in universities worldwide has broadened. This should potentially open up more opportunities for women to get involved in the renewable energy sector. However, despite this progress, there remain limited opportunities for the direct involvement of women in the sector. Oftentimes, their roles in this sector are limited to supporting functions, such as general and administrative work, rather than the core activities of the industry. It is argued that off-grid renewable energy creates more opportunities for women to get involved given that it tends to have a strong social focus (e.g. through improving quality of life).

This research finds that higher education institutions and renewable energy companies encourage women to apply for some advertised posts. However, among professionals and college students, job advertisements for male-dominated occupations with strong masculine language (words associated with male stereotypes) are still given more exposure than those for female-dominated occupations. The use of gendered language within job advertisements is seen as a subtle mechanism of preventing women from applying for male-dominated jobs, hence promoting gender inequality (Gaucher et al., 2011).

Our research also reveals that job advertisements that specifically

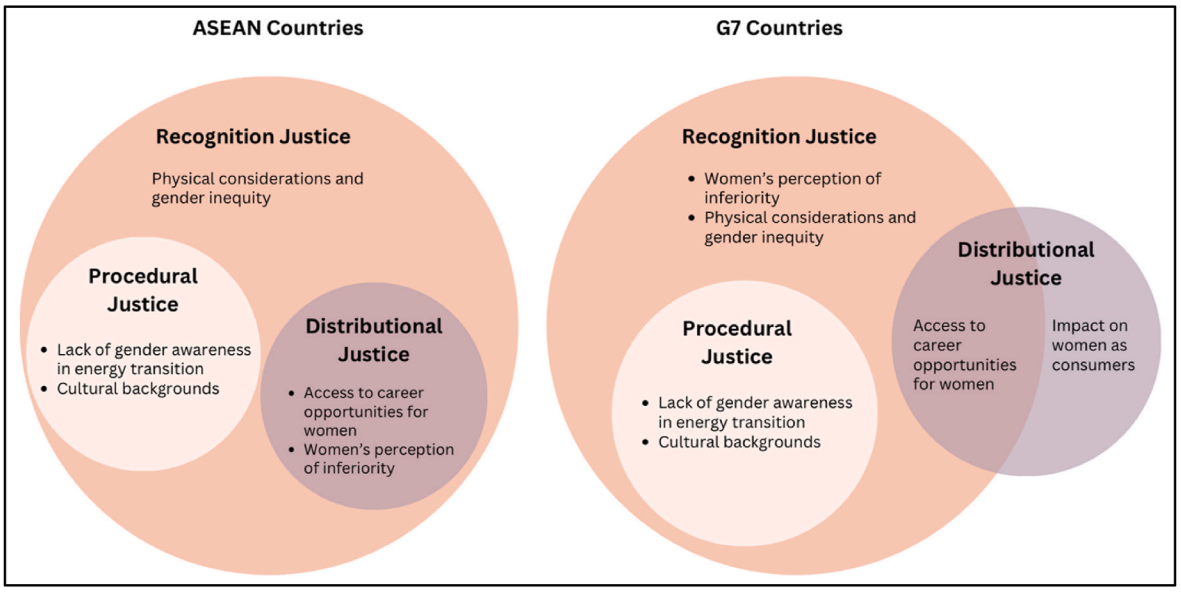

Fig. 6. Challenges in ASEAN and G7 countries.
Source: Developed by Authors (2023).

target and encourage women to apply tend to affect women's psychology regarding job opportunities. They may question whether they are being employed based on their qualifications or simply because they are women. While job advertisements can help raise awareness of women's role in the renewable energy sector, they can also create bias in certain specific roles.

Access to opportunities for women in the renewable energy sector is closely tied to raising gender awareness within the sector. By increasing the awareness of women's role in the energy transition, we can unlock more opportunities for women in the renewable energy sector.

4.1.3. Women's psychological belief—the perception of inferiority

Our findings show that women's perception of inferiority often significantly influences job application decisions in the renewable energy sector. According to Rhoton (2011), women often feel that they have to distance themselves from other women who do not pursue degrees or careers in STEM subjects. Despite industry efforts to increase the number of women employees by encouraging women to respond to job advertisements, only 10% of applicants are women. The number of women applying for jobs in this sector falls below expectations. Women have more distinct mind-sets and psychological backgrounds when compared to men when applying for STEM jobs in the energy sector. Consequently, women may lack the same negotiation skills as men, leading to them receiving fewer benefits (e.g. salary). Additionally, women in leadership roles may occasionally experience emotional challenges when interacting with their team members. This is a common challenge within ASEAN and G7 countries as they strive to increase women's participation in the energy transition process.

4.1.4. Cultural background and Country's economy

Wong (2017) contends that women who pursue careers must also navigate the challenge of achieving a balance of work and family life. However, we have found that cultural backgrounds and a country's economy significantly influence gender roles in almost every aspect. Within ASEAN countries, strong cultural beliefs persist throughout society. A common assumption is that women should stay at home and manage family affairs while men are expected to work and earn money to support the family. This belief permeates other facets of life, including education, which serves as the foundation of an individual's career. Notably, this cultural norm is rooted strongly in countries like Indonesia, the largest country in ASEAN. Despite having a similar culture, women in Brunei Darussalam and Malaysia enjoy better access to education compared to their counterparts in other ASEAN member countries. This difference is attributed to both countries' economies being more developed, resulting in a shift in belief whereby women pursuing higher education are now perceived as normal. In G7 countries, cultural background does not appear to be a significant barrier to enhancing women's role in the energy transition. This is a major difference in terms of how a country perceives women in work and their activities in daily life.

Access to education remains critical for women's participation across various sectors, especially in STEM-based industries such as the energy sector. Governments must improve education access to allow more women to participate in the process of energy transition in their countries, implementing policies that support women in education. This is particularly important in more patriarchal countries such as Indonesia.

4.1.5. Physical considerations and gender inequity

In most cases, fieldwork tends to involve more men than women. Even when women and men possess equivalent expertise for the task, men are usually chosen due to their perceived physical adaptability to the outdoor environment and the specific type of activities being undertaken. Working in the energy sector, particularly in construction, reflects an industry with a very masculine culture and a historical bias against women (Bagilhole et al., 2000). Dainty et al. (2004) describe how difficult the construction environment is for women to work in, along with the potential conflicts and crises resulting from physical differences. This could also be associated with facilities in the field, such as changing rooms and toilets that fail to adequately accommodate women. Consequently, women often tend to choose to work in safer environments. Women who are interested in working in male-dominated environments may find themselves navigating a difficult balance. To be successful, they may need to assimilate into the existing culture, having to act like men. Alternatively, they may have to leave the industry if they cannot adapt to the existing culture (Davidson, 1996).

4.2. Three tenets of justice framework to improve Women's participation in energy transitions

Government policies about the energy sector must comprehensively address these challenges to accelerate the energy transition within

countries. The following section will further discuss the policy implications while addressing these challenges through the lens of the three tenets of justice.

4.2.1. Recognition justice

The following figure shows the interconnectedness of the barriers identified under the recognition justice principle where each barrier affects the other barriers in certain ways (see Fig. 7).

Primarily, cultural background plays a significant role in shaping society's beliefs and views on different responsibilities held by women and men (El-Hout et al., 2021; Noy and O'Brien, 2019). Raising awareness of gender equality in terms of career and education opportunities is important in countries with strong cultural backgrounds, given that in such countries, men have more access to STEM careers than women. According to Davila Dos Santos et al. (2022), cultural background has a significant influence on all individuals from early childhood. This affects how communities perceive career opportunities and other decisions related to STEM education. Improving the recognition of women in any region faces similar challenges. Campaigns to raise awareness can be initiated in schools, in which STEM teachers can promote these areas of study to female students. According to Raabe et al. (2019), female students' attitudes towards STEM education are significantly influenced by their environments (such as parents and friends) and their social context. STEM career information should be introduced in communities and schools throughout all levels, from introductory-level science onwards (Cohen et al., 2013). According to one of the interview participants, providing career opportunities in the energy sector (in the context of energy transition) and raising awareness of the importance of women's participation should be performed concurrently. These efforts are expected to affect women's psychological beliefs, shifting from believing that STEM careers are exclusively for men to recognising that they are accessible to everyone, regardless of gender (Noy and O'Brien, 2019). Another barrier that has been identified pertains to the physical considerations between men and women. Johnson et al. (2020) and Alda-Vidal et al. (2023) conducted research on the impact of energy transitions on gender equity. Their research highlights that energy transition projects alone cannot achieve gender equity. Gender equity is equally important in the energy transition process. While both men and women have equal career opportunities in STEM, the government must ensure fairness in these opportunities. The physical differences between women and men should never be regarded as hindrances to women pursuing STEM careers in the energy sector. Leach et al. (2016) assert that one of the central requirements for an ethical world order is developing equitable policies that support the dignity and capabilities of women. Therefore, increasing women's recognition and dignity plays a significant role in achieving sustainable development goals, particularly within the energy sector. This recognition involves challenging the 'stereotypes around masculinity and femininity, assuring freedom from violence and violations of dignity and security; assurance of bodily integrity and sexual and reproductive health and rights; and recognition and respect for diverse forms of knowledge production and application' (Leach et al., 2016).

4.2.2. Distributional justice

Within the framework of distributional justice, this research identifies challenges from two perspectives: women as key players in energy production and those as key players in energy consumption (Fig. 8).

The findings emphasise that a just energy transition cannot be achieved by addressing only one side because both aspects affect each other. To ensure that the energy transition is just and fair, both the benefits and the risks or negative impacts of the energy transition process on women must be evaluated. Women typically serve as energy managers within households and use energy more than men for their day-to-day activities (Sovacool, 2012). Therefore, they are directly impacted when energy sources change from one source to another. For example, when coal, wood or fossil fuels are used for daily tasks that require them to be burned, they create toxic fumes. Although they may not be aware of the health impact of using these sources of energy, they benefit from being able to utilise an affordable energy source. According to Wüstenhagen et al. (2007), replacing these types of energy sources with cleaner energy sources may require further efforts from the government or NGOs to enhance social acceptance of these new sources. Recognising that renewable energy development can be decentralised in various regions can provide more benefits and opportunities for women to both use and,

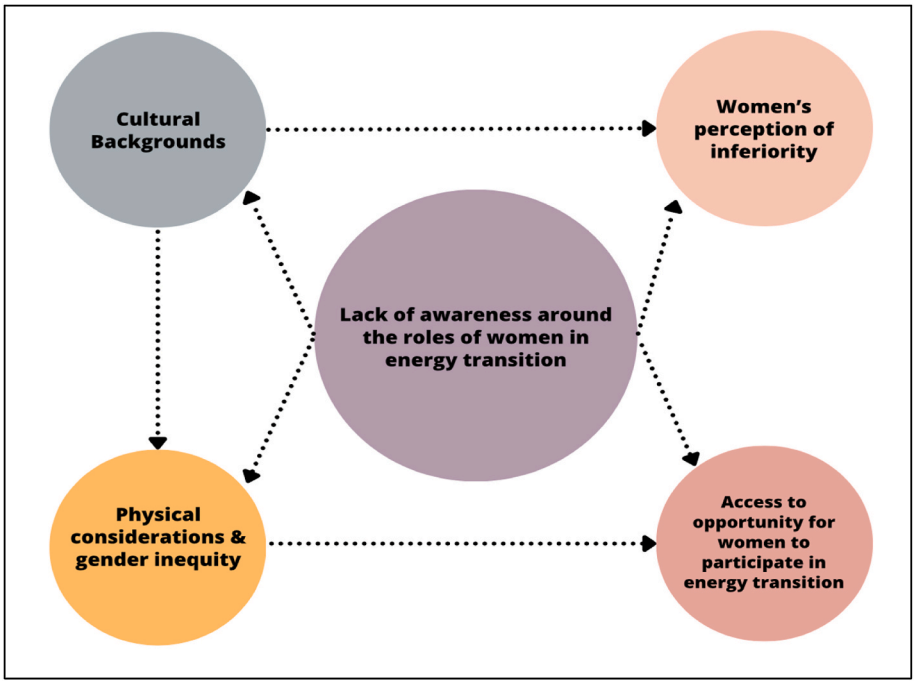

Fig. 7. Interconnectedness of barriers regarding women's recognition of justice in the energy transition.
Source: Developed by Authors (2023).

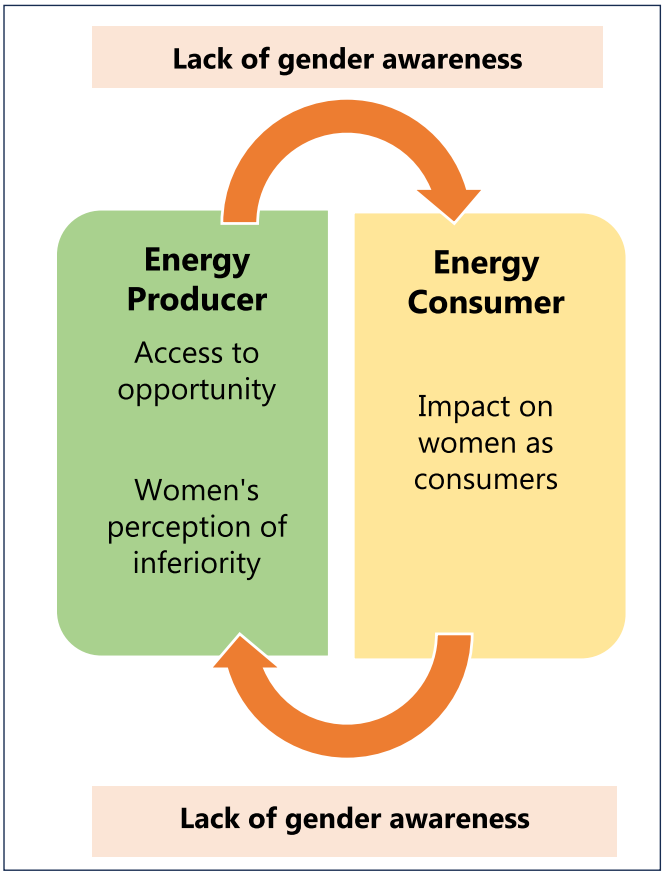

Fig. 8. Interconnectedness of barriers to increasing women's participation in the energy sector from the aspect of distributional justice.
Source: Developed by Authors (2023).

at the same time, produce renewable energy (Mishra, 2021; Stritzke and Jain, 2021). Women who live in rural areas play important roles in renewable energy development and can receive the benefits of these projects. Women affected by the energy transition process must be acknowledged and included in the decision-making process.

The question that subsequently arises is to what extent women as energy consumers relate to women as energy producers. As discussed within the context of recognition justice, access to opportunities for women to build careers in the energy sector must be broadened. In the realm of distributional justice, this relates to the equitable distribution of benefits among employees in renewable energy companies. This research reveals that women often receive lower pay than men due to their psychological beliefs rooted in cultural backgrounds and gender stereotypes. This aligns with the findings of the IEA (2022), which found that the gender wage gap is higher in the energy sector than in other industries. Women, as energy users who have been educated and realised the urgency of energy transition, can influence their communities and encourage more women to pursue careers in STEM and work in the renewable energy sector. This can be achieved by providing them with an understanding that women and men can receive the same benefits and assume the same roles and yet must concurrently shoulder the same responsibilities.

4.2.3. Procedural justice

In the context of procedural justice, the inclusion of women in the decision-making process has faced challenges stemming from cultural backgrounds, physical considerations and a lack of awareness regarding how women can contribute significantly to the energy transition process (Fig. 9).

Cultural backgrounds and stereotypes that assign women primarily

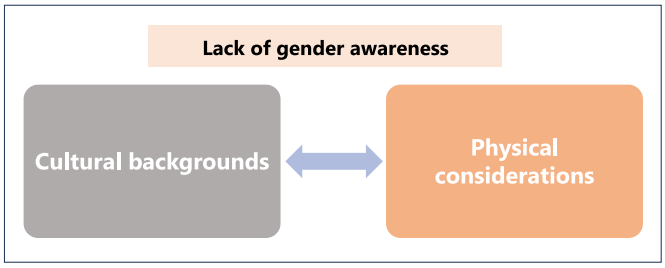

Fig. 9. Interconnectedness of barriers to increasing women's participation in the energy sector from the aspect of procedural justice.
Source: Developed by Authors (2023).

to administrative roles and housework due to their perceived physical differences have significantly impacted the representation of women in decision-making roles. One of our interview participants acknowledges that the number of women in leadership roles is low. This aligns with the findings of IEA reports, which highlight that the percentage of women in leadership roles within the renewable energy sector remains considerably lower than that of men (IEA, 2022b).

Research conducted by Bell et al. (2020) stated that women could bring new perspectives that are essential to developing a more sustainable energy culture and a more just energy system. According to Cecelski (2000), women's participation could help prevent failures in renewable energy projects. Furthermore, studies indicate that energy companies with more gender-diverse employees exhibit better financial performance when they actively support women's empowerment (Johnson et al., 2019; Pearl-Martinez and Stephens, 2016a).

5. Conclusion and policy implications

5.1. Policy implications based on the three tenets of justice

The process of transitioning to cleaner energy sources remains far from gender-neutral, despite its potential benefits for communities and the positive ripple effects it can create (Johnson et al., 2019). Researchers have also found that the impact is not equitably distributed between men and women because of their cultural backgrounds and norms. According to the IEA (n.d.), '*Innovative solutions require a diverse and equitable energy sector*'.

Addressing policy implications, a lack of awareness of the importance of women's participation in energy transition is one of the most significant underlying issues across the three tenets of justice (Fig. 10). This research underscores the need to raise awareness about women in STEM fields and the importance of women's participation in the energy transition process. Transitioning from a gender-blind energy policy to a gender-responsive energy policy is crucial.

Both ASEAN and G7 countries must intensify efforts to raise gender awareness during the energy transition, create more opportunities for women to work in renewable energy and energy transition initiative projects as well as promote a new paradigm where women can do the same jobs that men do within the field and increase the number of women working in the sector to dispel the psychological beliefs that limit women. Enhancing job opportunities for women in the renewable energy sector will encourage women to choose STEM fields as their educational trajectory. Therefore, women's communities must educate with these opportunities, and their direct participation in the energy transition is crucial. Many women in ASEAN are affected directly as consumers of cooking fuel, especially those who are still using biomass (wood). ASEAN and G7 countries must frame their gender-responsive energy policies to ensure an inclusive and just energy transition across both regions.

All stakeholders in both regions should actively participate in ensuring an inclusive and just energy transition process. This paper

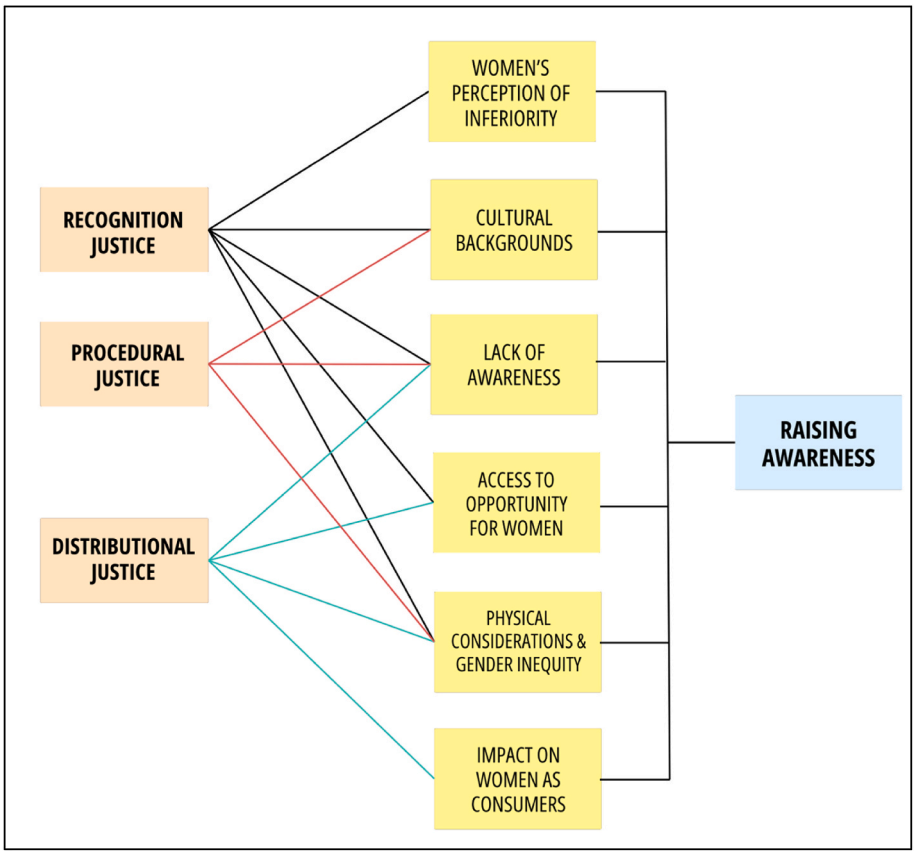

Fig. 10. Mapping of the three tenets of justice and the challenges of increasing women's participation in the energy sector.
Source: Developed by Authors (2023).

recommends that governments create targeted policies to address the identified challenges. These policies can be categorised into motivating policies and enabling/supporting policies. Therefore, governments must also establish ad hoc institutions or dedicated departments to execute and monitor the progress of policy implementations at all levels (communities, institutions and governments).

5.1.1. Motivating/driver policies

Motivating policies are designed to instigate, direct and sustain the just transition efforts of G7 and ASEAN countries. Various factors, such as individual goals, values and societal influences, can shape motivation. These policies play a crucial role in significantly enhancing industrial motivation and serving as a compelling rationale for involvement in the energy transition. The following are the proposed driver policies that could be applied to address the challenge:

- Establish collaborations with international financial institutions to provide technical and/or financial support to ensure an inclusive and just energy transition. This policy can be applied to address the challenge of increasing access to opportunities for women to participate in the energy transition.
- Enforce an inclusive culture in current or new policies in place in all types of institutions (e.g. companies, local community organisations, NGOs and educational institutions). This measure can be implemented to address the challenges of cultural backgrounds, psychological aspects, gender inequity and the impact of women on energy transition.

5.1.2. Enabling policy/policy support

Policy support plays a vital role in guaranteeing the legitimacy of policy design and ensuring the successful formulation and implementation of policies (Zhou et al., 2022). There are six policy supports proposed in this paper to address the needs of G7 and ASEAN countries in creating an enabling environment for increasing women's participation in the energy transition pertaining to two key objectives: (1) policy supports to address the challenge of increasing access to opportunities for women to participate in the energy transition and (2) policy supports to address the challenge of cultural backgrounds, psychological belief, gender inequity and impact of women on energy transition.

1) Propose policy supports to increase access to opportunities for women:
   - Reallocate fossil fuel subsidies to renewable energy or green technology development.
   - Establish a comprehensive database on related issues: men versus women in STEM education (at all levels), men versus women in STEM careers (at all levels) and STEM within the broader energy sector.
   - Set targets for increasing the percentage of women working in the energy sector, particularly in renewable energy technology or energy transition technology. This target should be enforced by governments through policy documents.
   - Establish a centralised database where each institution/company can submit reports on women's participation in the STEM field and the energy sector.
2) Propose policy supports to address the challenge of cultural background, psychological aspects, gender inequity and the impact of women on energy transition.
   - Facilitate access to communities for the private sector, academia and NGOs.

- Establish or update a database specifically focused on clean energy access.

5.1.3. Role of the private sector, NGOs, academia and communities

In addition to policy drivers and support policies, a bottom–up approach is necessary to tackle the challenge of increasing women's participation in energy transition. This paper identifies several recommendations that can be implemented to address the challenge of increasing access to opportunities for women to participate in the energy transition.

- The private sector, along with governments, should invest in renewable energy infrastructure technologies that are manageable by women as end users (e.g. hydropower and solar photovoltaic systems).
- Fossil fuel-related companies should allocate budget for new technology training (renewable energy, carbon capture storage) for both women and men.
- At the industrial and institutional levels, women should be actively encouraged to assume leadership roles when they demonstrate the capacity to do so.
- At the industrial and institutional levels, progress reports regarding women's participation in the STEM field/energy sector should be submitted to government portals.

Furthermore, there are four approaches proposed in this paper that can be applied to tackle the challenge of cultural backgrounds, psychological aspects, gender inequity and the impact of women on energy transition.

- Encourage women in communities who have the capacity and capability to assume leadership roles.
- Allocate financial resources to raise awareness about the roles and importance of women's participation in the process of energy transition and improve the social acceptance of renewable energy and energy transition.
- Foster collaboration among stakeholders (private sector, academia and CSO/community organisations) to promote women in STEM through education and community engagement.
- As part of corporate social responsibility, energy companies should promote women's participation at all levels, including leadership positions, engineers/skilled workers, students and community members (including housewives). Simultaneously, at the community level, women should be directly involved and encouraged to contribute to accelerating an inclusive and just energy transition.

5.2. Conclusions

The number of women in STEM fields and sciences is still low compared to men (IEA, 2022b; Rossi, 1965; Ryan, 2014). Ryan (2014) highlights four study priorities for continued development in the energy sector, namely (1) decreasing indoor air pollution, (2) enhancing community resource management, (3) developing feminist energy law and (4) expanding women's representation in the STEM and energy sectors.

This research concludes that despite the advanced progress in energy transition within the G7, similar challenges persist in both the G7 and ASEAN spheres. In terms of women's involvement in the just energy transition in ASEAN and G7 countries, we find that women are often overlooked, resulting in a lack of visibility for them in the renewable sector across ASEAN and G7 countries. There has been insufficient awareness of the importance of women in the energy transition and the significance of women being part of the process. Key challenges include limited access to employment opportunities in the energy sector and a gap in income distribution between men and women (IEA, 2022a). This is primarily due to the current mind-set and belief that associate STEM fields with men. Even when women within the STEM field obtain the same level of expertise, they often think that they deserve to be paid less. Women should be given more opportunities to take leadership roles to ensure an inclusive and just energy transition in ASEAN and G7 countries. In ASEAN countries in particular, cultural backgrounds significantly impact recognition within the sector. The prevailing viewpoint, grounded in cultural norms, is that women should be confined to traditional roles, staying at home and looking after children. Women are also considered weak and unable to deal with fieldwork due to perceived physical differences with men.

From the perspective of women as the primary users of energy, they will be directly impacted during the transition from fossil fuels to renewable energy sources. Currently, women in ASEAN spend significant amounts of time and energy collecting wood for cooking, leading to them being directly affected by indoor pollution when burning the wood as fuel. Women as energy users can provide different perspectives on this matter and drive innovation in renewable energy technology. Moreover, they can become more efficient and effective in their daily lives as they have more time to spend on more useful activities. An inclusive and just energy transition will eventually boost the economy of the region.

Finally, this paper underscores that both regions face a fundamental challenge: a lack of gender awareness at all levels. Ultimately, this is the underlying issue encountered when a country is trying to increase women's participation in the energy transition. Raising awareness alone will not be sufficient; therefore, government policies are required to enable more women to participate in the energy transition process. These policies should encourage other key stakeholders to adopt gender-responsive strategies and align their efforts so that they comply with these policies.

CRediT authorship contribution statement

Theresia B. Sumarno: Writing – review & editing, Writing – original draft, Visualization, Project administration, Investigation, Formal analysis, Conceptualization. **Inka B. Yusgiantoro:** Validation, Supervision, Conceptualization. **Vivi Fitriyanti:** Writing – review & editing, Writing – original draft, Visualization, Methodology, Formal analysis. **Vivid A. Khusna:** Writing – review & editing, Visualization, Project administration.

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work, the authors used:

1. VOSviewer to analyse the gap in the existing literature related to the topic under discussion in our article. VOSviewer generated existing literature mapping regarding gender, women within the energy transition and energy policy. The authors reviewed the results (mapping) and wrote the analysis based on the results.
2. NVivo software to analyse the results of the interviews. We uploaded the interview transcripts and used the NVivo software to analyse them. The authors conducted a thematic analysis of the interview results. We carefully reviewed each transcript and classified the key points that aligned with the aim and objectives of this paper.

The authors take full responsibility for the content of the publication.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

Acknowledgement

We would like to thank the Purnomo Yusgiantoro Center, Indonesia, for providing support in terms of funding and support facilities throughout the project. We also would like to thank all the interview participants for the insights that they provided, which were analysed in this article.

APPENDICES.

Appendix A. VOSviewer Processing Steps

We compile our literatures (references) from the Scopus database (see below Figure) using a Boolean search with the keywords "gender" and "energy" in the title, abstract, and keywords (TITLE-ABS-KEY) "gender AND energy" OR "just energy transition" OR "just transition". We exclude any irrelevant journals from the extracted. We have no restriction on publication years. We only include articles in terms of document type, and we only selected journals as the source of type. We transfer the references to the VOSviewer and produce our network analyses based on the title, abstract, and keyword co-occurrence. To enable us producing the network analyses, we upload a thesaurus of keywords to VOSviewer.

The nodes of the network were the terms identified by VOSviewer according to their frequency in the papers, using a twelve-times threshold. We group 120 terms (items) based on the clustering procedure into four distinctive clusters, with each term solely belonging to a single cluster. This results in 3087 relationship that we use for further analysis.

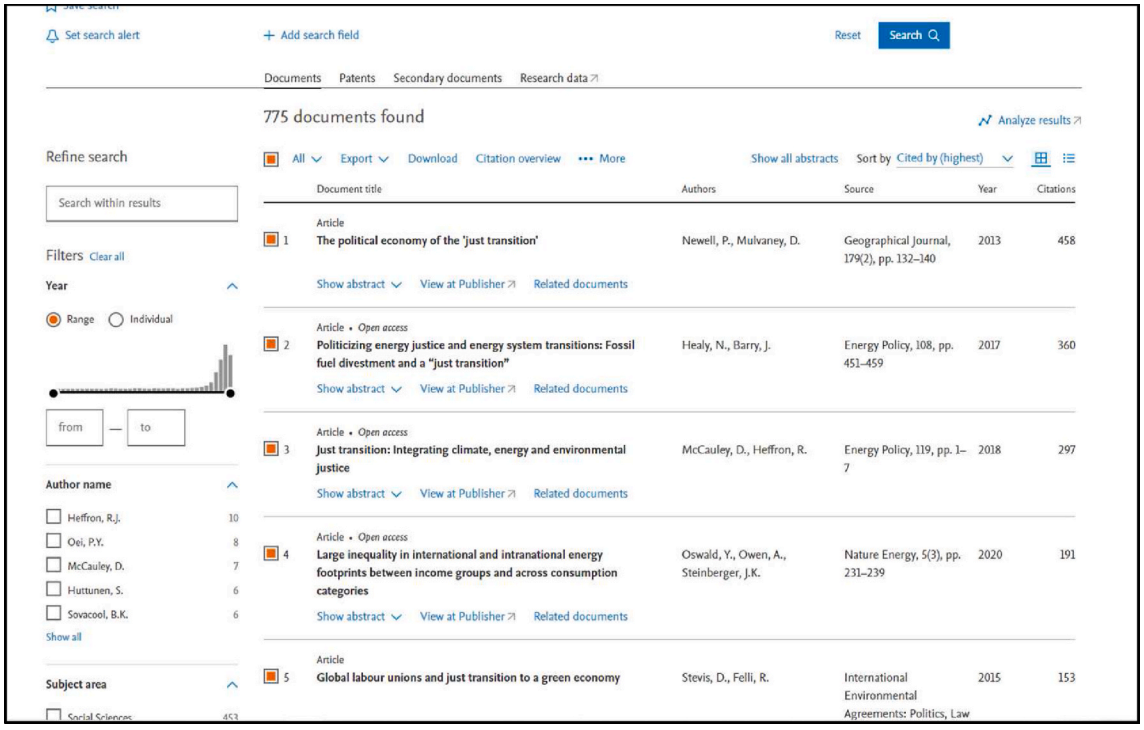

Figure: Scopus database (2023).

Appendix B. List of Interview Participants

Code	Role	Company	Company Sector	Region	Expertise
N1A	Researcher	ASEAN Centre for Energy	Intergovernmental Organisation	ASEAN	Energy Policy and Climate Change Mitigation
N2B	Project Engineer and Manager	DNV	Industry	G7	
N3B	Assistant Professor	TU Delft	Education	G7	Sustainable Energy Research
N4B	Senior Geologist	Cornish Lithium Ltd	Industry	G7	
N5B	Lead Researcher	Imperial College London	Education	G7	Energy Research
N6B	CTO and Co-Founder of Oorja Solutions	Oorja Solutions	Industry	G7	Solar Energy
N7B	Renewable Energy Engineer and Researcher	UKRIM	Education	G7	Thermal Energy

Appendix C. Interview Thematic Analysis on Challenges Identification

Name	Coding	Barriers/Challenges	Description
N4B	Industry and promoting women in the energy transition (ET)	Barriers/Challenges: Procedural justice, raising awareness of issues in the industry, recognition justice	The industry is not genuinely promoting the role of women in the energy transition. There are some non-profit or voluntary organisations, but nothing from industry.
N4B	Industry and promoting women in ET	Barriers/Challenges: Procedural justice, raising awareness of issues in the industry	Companies are trying to get more female employees, but there is no clear intention of promoting the role of women in the energy transition.
N4B	Awareness/education	Barriers/Challenges: recognition, raising awareness of issues in the industry	There has been a lack of awareness that energy transition is very much related to mineral and mining activities. People cannot see the connection between them. What has occurred is that fewer people wanted to study geoscience and instead went straight to climate/environmental courses, ignoring the significance of roles in engineering, geology or geoscience. Not only are fewer people in general going into this field, but even fewer women than before are doing so.
N4B	Job advertisements	Barriers/Challenges: procedural justice, raising awareness of issues in the industry, psychological aspect of females, recognition justice	Job ads are placed in women's societies, but still only 10% of applicants are female. Those who do apply are often unsuitable for the role. It is not a question of effort, more that the number of female applicants is less than what is expected.
N4B	Awareness/education	Barriers/Challenges: recognition, raising awareness of issues in the industry	There is a need to educate or raise awareness in female communities about these areas, and to advertise that there are opportunities for women to participate directly in the energy transition.
N4B	ASEAN countries to have a gender policy in ET	Barriers/Challenges: Procedural justice, raising awareness of issues in the industry, recognition justice	There is a great opportunity for countries like Indonesia and other ASEAN countries to involve women in the energy transition. The policy is not necessarily in place - it still must be framed. There is a lot that can be considered as part of the policy that will increase the involvement of women in the energy transition. Whereas in the UK, some policies are in place and changing them is difficult. Again, education is important, and with better educational access and awareness, Indonesia and other ASEAN countries have a great opportunity to involve women and make changes to the system, in particular within the energy sector.
N4B	Awareness/education	Barriers/Challenges: recognition, raising awareness of issues in the industry	How to encourage females to participate directly in the energy transition and the mining sector. There is a need to raise awareness - "*you cannot be what you cannot see*".
N4B	Awareness/education	Barriers/Challenges: recognition, raising awareness of issues in the industry	The need to raise awareness from an early stage.
N4B	Psychological aspects	Barriers/Challenges: psychological aspect, recognition	There have been different mindsets and psychological points of view when applying for a STEM job as an engineer/geologist.
N4B	Job advertisements	Barriers/Challenges: Procedural justice	Job ads should be more open and welcoming for all applicants, including women.
N3B	Awareness/education	Barriers/Challenges: recognition, raising awareness of issues in the industry	There are a lot of exchanges between different generations. The understanding of gender roles among different generations becomes more fluid over time. There is a need to inform about this issue to all generations.
N3B	Access to women	Barriers/Challenges: Distributional justice, access to opportunities	Young women, older women, and women with special abilities: intersectionality strives to ensure the provision of designated spaces for women, however, these areas have traditionally been male-dominated. The rules of the game have been established by mainstream groups, primarily men.
N3B	Developed vs developing economies in terms of gender issues	Barriers/Challenges: distributional justice, occurring in both developed and developing countries	The problems are absolutely still there. Gender issues are perhaps even worse than before. Money does not solve all problems and sometimes it creates additional problems. It has been observed that in the energy sector, particularly in the oil industry, the money that is generated has created deeper gender disparities.
N2B	Condition in company/project	Barriers/Challenges: Procedural justice, raising awareness of issues in the industry	The number of women working in energy transition varies depending on the department. Some technical and engineering departments may have fewer women, but some other departments such as the analytical department (project evaluation) may have an equal number of women and men. This is because there are more engineering departments, more analytical departments, and more inspection departments.
N2B	Condition in company/project	Barriers/Challenges: Procedural justice, raising awareness of issues in the industry	There are not enough women participating in the energy transition, however, this may not be caused by companies not wanting to hire women as much as the sheer number of applications from men.
N2B	Bias in employing women	Barriers/Challenges: recognition justice	The issue with the specific jobs that refer to women being prioritised is that they lead women to think that if they are hired it is not because they are capable or the best candidates, but simply because they are women.
N2B	Awareness/education	Barriers/Challenges: Distributional justice, access to opportunity	There are people who do not have the means to access university, but also others who can afford to attend but do not want to pursue their studies.
N6B	How women are treated in meetings/discussions/ management roles	Barriers/Challenges: recognition justice	There have been occasions where one of the interviewees was in a meeting with a man who was unable to make eye contact with her.
N6B	What is just for women? What is equality?	Barriers/Challenges: recognition justice, procedural justice	There have been some instances when female employees need to be cautious and take additional care when they go into the work environments. They need to ensure that they are safe. However, there are other safety considerations beyond the aspect of gender.
N6B	What is just for women? What is equality?	Barriers/challenges: recognition of physical aspects	In rural areas, it is extremely difficult to hire women, especially for the kind of work that is related to technical activities, because it takes place outdoors. It involves travelling around on a motorcycle and talking to strangers. This is not something that women are socialised to do.

(*continued on next page*)

(*continued*)

Name	Coding	Barriers/Challenges	Description
N6B	Access to women's opportunity	Barriers/challenges: distributional justice, access to opportunity	Not every woman has the same opportunity to access jobs or work in the energy field.
N6B	Awareness/education	Barriers/challenges: distributional justice, access to opportunities	Women's representation is important at all levels of society to enable the advocacy of women and create more opportunities for communities.
N6B	Importance of women in the ET	Barriers/Challenges: Distributional justice, recognition justice	Many big solar plant projects are usually male-dominated, in the same way that the coal industry is male-dominated. However, off-grid energy tends to require more of a social focus, it usually will have more women involved.
N6B	Awareness/education	Barriers/Challenges: recognition justice, raising awareness of issues in the industry	There is still a need to promote and showcase technical tasks (STEM-related jobs), demonstrate how it can be done, and how to do it effectively and efficiently.
N6B	Awareness/education, role models	Barriers/Challenges: Distributional justice, access to opportunity	There is a link between educational opportunities and better representation of women in the industry. This is a very important issue. Other than that, role models within the industry also play an important role.
N1A	Industry and promoting women in ET	Barriers/challenges: Procedural justice	In an intergovernmental institution, gender equality is a very important consideration as such institutions carry out projects and receive external funding. The energy transition requires the existence of a gender equality factor. However, there are no specific rules or policies related to gender equality in some intergovernmental institutions.
N1A	Women as energy consumers	Barriers/challenges: distributional justice, impact on energy consumer benefits	In Indonesia, gas cylinders are cheap as they are subsidised. Gas stoves are cheaper than electric stoves. The use of electric stoves will increase the cost of using electricity, which is already expensive. The electric stove will contribute significantly to an increase in monthly electricity bills. One of many ways of incentivising the use of electric stoves is by subsidising the price of electric stoves and the use of electricity.
N1A	Cultural background	Barriers/challenges: recognition justice, cultural background	Culture does matter and impacts women's participation in the energy transition. The cultural backgrounds of Malaysia, Brunei and Indonesia are similar. However, the status of women in the STEM sector in Indonesia is very different compared to the other two countries. According to one of the interviewees, it may be worse in Indonesia, given that in Brunei and Malaysia women have better access to education than in other ASEAN countries. In Indonesia, there is a societal stereotype about women not requiring further education as they will have to be housewives in the future. The economy of Malaysia and Brunei may also be a factor in the number of opportunities for girls to pursue higher education.
N1A	Cultural background, awareness/ education	Barriers/challenges: recognition justice, cultural background	The issue of equality is very complex. Access to education is important to increase the level of employment for skilled women and change the perspective of women who can only work as admins, cooks, or typists. This must be assisted through the existence of policies, especially in ASEAN countries which tend to be highly patriarchal. The government can specifically mandate the involvement of women in every government agency or educational institution, and this could have a beneficial effect on increasing gender inclusivity. In ASEAN, especially in Indonesia, there is a stereotype that women must be housewives and if they do work they still be subservient to their husbands. Considering the awareness aspect, the building of capacity is vital to change the general stereotype.
N1A	Cultural background	Barriers/challenges: recognition justice, cultural background	In some energy companies (within the private sector) from developed countries that open branch offices in ASEAN, the influence of cultural background is very strong regardless of the gender equality policy that is in place in these companies. There is still more male participation compared to women due to the patriarchal nature of society.

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