Abd Majid, Nurshahirah; Amar Hisham Jaaffar; Alzoubi, Raed Hussam Mansour

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The Impact of Women's Role in Corporate Governance on Carbon Disclosure Performance: A Descriptive Study of Top 100 Global Energy Leaders

Nurshahirah Abd Majid[1]*, Amar Hisham Jaaffar[2], Raed Hussam Mansour Alzoubi[3]

[1]College of Graduate Studies, Universiti Tenaga Nasional, Jalan IKRAM-UNITEN 43000, Kajang, Selangor, Malaysia, [2]Institute of Energy Policy and Research, Universiti Tenaga Nasional, Jalan IKRAM-UNITEN 43000, Kajang, Selangor, Malaysia, [3]Department of Administrative Sciences, Prince Hussein Bin Abdullah Academy for Civil Protection, AL Balqa Applied University, Jordan. *Email: shahirahmajid@gmail.com

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ABSTRACT

Global leaders in the energy sector have significantly improved their environmental governance practices by incorporating women into their management teams to enhance carbon reporting practices. Based on a content analysis of annual reports, sustainability reports, and websites of the top 100 global energy leaders, we describe the trend of women of the board member who are industry experts, act as advisors, and pose as community leaders as well as the level of their carbon disclosure (CD) performances over the 3 years from 2018 to 2020. The results show that the number of women on the boards of the top global energy leaders is increasing in line with the level of carbon disclosure over 3 years. This development exemplifies the significance of women in leadership roles in the top global energy leader's journey to achieve net zero carbon emissions. Women in managerial positions are therefore crucial, and their presence will be one of the most critical influences in the energy sector's potential to enhance firm carbon performance and draw in more sustainable economic growth.

Keywords: Carbon Disclosure, Energy Industry, Women Leadership, Resource Dependency Theory
JEL Classifications: F64, G34, M14, O13, Q56, Q49, Q54, R11

1. INTRODUCTION

The global average surface temperature has risen by approximately 1.1°C (°C) relative to the preindustrial average during 1850-1900, amplifying the frequency and severity of climate shocks worldwide (Cevik, 2022). The risk of extreme weather events such as heat waves, wildfires, droughts, flooding, and severe storms is expected to increase over the next century as the global mean temperature continues to rise by up to 4°C (Masson-Delmotte et al., 2021). The corporate world, particularly the energy sector, is a major contributor to climate change, accounting for more than two-thirds of all greenhouse gas emissions worldwide (International Energy Agency, 2022). Coal accounted for more than 40% of the overall increase in global CO_2 emissions in 2021, reaching an all-time high of 15.3 billion tons. CO_2 emissions from natural gas increased significantly from 2019 levels to 7.5 billion tons. The world's energy supply must be completely decarbonized by 2050 if we are to keep temperature increases below 1.5°C.

Previous studies have shown that the increasing number of women in governance is related to climate change decisions, such as in publicly listed companies (Ciasullo et al., 2022; Glass et al., 2016). Nevertheless, there is a lack of studies examining the contribution of women to corporate governance in the energy sector, notably in the performance of CD (e.g., [Charumathi and Rahman, 2019]). Women's involvement at the corporate governance level is crucial for energy businesses to convey the message that they value gender equality and that they have women's expertise to help with carbon mitigation efforts, which results in high-quality carbon performance disclosure (Pinheiro et al., 2021). In the energy-related sector, which is majority dominated by men, women's representation in the senior management position is deficient, where <5% of candidates are selected for the top positions (such as chair of the board, CEO, and president) (Pilgrim et al., 2021).

In this study, the involvement of women in the governance level of the company has been measured based on (1) the percentage of women board members; (2) the percentage of women board members who are industry experts (IE); (3) the percentage of women board members who act as advisors (ADV) and (4) the percentage of the women board member who represents as community leaders (CL) over the board size serve on board for each energy companies (Ramon Llorens et al., 2020). Meanwhile, the CD performance was measured based on the CD index adopted from de Grosbois and Fennell (2022), Alrazi et al. (2016), and Bae Choi et al. (2013). This CD performance comprised 90 CD practice indicators with 9 subcategories including (1) strategy and policy; (2) climate change risks and opportunities; (3) corporate GHG emission targets; (4) companywide carbon footprint; (5) GHG emission change over time; (6) energy related reporting; (7) emission reduction initiatives implementation; (8) carbon emission accountability; and (9) quality of disclosure.

The objective of this paper is to examine the trend of women's involvement in the corporate governance level and its relation with the level of CD performance of global energy companies. More specifically, this study analyses the content of the top 100 global energy leaders over the 3-year period from 2018 to 2020. This paper contributes to the body of knowledge on the performance of CD by highlighting the importance of women's participation in corporate governance for energy companies in order to improve their CD performance, which can then facilitate sustainable governance and policies, particularly those involving future sustainable economic and social growth and promoting climate change mitigation actions.

2. LITERATURE REVIEW

2.1. Women's Role in Corporate Governance and CD Performance in Energy Companies

The role of the business sector in addressing climate change is rapid urgency around the world especially among energy sectors which contribute most of the greenhouse gas emissions in the atmosphere (He et al., 2022; United Nations Framework Convention on Climate Change, 2015). The environmental researchers stress these carbon-intensive industries to oblige in halting global warming and curb climate change (de Grosbois and Fennell, 2022; Luo et al., 2012). Multiple stakeholders are urging these industries to upsurge their transparency by revealing non-financial information (HomRoy et al., 2020) which includes their carbon emissions data (Arena et al., 2018; Bui and de Villiers, 2017; United Nations Framework Convention on Climate Change, 2015). CD performance can be portrayed as the key approach toward resolving climate change concerns and curbing the company's carbon release (Ben-Amar et al., 2017) by disclosing their carbon footprints (Gray et al., 1996; Hollindale et al., 2017) through sustainability reporting which usually includes in the companies' annual, stand-alone sustainability, corporate social responsibility, integrated, or online reports either mandatorily or voluntarily (Borghei, 2021). Meanwhile, the academicians stated that the level of CD among businesses needs to be enhanced and strengthened (Kouloukoui et al., 2020; Radu et al., 2020; Zhang and Liu, 2020). Aligned with this issue, gender diversity is one of the powerful corporate governance mechanisms to improve sustainability performance especially in environmental concern (Bear et al., 2010; Charumathi and Rahman, 2019; Harjoto et al., 2015; Khan, 2022; Kılıç and Kuzey, 2019; Kyaw et al., 2017; Landry et al., 2016; McGuinness et al., 2017; Rao and Tilt, 2016; Xie et al., 2020; Zahid et al., 2020). Previous literature also argued that women on board positively influence the environmental performance in many countries context such as in French firms (Lahyani, 2022); in Chinese firms (Wang et al., 2022), Canadian firms (Radu et al., 2022), in Nigerian firms (Jibril et al., 2022); in UK firms (Wang et al., 2022); and in Korean firms (Park et al., 2022) and the propensity to disclose carbon information (Elsayih et al., 2018; Hollindale et al., 2017; Liao et al., 2015). Thus, Table 1 depicted the paradigm of prior scholars who examined women's role in corporate governance and environmental-related reporting in energy-related industries or carbon-intensive industries. Based on Table 1, most of the previous scholars demonstrated the similar findings even though their studies' scope is from the energy or carbon-intensive industries. In addition, there hasn't been much research on CD practices in the energy sector, despite their significance and possible advantages (de Grosbois and Fennell, 2022). Moreover, the inconsistency and lacking overall clarity on specific effects in literatures (Bolourian et al., 2021) such as the relationship between board gender diversity and carbon disclosures (Ben-Amar et al., 2017; Hollindale et al., 2017; Liao et al., 2015; Prado-Lorenzo and Garcia-Sanchez, 2010). The role of women directors specifically on carbon-related disclosure practices is still primarily unexplored (Galbreath, 2011; Liao et al., 2015; Prado-Lorenzo and Garcia-Sanchez, 2010; Rodrigue et al., 2013). As a result, the evidence of the women role in corporate governance especially in addressing environmental concerns is inconclusive (Haque, 2017; Nguyen et al., 2020).

2.2. Theoretical Background

Empirical evidence indicates that boards expected to engage with environment-related actions and turned out to be an effective environmental outcome when they are independent, diverse in expertise and gender (de Villiers et al., 2011; Dixon-Fowler et al., 2013; Elsayih et al., 2018; Liao et al., 2015; Post et al., 2015; Shaukat et al., 2016). However, a few scholars argued that women board member who are financial expertise or industrial background negatively impact the carbon emissions information (Al-Qahtani and Elgharbawy, 2020; Ramon Llorens et al., 2020). The women directors' distinctive skills, experiences, backgrounds, professional experience, and problem-solving skills and values, may have an impact on decisions involving environmental reporting, such as CD and needed to consider for overall corporate performance (Baysinger and Zardkoohi, 1986; Kuzey et al., 2022; Ludwig and Sassen, 2022).

Table 1: Women role in corporate governance and CD performance in energy-related companies

No.	Women role indicator/proxy	Relationship/findings	Scope of study	Title and authors (year)
1.	Gender Diversity (Percentage of women directors on corporate boards)	Positive	• Carbon-Intensive Africa and Asia Energy firms • GRI database	Climate Change Reporting and Corporate Governance among Asian and African Energy Firms (Asare et al., 2022)
2.	Gender Diversity (Percentage of female directors on board)	Negative	• Standards and Poor's 500 • Carbon-intensive VS Non-Carbon-Intensive industries • ESG and GHG Protocol	Board gender diversity, environmental innovation and corporate carbon emissions (Konadu et al., 2022)
3.	Gender Diversity proxy are: 1. Female proportion on board 2. Shannon Index 3. Blau Index	• Moderation analysis found insignificant for resource use and emission reduction (No significant effect – to stimulate them) • Shannon and Blau indices found stronger moderating effects towards IV DV (+)	• Thomson Reuters Eikon database • Transportation and logistics sector • Eco-friendly practices (DV) • CSR Strategy (MV)	Board gender diversity, CSR strategy, and eco-friendly initiatives in the transportation and logistics sector (Kuzey et al., 2022)
4.	Gender Diversity (Percentage of female directors on board)	Positive	• UK extractive and retail Sectors • CSR (Environmental, Social, Governance Disclosure Score)	Antecedents of corporate social responsibility disclosure: evidence from the UK extractive and retail sector (Wang et al., 2022)
5.	Gender Diversity proxy are: 1. Critical mass at least 2 directors on board 2. Percentage of female directors 3. Blau index	Positive	• European • Carbon intensity (measuring carbon performance and disclosure)	Board gender diversity and carbon emissions: European evidence on curvilinear relationships and critical mass (Nuber and Velte, 2021)
6.	Gender Diversity (Female members' percentage on the board)	Positive	• Energy sector • CSR (ESG Score)	Board attributes, CSR engagement, and corporate performance: What is the nexus in the energy sector? (Shahbaz et al., 2020)
7.	Gender diversity (dummy variable)	Positive	• Oil, gas, and mining companies in Kazakhstan • Sustainability Reporting index	Green governance and sustainability reporting in Kazakhstan's oil, gas, and mining sector: Evidence from a former USSR emerging economy (Mahmood and Orazalin, 2017)

Based on resource dependency theory, it provides a substantial insight to forecast the connection between environmental related disclosure and the women role on board (Pfeffer and Salancik, 1978). This theory support that diversity on boards improve and manage access to resources, reduce reliance on environmental resources, offer a variety of viewpoints, advice, skills, values, and legitimacy as well as business contacts, information channels and personal ties to the companies (Byron and Post, 2016; Cabeza-Garcza et al., 2018; Hillman et al., 2000; Liao et al., 2015; Pfeffer, 1972; Terjesen et al., 2009), effectively monitoring and encouraging management to make better decisions, which might improve firm performance (Benkraiem et al., 2017; Erhardt et al., 2003; Frias-Aceituno et al., 2013; Higgs, 2003; Hillman et al., 2002; Lu and Herremans, 2019) and also favors the adoption of environmental related regulations and policies (Bear et al., 2010; Cullinan et al., 2019). RDT further asserts that board members carry out their responsibilities and tasks more effectively when they offer image, expertise, background, reputation, capabilities, and external connections with other organizations. Consequently, a board's human and social capital may have a favorable effect on strategic business decisions, such as advocating environmental disclosure (Mallin and Michelon, 2011; Pechersky, 2016; Wang and Dewhirst, 1992) and they discharge their significant advisory role (Dass et al., 2014) by their individual professional background, skills, knowledge and expertise (Pechersky, 2016), bring reputation, outside acquaintances and engagement from outside representatives if they are outsiders (Baysinger and Butler, 1985; Pfeffer and Salancik, 1978). Hence, according to RDT, firms with women on boards will enrich the flow of information by better affecting the decision-making process, providing a wider range of perspectives, which could consequently result in a higher degree to disclose environmental related matters since this may strengthen links and relations with external stakeholders and organizations (Ramon Llorens et al., 2020; Wang et al., 2022). In China, Khan et al. (2022) who also argued that women directors who are politically connected and who are involved in academic or non-corporate organization, they tend to enhance the carbon information disclosure. Diverse expertise, knowledge, and values favorably influence decision-making processes (Konadu et al., 2022) which in line with resource dependency theory, firms will benefit from the varied abilities, viewpoints, and influences that women bring to the boardroom (Hillman et al., 2007) especially when dealing with high polluting sectors, these qualities and resources of women become more apparent. In addition, Ludwig and Sassen (2022) highlighted in their systematic reviews study on the importance of women directors' experience and knowledge in enhancing corporate sustainability in terms of intensifying environmental influence, reporting and performance, stakeholder engagement, socially responsible orientation, and transparency growth.

Women directors may diversify the board and contribute broader perspectives and viewpoints due to their advanced education, qualifications, prior employment experience, and history outside of the business sector (Hillman et al., 2000). Furthermore, boards comprised of industrial expertise might promote environmental related disclosure, including disclosure of carbon emissions, which would be highly valued by stakeholders and shareholders (Ramon Llorens et al., 2020). According to Giannarakis (2014), who asserts that prior experience as well as prior expertise, knowledge, and credentials (Shrader et al., 1997) provided by women board members results in more diverse and unique leadership styles and perspectives in comparison to their male counterparts, which in turn leads to promoting the environmental related disclosure, more oriented toward stakeholders and environmental related issues. Women board members who explicitly provide specific skills, experiences, and backgrounds in fields such as financial issues, different sectors, or environmental and social matters to boards (Shaukat et al., 2016), anticipated to have a favorable impact on strategic decisions specifically on environmental related issues (Adams and Ferreira, 2009; Galbreath, 2016; Helfaya and Moussa, 2017; Konrad et al., 2006; Rosener, 1997; Smith and Parrotta, 2018). Women board members who possessed expertise and backgrounds from their work in groups or communities like political parties or social organizations (Hillman et al., 2000) offer resources like social standing, reputation, legitimacy, or strong ties to pertinent stakeholders (Dang et al., 2014). They also will maintain contacts and relations with non-business or social communities (Ramon Llorens et al., 2020). These directors are respected, well-known, and influential in non-profit settings (Li et al., 2008) because they can offer credibility, transparency, and strong external ties with other groups (Chen, 2014; Hillman and Dalziel, 2003; Tsai and Ghoshal, 1998). These directors are having better monitoring, viewpoints, and orientations toward social and environmental issues in addition to better resource acquisition (Nielsen and Huse, 2010) and bring non-business perspectives and strategies to the decision-making process (Hillman et al., 2002). Therefore, this study is mainly focused on women role in corporate governance and the influence on CD performance among energy companies. As well as their past and current specific roles may influence the level of CD performance among the energy companies in order to contribute to the body of knowledge for the absence of this topic from the best of our knowledge and still needed to debate.

In this regard, this study proposes the following hypothesis:
Hypothesis 1: The increase of women role in corporate governance will improve the level of CD performance of top 100 global energy leaders.
Hypothesis 2: The effect of women role in corporate governance on CD performance of top 100 global energy leaders will differ based on their past and current specific role.

3. METHODOLOGY

3.1. Research Design

To test the hypotheses and meet our research objectives, this study will use purposive sampling and we sampled Top 100 Global Energy Leaders (Appendix 1) listed in the 2017 Thomson Reuters. Based on the Fortune 500 list of energy companies around the world, the Top 100 Global Energy Leaders appear in their listings. The unit of analysis was the Top 100 Global Energy Leaders which also listed by Thomson Reuters in 2017. This study reaches the secondary data through all of them from the year 2018-2020 due to implementation of the Paris Agreement in which became effective on November 4, 2016, the Top 100 Global Energy Leaders listed in the 2017 Thomson Reuters, we can see the development and changes by the next financial year. In addition, based on the Congress Climate History, the tax credits and carbon pricing introduced aimed to strengthened and extended important financial incentives for investments in several cutting-edge low-carbon technologies in 2018. Then, the renewed interest in climate change introduced in 2019. Meanwhile, in 2020, the major energy legislation mandated a bipartisan plan and contains funding for clean energy research and development (R&D) and implementation, clean energy tax credits, and the Environmental Protection Agency (EPA) mandate to reduce hydrofluorocarbon (HFC) production and use over 15 years. Therefore, the year of 2018 and 2020 are the ideal year to do the investigation as our major concern towards the impact of woman leadership on CD of top 100 global energy leaders as climate change concerns have received increased attention, and several bipartisan initiatives have surfaced. This study initially considered Top 100 Global Energy Leaders companies based on Thomson Reuters database, but we successfully collected 97 companies which the other 3 companies were being acquired by the same companies listed in the top 100 global energy leaders in the year 2018 and 2020. The final sample is 97 companies with 194 observations throughout the 2 years. Corporate websites for all companies were reviewed for climate change-related information and, if available, in the latest sustainability or environmental reports, annual and integrated reports and other documents posted on corporate websites (e.g., Carbon Disclosure Project (CDP) questionnaire responses if available on the corporate website).

This study uses content analysis technique based on the measurement index related to firms' CD related reporting information from de Grosbois and Fennell (2022), Alrazi et al. (2016), and Bae Choi et al. (2013). Based on the literature and content analysis, the interpretative technique is deployed in this study as the technique is based on measurement of CD practices by qualitative character of the narrative which focuses on interpretation of text (Beck et al., 2010). This technique captures the meaning of CD practices by disaggregating narrative into its constituent parts and then describing the contents of each disaggregated components, thereby gaining a greater understanding of the CD practices (Albertini, 2014). This study also used paired t-test to compare the two samples between 2018 and 2020 to obtain mean score and total score of CD practices. The results also determined whether there are significant differences in the total score of CD practices in 2020 compared with 2018.

3.2. Measurement of Variables

As the dependent variable in this study, the CD practices indicators were adopted from the CD index developed by de Grosbois and Fennell (2022), Alrazi et al. (2016), and Bae Choi et al. (2013) which they incorporate a list of characteristics for the measurement of CD or climate-related risk disclosure. There are 90 CD practices indicators with 9 subcategories as presented in Table 2. The indicators are the proxy for CD practices measurement with the value of 1 for "disclose" and the value of 0 for "not disclose" for each of the proxy using scoring methodology (Siddique et al., 2021). Meanwhile, for the independent variables, this study assessed women leadership by four predictors; (1) percentage of women board members;

Table 2: CD index

No.	Disclosure items	Scores of CD performance (Disclose=1, Not disclose=0)
	Dimension 1. Strategy and policy	
1.	Mentioning "climate change"	
2.	Mentioning "emission reduction"	
3.	Mentioning "energy savings"	
4.	Commitment to reduce GHG emissions	
5.	Commitment to reduce energy use	
6.	Sustainability policy	
7.	Environmental supply chain policy	
	Dimension 2. Climate Change Risks and Opportunities	
1.	Recognition of climate change risks	
2.	Explanation of climate change risks	
3.	Discussion of climate change opportunities	
4.	Response to risks and opportunities	
5.	Assessment of financial implications of selected risks or opportunities	
	Dimension 3. Corporate GHG Emissions Targets	
1.	Target of carbon neutrality	
2.	Commitment to or adoption of science based GHG emissions targets	
3.	Absolute GHG emissions reduction target	
4.	GHG emissions intensity reduction target	
5.	GHG emissions target breakdown	
	Dimension 4. Company Wide Carbon Footprint	
1.	Disclosure of total GHG emissions in absolute terms	
2.	Breakdown of total GHG emissions	
3.	Disclosure of Scope 1 GHG emissions	
4.	Breakdown of Scope 1 GHG emissions	
5.	Disclosure of Scope 2 GHG emissions	
6.	Breakdown of Scope 2 GHG emissions	
7.	Disclosure of Scope 3 GHG emissions	
8.	Breakdown of Scope 3 GHG emissions	
9.	Disclosure of GHG emissions intensity	
10.	Breakdown of GHG emissions intensity	
11.	Scope 1 GHG emissions intensity	
12.	Scope 2 GHG emissions intensity	
13.	Scope 3 GHG emissions intensity	
	Dimension 5. GHG Emissions Change Over Time	
1.	Comparison of absolute GHG emissions with previous year	
2.	Explanation of changes in absolute GHG emissions over time	
3.	Breakdown of absolute GHG emissions change	
4.	GHG emissions intensity change from last or base year	
5.	Breakdown of GHG emissions intensity change over time	
6.	GHG emissions saved due to a specific initiative	
	Dimension 6. Energy Related Reporting	
1.	Energy-related targets	
2.	Total energy consumption	
3.	Breakdown of energy consumption	
4.	Energy consumption change over time	
5.	Breakdown of energy consumption change	
6.	Energy intensity	
7.	Breakdown of energy intensity	
8.	Energy intensity change over time	
9.	Breakdown of energy intensity over time	

(*Contd*...)

Table 2: (*Continued*).

No.	Disclosure items	Scores of CD performance (Disclose=1, Not disclose=0)
10.	Targets related to renewable energy use	
11.	Renewable energy consumption	
	Dimension 7. Emission Reduction Initiatives Implementation	
1.	Carbon offsetting or purchase of renewable energy credits	
2.	Investment in low carbon or energy R&D	
3.	Sustainable building construction and renovation process	
4.	Improving efficiency of everyday operations	
5.	Installing energy-efficient lighting	
6.	Heating and cooling systems improvements	
7.	High-efficiency equipment	
8.	Efforts to reduce transportation related emissions	
9.	Renewable energy use	
10.	Customer engagement in emissions reduction	
11.	Employee engagement in emissions reduction	
12.	Supplier engagement in climate change efforts	
13.	Engagement with business partners on climate change	
14.	Participation in external collaborations on climate change	
15.	Targets related to specific initiatives	
16.	Performance-related to specific initiatives	
17.	Product classified as low-carbon, carbon-neutral or carbon positive	
18.	Cost of future emissions factored into capital expenditure planning	
19.	The contribution of renewable electricity to the company's EBITDA in the current reporting year	
20.	The projected contribution of renewable electricity to the company's EBITDA at a given point in the future	
	Dimension 8. Carbon Emission Accountability	
1.	Indication of which board committee/other executive body has overall responsibility for actions related to climate change	
2.	Description of the mechanism by which the board/other executive body reviews the company's progress regarding climate change	
3.	Carbon policy/mission/vision statement	
4.	Description of stakeholder engagement programs	
5.	Support for organizations promoting climate change	
6.	Awards received	
	Dimension 9. Quality of Disclosure	
1.	Boundaries for GHG emissions calculations are specified	
2.	The reporting period which the data covers is specified	
3.	Scope of total emissions is specified	
4.	Scope 2 emissions are specified as either location- or market-based	
5.	Both location- and market-based Scope 2 GHG emissions are reported	
6.	Inclusions of emissions sources for each scope are explained	
7.	Exclusions from GHG emissions calculations are explained	
8.	Targets have clearly stated base year, target year and target value	
9.	Methodology for GHG emissions calculations is provided	
10.	Methodology for GHG emissions calculations follows global or national standards	
11.	External assurance statement in English is available	
12.	Independent assurance of Scope 1 emissions	
13.	Independent assurance of Scope 2 emissions	
14.	Independent assurance of Scope 3 emissions	
15.	Independent assurance of emissions intensity	
16.	Independent assurance of energy consumption	
17.	Independent assurance of energy intensity	

(2) the percentage of women board member who are industry experts (IE); (3) the percentage of women board members who act as advisors (ADV) and (4) the percentage of women board member who represent as community leaders (CL) over the board size serve on board for each company. Based on the taxonomy of director roles proposed by Hillman et al. (2000) and adopting the study of Ramon Llorens et al. (2020), this paper indicates IE, ADV, and CL as presented in Table 3. Finally, we controlled board size, board independence, board meetings, CEO duality, firm size, firm age, profitability, and leverage that may significantly affecting the relationship between women leadership and level of CD in the Top 100 Global Energy Leaders. Board size (BSize) is measured by the total number of directors on the board (Datt et al., 2018; Jizi, 2017; Rodrigues et al., 2017). Board independence (BInd) is measured as the proportion of independent directors on the board (Zeng et al., 2020). Board meeting (BMeet) is measured by the number of meetings held per year (Ofoegbu et al., 2018; Stefanescu, 2013; Yusoff et al., 2016). CEO duality is measured through a dummy variable which equal to 1 if the Chairman and CEO roles are

Table 3: Women board members classification

No.	Woman board members description	Classification
1.	Current and former women senior officers, directors who serve currently or have served in the past as active managers, employees or owners of the firm, directors who are active or retired executives in other for-profit organizations or other large companies; whom provide the company with their professional background, experiences, advice and alternative positions; bring a working knowledge, expertise of strategic decision making, problems solving about internal business affairs; and be the channels of communication between firms legitimacy.	Industry Expert (IE)
2.	Directors or, the current or former officers of the firm or the other large for-profit firms, who have professionals specialized in individual fields, such as law, finance or marketing, banking, insurance, and public relation among others, who offer companies their specific knowledge and specific expertise and/or access and information about environmental contingencies, who provide support for the general and competitive strategy of the firm, who also provide support for senior management in areas requiring specialized expertise, to meet the need for specialized expertise and linkages to support organizations outside the firm's product markets, such as financial institutions, law firms, public relations firms, and also provide channels of communication to large and powerful suppliers or government agencies which ease an access to vital resources for instance financial capital and legal support but they lack general management experience	Advisors (ADV)
3.	Non-executive directors who can be classified as politicians, heads of non-profit foundations, clerics and other public celebrities who bring reputation opportunities and networking to the firm, who also having experience and linkages relevant to the firm's environment beyond competitor firms and suppliers, who possess knowledge about or influence over important non-business organizations, provide non-business perspectives on issues, problems and ideas including the retired politicians, university or other institutional representatives, and officers of social organizations who are having expertise about and influence with powerful groups in the community such as political leaders, university faculty, members of clergy, leaders of social or community organizations	Community Leaders (CL)

separated and 0 if otherwise (Arayssi et al., 2016; Castilla-Polo et al., 2018; Elfeky, 2017; Michelon and Parbonetti, 2012; Shahab et al., 2018). Firm size (FSize) is measured as the natural logarithm of total assets (Ben-Amar et al., 2017; Khaireddine et al., 2020; McGuinness et al., 2017; Yarram and Adapa, 2021; Zahid et al., 2020). Return on assets (ROA) is our measure of profitability. It is the quotient between the earnings before taxes and total assets (Ramón-Llorens et al., 2019). Firm leverage (FLev) is measured by the ratio of total debt divided by total assets (Michelon et al., 2015; Zeng et al., 2020). Additionally, we control for firm age (Firm_Age), measured by the years a firm has been in existence (D'Amato and Falivena, 2020). Finally, a set of dummy variables to control for industry and year effects are included in the models.

4. RESULTS

Table 4 shows the sample distribution based on the industry in the energy sector of the top 100 global energy leaders. Oil and gas companies make up most of the sample, which is 62.9%. Oil and gas related equipment and services comprise the second highest sample, which comprises 17.5%, followed by multiline utilities, which comprise 13.4%, renewable energy companies, which comprise 5.2%, and uranium, which comprises 1%.

Table 5 shows comparison of the total scores of CD performance in 2018 and 2020 based on the level of CD according to the 90 CD index. Table 5 shows the results of the statistical t test ($P < 0.01$) where there is a significant difference in the averages of CD performance scores in 2018 and 2020. The mean score of CD performance in 2018 was 65.2165, which increased by 10% to 71.7526 in 2020. This result shows that for all the 90 CD index measurement indicators, the average level of a firm's CD performance moving to incline by years. This result supports the argument on this study and the previous scholars that the businesses are acting on increasing their transparency to reveal carbon footprint by disclosing CD performance by years.

Table 4: Sample distribution based on industry in energy sector of top 100 global energy leaders

Industry	Frequency	Percentage
Multiline utilities	13	13.4
Oil and gas	61	62.9
Oil and gas related equipment and services	17	17.5
Renewable energy	5	5.2
Uranium	1	1.0
Total	97	100

Subsequently, Table 6 indicates the comparison in the distribution of women roles in corporate governance for the energy leaders' companies in 2018 and 2020 towards the CD performance for each company of the stated years. To begin with, the Table 6 shows that women role on board are increasing by 8% with the mean difference 0.0192. On the other hand, the mean value in 2020 is remained in quite a lower domination on corporate board by 25% of the total board of directors. Then, Table 6 depicted the women role on board as the industry experts increasing by 11% with the mean difference of 0.0226. The role of women on board as the industry expert also shows similar trend by only 22% domination towards the corporate board. Further, the Table 6 illustrated the women role as advisors increased by 6% with the mean difference of 0.0114, and showing board domination by 21% of the total board. Nevertheless, the women role as advisors indicated there is no significance difference between 2018 and 2020. Afterwards, the women role as community leaders in the energy leaders' companies displaying 12% increased with the mean difference of 0.0154, and it shows only 15% domination towards corporate board. The results in the Table 6 support the Hypothesis 1 and Hypothesis 2.

To continue, Table 7 exhibit the CD performance score by category of the CD index in comparison to the year of 2018 and 2020. There is a decreased in trend of disclosure by the Strategy and Policy aspects between 2018 and 2020. Surprisingly, the other aspects such as Climate Change Risks and Opportunities, Energy Related Reporting, and Carbon Emission Accountability

Table 5: Comparison of CD performance score in 2018 and 2020

Comparison for CD score 2018 and 2020	N	CD mean score	CD standard deviation	Mean standard error	CD mean score difference	t-value	Significance (two-tailed) of T-Test for the equality of two mean
CD 2018	97	65.2165	14.83256	1.50602	−6.5361 (10%)	−7.761	0.000***
CD 2020	97	71.7526	15.00210	1.52323			

Table 6: The distribution of women board members and CD performance score in 2018 and 2020

Variables	Mean in 2018	Mean in 2020	Mean Difference	t Value	Significance (two-tailed) of t-test for the equality of two mean
WBMP	0.2271	0.2463	−0.0192 (8%)	−2.500	0.014**
WBMIE	0.1990	0.2216	−0.0226 (11%)	−2.156	0.034**
WBMADV	0.2010	0.2124	−0.0114 (6%)	−1.054	0.294
WBMCL	0.1289	0.1443	−0.0154 (12%)	−1.704	0.092*
CD	65.2165	71.7526	−6.5361 (10%)	−7.761	0.000***

Table 7: CD performance score by categories of CD index

Category of CD index	2018		2020		Trend between 2018 and 2020
	Mean score	Percentage	Mean score	Percentage	
1. Strategy and policy	7	100	6	86	Decreased (14%)
2. Climate change risks and opportunities	5	100	5	100	Unchanged (0%)
3. Corporate GHG emissions targets	2	40	4	80	Increased (40%)
4. Company wide carbon footprint	9	69	10	77	Increased (8%)
5. GHG emissions change over time	2	33	4	67	Increased (34%)
6. Energy related reporting	8	73	8	73	Unchanged (0%)
7. Emission reduction initiatives implementation	17	85	18	90	Increased (5%)
8. Carbon emission accountability	6	100	6	100	Unchanged (0%)
9. Quality of disclosure	10	59	11	65	Increased (6%)

Table 8: The distribution of energy leaders' companies based on the continents

Continents	Frequency	Percentage
Africa	1	1.0
Asia	24	24.7
Australia	3	3.1
Europe	44	45.4
North America	23	23.7
South America	2	2.1
Total	97	100

lay out the remain-unchanged trend between 2018 and 2020. Finally, in Table 7 demonstrated the increased in CD performance score from 2018 and 2020 for the CD index aspects essentially on Corporate GHG Emissions Targets, Company Wide Carbon Footprint, GHG Emissions Change Over Time, Emission Reduction Initiatives Implementation, and Quality of Disclosure.

After all, the final Table 8 provides an interpretation of the geographic distribution of the energy leaders' companies. Table 8 revealed that nearly half or 45.4% of the energy leaders were comes from Europe continent. Meanwhile, 24.7% of the energy leaders' companies were based in Asia. The other 23.7% or 23 companies were headquartered in North America.

5. DISCUSSION AND CONCLUSION

The purpose of this study is to describe trends in women participation in corporate governance level among top 100 global energy leaders from the year 2018 to 2020 in relation to the level of CD performance. Results provide evidence to suggest that the increase of woman role in the corporate governance level has improved the CD performance of the top 100 global energy company. This first finding suggests that the rise in the percentage of women in corporate governance and CD performance may be related to the significant institutional pressure on the energy sector to transition to net zero carbon by 2050. The results are in line with a study by Morrone et al. (2022), which revealed that CD can help businesses increase their financial soundness by luring in sustainable investments that come from a more sustainable business perspective. The inclusion of women at the corporate governance level of the top 100 global energy companies will provide greater opportunities for those businesses to address new strategic climate change concerns, improve their CD performance, and inform stakeholders about their initiatives (Charumathi and Rahman, 2019). The second finding suggests that the effect of women role in the corporate governance level will differ based on their past and current specific role. The women role on board as the community leaders show the highest increase (12%), followed by industry experts (11%) and advisors (6%). The study reveals that a woman's capacity to serve on a board depends on their prior experience and present job description (Lopes de Sousa Jabbour et al., 2020). Energy firms may need women on board with their community leadership expertise to boost their credibility, and women on board as industry experts may be crucial to developing a sustainable transition strategy towards net zero emissions by 2050. This paper contributes to the body of knowledge on the performance of CD by highlighting the importance of women's participation in corporate governance for energy companies in order to improve their CD performance, which can then facilitate the corporate sustainability practices, particularly those involving future sustainable economic and social growth. The appointment of women in the corporate governance level will increase the sustainable economic risk and reducing the cost of capital in sustainable economic consequences.

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7. CONFLICT OF INTEREST

All authors declare no conflicts of interest in this paper.

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APPENDICES

Appendix 1

Table 1A: List of top 100 global energy leaders

No.	Organization	Industry	Country/region
1.	Acea SpA	Multiline Utilities	Italy
2.	Aker Solutions	Oil and Gas Related Equipment and Services	Norway
3.	Amec Foster Wheeler (Acquired by John Wood Group PLC)	Oil and Gas Related Equipment and Services	United Kingdom
4.	Andeavor (Acquired by Marathon Petroleum)	Oil and Gas	United States of America
5.	Anadarko (Acquired by Occidental Petroleum Corporation)	Oil and Gas	United States of America
6.	Avangrid	Multiline Utilities	United States of America
7.	Bharat Petroleum	Oil and Gas	India
8.	BP	Oil and Gas	United Kingdom
9.	Cairn India	Oil and Gas	India
10.	Cameco	Uranium	Canada
11.	Canadian Natural Resources	Oil and Gas	Canada
12.	Chevron Corporation	Oil and Gas	United States of America
13.	China Petroleum and Chemical (SINOPEC)	Oil and Gas	China
14.	CMS Energy	Multiline Utilities	United States of America
15.	CNOOC Limited	Oil and Gas	China
16.	ConocoPhillips	Oil and Gas	United States of America
17.	DCC	Oil and Gas	Ireland; Republic of
18.	E. ON SE	Multiline Utilities	Germany
19.	Ecopetrol	Oil and Gas	Colombia
20.	Électricité de France	Multiline Utilities	France
21.	Enagás	Oil and Gas Related Equipment and Services	Spain
22.	Enbridge Inc.	Oil and Gas Related Equipment and Services	Canada
23.	Encana	Oil and Gas	Canada
24.	Engie	Multiline Utilities	France
25.	Eni	Oil and Gas	Italy
26.	ExxonMobil	Oil and Gas	United States of America
27.	Fairmount Santrol	Oil and Gas Related Equipment and Services	United States of America
28.	First Solar	Renewable Energy	United States of America
29.	Formosa Petrochemical Corporation	Oil and Gas	Taiwan
30.	Galp Energia	Oil and Gas	Portugal
31.	Gazprom	Oil and Gas	Russia
32.	Global Pvq SE i I	Renewable Energy	Germany
33.	Grupa Lotos	Oil and Gas	Poland
34.	Halliburton Company	Oil and Gas Related Equipment and Services	United States of America
35.	Hellenic Petroleum	Oil and Gas	Greece
36.	Hera	Multiline Utilities	Italy
37.	Hess Corporation	Oil and Gas	United States of America
38.	Hindustan Petroleum Corporation	Oil and Gas	India
39.	Idemitsu Kosan Co., Ltd.	Oil and Gas	Japan
40.	Indian Oil Corporation	Oil and Gas	India
41.	Inpex Corporation	Oil and Gas	Japan
42.	IRPC	Oil and Gas	Thailand
43.	JXTG Holdings	Oil and Gas	Japan
44.	Mangalore Refinery and Petrochemicals Ltd.	Oil and Gas	India
45.	Marathon Oil Corporation	Oil and Gas	United States of America
46.	Marathon Petroleum Corporation	Oil and Gas	United States of America
47.	MOL	Oil and Gas	Hungary
48.	Motor Oil Hellas	Oil and Gas	Greece
49.	National Grid	Multiline Utilities	United Kingdom
50.	Neste Oyj	Oil and Gas	Finland
51.	NiSource	Multiline Utilities	United States of America
52.	Lukoil	Oil and Gas	Russia
53.	Occidental Petroleum Corporation	Oil and Gas	United States of America

(*Contd...*)

Table 1A: (*Continued*)

No.	Organization	Industry	Country/region
54.	Oil and Natural Gas Corporation	Oil and Gas	India
55.	Oil Refineries Ltd.	Oil and Gas	Israel
56.	OMV AG	Oil and Gas	Austria
57.	Ørsted	Multiline Utilities	Denmark
58.	Pennon Group	Multiline Utilities	United Kingdom
59.	PetroChina Co., Ltd.	Oil and Gas	China
60.	Petrofac	Oil and Gas Related Equipment and Services	Jersey
61.	Petronas	Oil and Gas	Malaysia
62.	Phillips 66	Oil and Gas	United States of America
63.	PKN ORLEN	Oil and Gas	Poland
64.	PTTEP	Oil and Gas	Thailand
65.	PTT Public Company Limited	Oil and Gas	Thailand
66.	Reliance Industries	Oil and Gas	India
67.	Repsol	Oil and Gas	Spain
68.	Rosneft	Oil and Gas	Russia
69.	Royal Dutch Shell	Oil and Gas	Netherlands
70.	Rubis	Oil and Gas	France
71.	RWE	Multiline Utilities	Germany
72.	Saipem	Oil and Gas Related Equipment and Services	Italy
73.	Santos	Oil and Gas	Australia
74.	Saras	Oil and Gas	Italy
75.	Sasol	Oil and Gas	South Africa
76.	Saudi Basic Industries Corporation (SABIC)	Oil and Gas	Saudi Arabia
77.	Schlumberger	Oil and Gas Related Equipment and Services	United States of America
78.	Scorpio Tankers Inc.	Oil and Gas Related Equipment and Services	Monaco
79.	Sempra Energy	Multiline Utilities	United States of America
80.	Showa Shell Sekiyu K.K. (Acquired by Idemitsu Kosan)	Oil and Gas	Japan
81.	Siemens Gamesa Renewable Energy	Renewable Energy	Spain
82.	SK Innovation Co., Ltd.	Oil and Gas	Korea; Republic (S. Korea)
83.	Snam	Oil and Gas Related Equipment and Services	Italy
84.	S-Oil	Oil and Gas	Korea; Republic (S. Korea)
85.	Statoil	Oil and Gas	Norway
86.	Suncor Energy	Oil and Gas	Canada
87.	SunPower	Renewable Energy	United States of America
88.	Técnicas Reunidas	Oil and Gas Related Equipment and Services	Spain
89.	Tenaris SA	Oil and Gas Related Equipment and Services	Luxembourg
90.	ThaiOil	Oil and Gas	Thailand
91.	Total	Oil and Gas	France
92.	TransCanada	Oil and Gas Related Equipment and Services	Canada
93.	Tullow Oil	Oil and Gas	United Kingdom
94.	Tüpraş	Oil and Gas	Turkey
95.	Ultrapar Participações S.A.	Oil and Gas	Brazil
96.	Vallourec	Oil and Gas Related Equipment and Services	France
97.	Vestas	Renewable Energy	Denmark
98.	Weatherford International	Oil and Gas Related Equipment and Services	Switzerland
99.	Woodside Petroleum	Oil and Gas	Australia
100.	Worley Parsons	Oil and Gas Related Equipment and Services	Australia