

## Article

# Greenhouse Gases and Circular Economy Issues in Sustainability Reports from the Energy Sector in the European Union

Agnieszka Janik , Adam Ryszko \*  and Marek Szafraniec 

Faculty of Organization and Management, Silesian University of Technology, 41-800 Zabrze, Poland; agnieszka.janik@polsl.pl (A.J.); marek.szafraniec@polsl.pl (M.S.)

\* Correspondence: adam.ryszko@polsl.pl

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**Abstract:** The achievement of climate neutrality and eco-economic decoupling requires explicit measures to reduce greenhouse gases (GHG) emissions and to implement circular economy (CE) principles in practice. The energy sector is of particular importance in meeting these challenges because it exerts a substantial environmental impact. Therefore, it is extremely important to determine how essential GHG and CE issues are for companies operating in the energy sector. This can be reflected in corporate strategies, but it can also be disclosed to the public in sustainability reports. For this reason, this article presents a comprehensive analysis of sustainability reports based on the latest GRI Standards published by companies representing the energy sector in the European Union to determine the existence, quality, and specificity of reporting GHG and CE issues. The research results demonstrate that sustainability reports from the energy sector companies tend to focus more on GHG issues. They rarely point to actions related to CE, including actions enabling a reduction in GHG emissions, as those with high priority. In addition, declarations from the analyzed companies regarding intentions related to GHG and CE issues at the strategic level find a rather poor reflection in the description of specific actions in this area or in demonstrating appropriate indicators at the operational level. Considering the indicators included in the reports, the analyzed companies insufficiently describe the methods they use to gather, compile, and analyze information on the effectiveness of actions taken to address GHG and CE issues. As for the identification of potential determinants of the quality of reporting GHG and CE issues, the research results indicate that it is mostly influenced by external assurance and the report option. Sustainability reports submitted for external assurance and reports with the comprehensive option are significantly more developed than other types of reports. However, the clarity of reports with the core option is higher compared to the comprehensive group. In addition, it was indicated that the clarity of stand-alone reports is higher compared to other types of reports.

**Keywords:** sustainability reporting; energy sector; greenhouse gases; circular economy

## 1. Introduction

Climate change resulting from the emission of a significant amount of greenhouse gases (GHG), the depletion of non-renewable resources, and the increasing amount of waste is among the most serious challenges the world is facing today. Its occurrence increasingly affects people, ecosystems, and the functioning of economic operators, threatening their safety and stability. For this reason, the international community is constantly looking for solutions to help reduce GHG, tackle climate change, prevent the excessive depletion of resources, and reduce the amount of waste generated.



Statistics show that the European Union (EU) is the third biggest GHG emitter (after China and the United States) [1]. Acknowledging that climate change can have a number of serious consequences, the EU has adopted a series of ambitious climate and energy targets in recent years [2–4]. Their implementation will enable the EU economy to achieve climate neutrality by 2050 (i.e., it will become an economy with net zero GHG). The European Commission assumes that achieving this goal will be possible provided that the following actions are taken [4]:

- maximizing energy efficiency, including effective energy management in buildings;
- maximizing the use of renewable energy sources;
- implementing the principles of clean, safe, and connected mobility;
- implementing the concept of circular economy (CE) as a key factor in reducing GHG emissions;
- developing an appropriate intelligent network infrastructure and interconnections;
- harnessing the bioeconomy and creating the necessary carbon sinks;
- tackling residual CO<sub>2</sub> emissions through carbon capture and storage (CCS).

The energy sector, which in 2018 was responsible for over 83% of GHG emissions produced in the EU, will have a key role in the transition to a climate neutral economy. The companies of this economic sector were obliged many years ago to implement measures to reduce GHG emissions, which resulted in declining GHG emissions in this sector. However, in order to achieve climate neutrality in 2050, further actions in the energy sector are necessary to increase the level of decarbonization of the energy production process, increase the use of carbon-free energy sources, develop energy-efficient technologies, and increase the use of carbon capture and sequestration/utilization/storage where GHG have not been prevented or reduced otherwise [5].

Meanwhile, the energy sector may apply the principles of the circular economy (CE), which have been identified in the long-term vision as key activities contributing to the reduction of GHG and ensuring the competitiveness of the EU economy [4]. This is ever more important because in 2020 the EU has adopted a new Circular Economy Action Plan [6]. The aim of CE concept is to maintain the value of products, materials, and resources as long as possible based on transition from a linear economic model (“take-make-dispose”) to a circular model (“take-make-re-use”) [7,8]. Applying the CE principles in the energy sector may encompasses [9]:

- efficiently using natural resources by reducing energy production based on non-renewable resources and increasing the production of energy from renewable sources;
- increasing the level of utilization of side streams and waste generated in the energy production process;
- reducing the energy losses occurring during its transmission thanks to the modernization of power grids;
- increasing the recycling of materials generated during the modernization of power plants and energy grids (for the use of secondary raw materials contained in them);
- increasing the utilization of excess energy and heat generated in production units in other industries through their receiving and transmission to the power grids;
- increasing the utilization of excess energy and heat generated by end energy consumers by connecting the micro-installations with the power grid;
- striving to replace products with a service.

The achievement of climate neutrality by the EU will be possible, provided that companies, especially in the energy sector, continue to take measures to reduce GHG emissions. The same applies to the practical implementation of the CE principles. Therefore, it becomes important to determine to what extent GHG and CE issues are considered essential by energy sector companies. It is believed that these issues should be included not only in the corporate strategies but also publicly disclosed, voluntarily or obligatorily (i.e., in accordance with Directive 2013/34/EU [10]) as a part of sustainability reporting.



In recent years, sustainability reporting has attracted growing interest from academics, business representatives, and policy makers constituting a key platform for communicating economic, environmental, and social performance as well as impacts caused by everyday activities of organizations. It can be considered as synonymous with other non-financial reporting terms such as corporate social responsibility reporting or triple bottom line reporting. There are different guidelines for sustainability reporting: GRI Sustainability Reporting Standards [11], the OECD Guidelines for Multinational Enterprises [12], the UN Global Compact (Communication on Progress) [13], and the ISO 26000 (International Standard for Social Responsibility) [14]. However, the GRI Standards seem to be the most trusted and widely used all around the world. These standards enable organizations to understand, measure, and assess sustainability performance and disclose the relevant results in a similar way. They are focused on disclosures related to material topics that reflect reporting organizations' significant impacts (positive or negative) on the economy, environment, and/or society or that significantly influences the assessments and decisions of stakeholders [11].

The range of evaluative information, including performance reporting such as sustainability reports, is still increasing. However, the notion of quality and the quality of evaluative information is multifaceted and contested [15]. This is because quality may in this respect be related to a specific product (i.e., the technical quality of the information), a specific process (i.e., the quality of the process applied to obtain the information), as well as the usefulness of the generated and disclosed information [16]. The problems related to the quality of sustainability reports are investigated fairly often, but studies in this research area hardly ever concentrate exclusively on the energy sector. In addition, although various publications on sustainability reports from the energy sector have been published in recent years, studies on GHG and CE issues are still scarce. In particular, this is due to the scarcity of research on the implementation of the latest GRI Standards. For this reason, this article presents an analysis of sustainability reports based on the latest GRI Standards guidelines published by companies representing energy sector in the EU to determine the existence, quality, and specificity of disclosures concerning GHG and CE issues. To the best of our knowledge such research has not been performed until now, and those that have been published on this subject so far, assessed reports that were prepared before 2018, when the concept of transition to a climate-neutral economy was adopted. The aims of the performed analyses were:

- to identify whether and to what extent energy sector companies include issues related to GHG and CE in sustainable reports;
- to assess the quality of reporting GHG and CE issues in sustainable reports of energy sector companies;
- to determine factors influencing the quality of reporting GHG and CE issues in the energy sector.

The remainder of this article is organized as follows: Section 2 presents the results of the literature review that especially explored the existing research on the quality assessment of sustainability reports of energy sector companies, with particular emphasis on GHG and CE issues. The research methodology is described in detail in Section 3. Section 4 shows and discusses the results of the statistical analysis of collected data, including descriptive statistics of relevant variables and comparative statistical analysis. Section 5 summarizes this article with conclusions and indicates possible directions for future research and limitations.

## 2. Literature Review

In order to facilitate the achievement of the aims established in this study, it was necessary to develop the theoretical background concerning: (1) the identification of the foremost research topics related to GHG issues in the energy sector, (2) the indication of publications concerning CE issues in the energy sector, (3) the analysis of existing research on quality assessment of sustainability reporting in the energy sector, (4) the exploration of studies that cover GHG and CE issues in sustainability



reports of energy sector companies, and (5) an overview of selected factors affecting quality of sustainability reporting.

The performed literature review indicates that the main sources of GHG emissions in the energy sector are combustion processes and energy losses occurring at the stage of energy production and distribution [17–20]. Due to the considerable share of the energy sector companies in GHG emissions and the significance of the emission impact on human life, the reduction in the emissions has become the main subject of many systematic and complex studies. It should be noted that the reduction in GHG emissions is often equated with the concepts of decarbonization, carbon footprint minimization, and low-carbon, zero-carbon, or carbon neutral power generation [21–24]. More in-depth analyses were carried out to determine specific actions to reduce GHG emissions in the energy sector [17,18]. The studies also point to the possibility of reducing GHG emissions in combustion processes that cannot be eliminated by using the carbon capture and storage (CCS) technology [25,26]. Nevertheless, the recent studies indicate the particular position of the comprehensive assessment of innovative solutions reducing GHG emissions based on lifecycle considerations [23,27,28]. In addition, optimization modeling techniques for sustainable energy systems to mitigate energy related GHG emissions are of particular importance [19]. GHG emissions cause unfavorable changes in the environment, which has a negative influence on the global economy and economic situation and prospects of individual countries. This significant research stream is focused on the forecasts concerning the effects of GHG impact and possible methods of the energy sector transformation [12,29–32]. An unequivocal conclusion from to-date research is that the main direction of the energy industry transformation is to increase the share of renewable energy sources in the energy mix. However, the volume of GHG emissions varies depending on the type of renewable energy sources [23,24,27,33].

Although the importance of the CE concept in the energy sector is more and more emphasized, the literature review points out that so far there have been few publications describing the implementation of CE principles in the energy sector. There are noteworthy reports prepared by the Deloitte team from Finland [9,34] which characterize CE principles that would enable the move from a linear to a circular model in the energy sector, including some examples of CE activities introduced by Finnish energy companies. There are also publications evaluating the readiness of energy companies to transition to a circular economy and discussing the issue of waste management from coal combustion as part of the CE concept. In this line of research, Bielecka and Kulczycka (2020) verified the readiness of the seven coal-fired power plants located in Poland to implement CE models for coal combustion products management [35]. Using a comparative analysis, Rosiek (2018) estimated the economic, social, and environmental benefits of introducing CE in the sector of coal combustion products, including those generated during the production of energy and heat in power plants [36]. Moreover, Gosh and Kumar (2020) presented several innovative uses of fly ash as part of the implementation of the CE concept [37]. Another group of research on the CE concept application in the energy sector is focused on specific aspects of renewable energy production methods (e.g., [38,39]). There are also studies investigating the industrial symbiosis between various entities, which allows for the use of energy excess and side streams generated in power plants and other industries, which is one of the principles of implementing the CE concept [40,41]. The last group of research in this area evaluates the effectiveness of introducing CE principles by companies in the energy sector (e.g., [42]).

The existing studies on sustainability reporting are remarkably diverse in terms of their subject and scope. It is noticeable that the vast majority of this research is qualitative and is based on content analysis. Nevertheless, many studies in this area cover small samples and concentrate on individual countries. Analyzing the research that cover the energy sector, we can distinguish studies concerning different sectors with energy being one of them, well as a few studies focused solely on the energy sector. A general overview of the research identified in this domain is presented in Table A1 in the Appendix A. The studies covering different sectors most often have general conclusions and do not take into account the characteristics of individual sectors such as energy [43–55]. However, among this type of research there are also exceptions, allowing conclusions to be drawn regarding the



specificity and quality of sustainability reporting in the energy sector [56–63]. Considering the studies focused solely on the energy sector, various research approaches, different assessment subjects and samples types and size have been adopted. Regarding research focused on a single country, Chang (2013) [64] assessed environmental information disclosures included in social responsibility reports published by Chinese electric firms. Moseñe et al. (2013) [65] compared levels of compliance with GRI environmental indicators in sustainability reports of Spanish wind energy companies. Using exploratory and comparative study, Camargos et al. (2014) [66] analyzed application of the GRI-G3 guidelines and indicators in sustainability reports of Brazilian companies from electric utilities sector. In order to assess the sustainability performance of electricity power industry in Brazil, Sartori et al. (2017) [67] applied data envelopment analysis making use of indicators from GRI reports. Taking into account research composed of multi-country samples, Alrazi et al. (2010) [68] assessed the quality of environmental information reporting published by electric utilities companies from worldwide countries. Bakhtina and Goudriaan (2011) [69] focused on the employment issues in CSR reports of large multinational energy companies. Based on the annual reports of global independent power producers, Ng and Nathwani (2012) [70] conducted a comparative case study implementing a sustainability performance scorecard. Steinweg and Wilde-Ramsing (2012) [71] applied a GRI content index template to overview the use of the GRI guidelines in CSR/sustainability reports and associated websites of European electric utility companies. The content analysis and logic and conversation theory were used by Slacik and Greiling (2019) [72] to explore the coverage and quality of documented material aspects in sustainability reports (based on GRI-G4 guidelines) published by English and German electric utility companies. In addition, the same authors assessed the sustainability reporting practices and coverage rates of G4-indicators included in sustainability reports (GRI-G4) published by electric utilities companies representing several dozen countries [73]. In turn, documentary analysis was applied by Traxler and Greiling (2019) [74] to evaluate the coverage of GRI indicators included in sustainability reports (GRI-G4) disclosed by electric utility companies worldwide.

It should be noted that there are also studies focusing on GHG issues within the sustainability reports of energy sector companies. Based on qualitative and inductive content analysis, Talbot and Boiral (2018) [75] investigated the impression management strategies and quality of climate information disclosed in sustainability reports (G3 or G3.1 guidelines) of 21 worldwide energy companies. Kraft (2018) [76] investigated the climate disclosure strategies in electric utilities in response to specific market characteristics. Alrazi et al. (2014) [77] performed a quantitative and qualitative assessment of carbon-related information included in annual reports, stand-alone sustainability reports, and websites of 9 Malaysian major power producers. A similar research by Alrazi et al. (2016) [78] focused on the quality of CO<sub>2</sub> emissions information disclosed by 205 electricity generation companies from 35 worldwide countries. In addition, based on the carbon disclosure index, Bahari et al. (2016) [79] examined the extent of carbon information in reports published by 90 electricity generating companies representing top GHG emitting countries in Asia (i.e., China, India, and Japan). Considering CE issues in sustainability reports of energy sector companies, to the best of our knowledge, there have been no in-depth analyses in this area so far.

The studies performed so far indicate that there are various factors affecting the quality of sustainability reporting. Companies that operate in multiple organizational fields are subject to complex regulatory regimes [80]. Therefore, industries may differ in terms of potential benefits from CSR initiatives [81]. Recent studies confirmed industry-level differences in sustainability reporting [56]. In particular, this is the issue for companies operating in environmentally sensitive sectors [45,48,49,52,82]. However, regardless of the industry related environmental risk and sensitivity, Outtes-Wanderley et al. (2008) indicated that companies representing the energy sector, banking, and telecommunications provide the highest quality CSR information disclosure [83]. The involvement of companies in international markets is expected to force them to disclose more information [84]. Nevertheless, studies on this topic provide mixed findings. Some researchers found that companies with international market orientation are more likely to report CSR issues [85], but others have not



found a relation between area of activity (i.e., domestic or international) and sustainability reporting quality [48,73]. There is also growing number of studies focused on ‘mandatory against voluntary’ non-financial disclosure issues, in particular in the context of the Directive 2014/95/EU requirements. It is suggested that mandatory regulations may enforce compliance of disclosures [86] and recent research confirms the role of legal requirements in improving the quality of non-financial information [87]. The recent studies indicate dynamic increase in the number of stand-alone sustainability reports, in particular among the largest firms [53]. Companies publish stand-alone reports to show their great commitment to sustainability issues [88], to signal their superior position in this area [89,90], or to provide higher quality information to adequately respond to public pressure [91]. However, it was found that stand-alone reports are not associated with overall quality index [53], and there are no indications that stand-alone reports are more credible than combined reports [52]. The prior literature provides evidence that external assurance of sustainability reports improves their credibility [92,93] and overall quality [50]. Moreover, auditor size and type affect the quality and amount of information in CSR disclosures [94,95]. Nonetheless, Michelon et al. (2015) found that external assurance is not associated with disclosure quality [53]. Voluntary standards are expected to achieve better reporting credibility, but an exaggerated focus on standards might be counterproductive of the aim of enhancing sustainability reporting [96]. Lock and Seele (2016) proved that CSR reports using standardized GRI guidelines are more credible than those without them. The high application levels also increase reports credibility [52]. However, Michelon et al. (2015) found that GRI Standards followers do not provide a higher quality of information [53].

The conducted review showed that although various publications on sustainability reporting in the energy sector have been published in recent years, the studies that cover GHG and CE issues are still rare in the literature. In addition, they focus on specific topics which undoubtedly requires expansion and updating due to the dynamism in the analyzed research domain. In particular, this is due to the scarcity of the research on implementation of the latest GRI Standards. Moreover, the quality of reporting GHG and CE issues and factors affecting the occurrence and scope of such disclosures of the energy sector companies operating in the EU seem to be very interesting and need to be further investigated.

### 3. Materials and Methods

In order to determine whether and how GHG and CE issues are included in the sustainability reports, an analysis of the sustainability reports published by companies representing the energy sector in the EU was carried out. The choice of the energy sector was due to the fact that this sector generates the most GHG of all sectors, and the use of the CE concept is more and more often indicated as one of the ways to reduce GHG emissions generated by energy companies and achieve climate neutrality in the EU by 2050.

The research presented in this article was carried out according to the following phases:

Phase 1: Study design.

Phase 2: Selection of the research sample.

Phase 3: Data collection.

Phase 4: Calculation of indicators to assess quality of reporting GHG and CE issues.

Phase 5: Statistical analysis of collected data.

Phase 6: Results interpretation and drawing conclusions.

The details of consecutive phases and particular steps of the research methodology adopted in this study are presented in Figure 1.



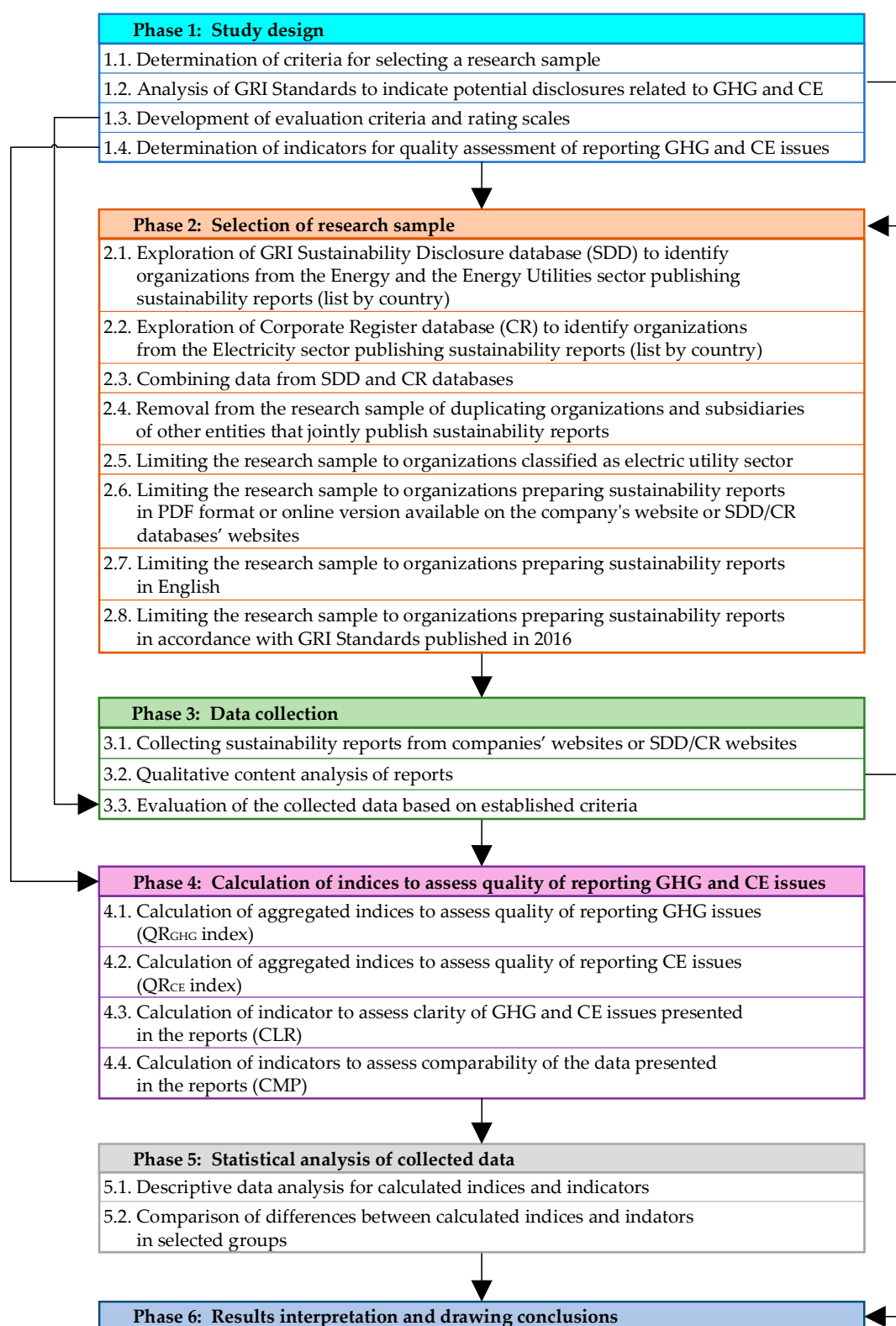


Figure 1. Research methodology.

### 3.1. Study Design

At the beginning of the first phase of this research, the criteria for selecting reports analyzed and assessed in the subsequent phases were defined. It was assumed that the research sample will consist of the following reports:



- prepared by companies from the energy sector whose headquarters are located in the EU countries;
- prepared based on the up to date GRI Standards guidelines (which is due to the fact that the GRI guidelines are one of the most popular guidelines chosen by companies voluntarily or obligatorily reporting non-financial data);
- available in an English version (it was decided that in order to avoid a translation error all reports available only in the native language will be rejected);
- available in PDF format or online version on the company's website or on websites where information on sustainability reports is collected.

It was decided that two databases would be used to achieve a suitable sample of sustainability reports prepared by companies from energy sector:

- GRI's Sustainability Disclosure Database (SDD)—a global online database containing over 63,000 sustainability reports published by nearly 15,000 organizations (more than 38,000 reports were prepared in accordance with the GRI Standards guidelines);
- Corporate Register (CR)—a global online directory of corporate responsibility reports containing over 124,000 reports prepared by over 20,000 organizations.

Due to the fact that GRI guidelines published in 2016 became effective for reports published on or after 1 July 2018, it was decided that only reports published after that date would be selected for analysis. In addition, it was assumed that the latest report disclosed by companies during this period would be considered for further investigation. This choice resulted from the fact that in subsequent reports, companies often duplicate information presented in reports from previous years (i.e., the risk of duplicating assessments) and there is no uniformity in the frequency of publishing sustainability reports (i.e., the number of analyzed reports from each company would be different). The last issue taken into account during designing the sample selection criterion was the assumption that three main types of reports will be analyzed: sustainability/CSR reports, integrated reports, and annual reports. This choice was influenced by the fact that each type of these reports can be prepared in accordance with GRI guidelines and each company decides what type of report will be chosen considering the scope of data that it intends to voluntarily or obligatorily present.

In the next step, the GRI guidelines published in 2016 were analyzed to indicate how and where the information on GHG and CE issues may be disclosed in the reports prepared by companies from the energy sector. It should be noted that this analysis does not include new topic-specific standard—GRI 306: Waste released in 2020, because it will apply to reports published on or after 1 January 2022. For this reason, the previous thematic standard—GRI 306: Effluents and Waste—issued in 2016 was taken into account as the basis for the waste-related issues. As a result of the analysis of the GRI guidelines, the assessment criteria and relevant scoring scales were determined. A detailed description of the assessment criteria and scoring scales is presented in Section 3.3.

The last step in this phase was the determination of the approach to quality assessment of reporting GHG and CE issues in sustainability reports prepared by companies from the energy sector. Based on the review of literature on reporting quality assessment using scoring frameworks (e.g., [44,51,59,63,72,97,98]) it was decided that separate indices will be calculated to assess the quality of reporting GHG issues ( $QR_{GHG}$  index) and quality of reporting CE issues ( $QR_{CE}$  index). In addition, distinct indicators to assess clarity of reports (CLR) and comparability of data (CMP) presented in the analyzed reports were proposed. The formulas for calculating relevant indices and indicators are presented in Section 3.4.

### 3.2. Selection of the Research Sample

The selection of the research sample took place in January 2020. As mentioned earlier, two databases were used to search the information about organizations publishing sustainability reports: GRI's Sustainability Disclosure Database (SDD) and Corporate Register (CR). In the first step of this



phase, the GRI SDD was explored, using two sector names (i.e., Energy Sector and Energy Utilities Sector) as a search criteria and names of individual countries that are the EU members. The review identified 260 organizations that have so far published at least one sustainability report, of which 170 belonged to the Energy Sector and 90 to the Energy Utilities Sector. A similar review was carried out for the CR database, except that in this case only one business sector name was used as the search criteria (i.e., Electricity Sector) and the names of individual countries that are the EU members. As a result, 152 companies from the electricity sector that have published at least one sustainability report so far were identified.

In the next step, data from the SDD and CR databases were combined, which allowed for the removal of duplicated organizations from the research sample. In addition, considering that energy companies operating in different countries may be part of a multinational energy group, the websites of all gathered companies were searched to determine if the company is part of such a group. In such a situation, it was checked whether the given group prepares one sustainability report presenting the impact of all the organizations belonging to the group. If the answer was positive, then only the parent company remained in the research sample and the subsidiaries were removed. This solution allowed us to avoid duplicating assessments of the same reports content. Consequently, the research sample was limited to 326 organizations.

Due to the fact that both SDD and CR include companies involved in the exploration, refining, transportation, and sale of crude oil, natural gas, and petrochemical products among the companies belonging to the energy sector, in the next step the areas of activity of these companies were reviewed. It was found that these companies may have a different approach to reporting GHG and CE issues than companies involved in energy production and distribution, which was confirmed by the separately prepared GRI Sector Information for the energy utilities sector and oil and gas sector. Therefore, we decided to remove from the research sample companies from the oil and gas sector whose activity is in no way related to the production, distribution and sale of electricity, leaving only the electric utility companies, i.e., companies in the electric power industry that engage in electricity generation, transmission, distribution, and sales [99]. These companies may be engaged in all or some specific aspects of the industry. There were 228 such companies in the research sample.

In the next step, the companies' websites were explored to check if a PDF format or an online version of the sustainability report was available. It turned out that only two companies from Finland, one company from Portugal, and one from Spain had no PDF format or online version available. For this reason, these organizations were excluded from further analysis. Then, it was verified whether an English version of the report was available. Unfortunately, as many as 101 organizations published their reports exclusively in their native language (mostly in Austria, Spain, and Italy). These reports were removed from the research sample to avoid translation errors.

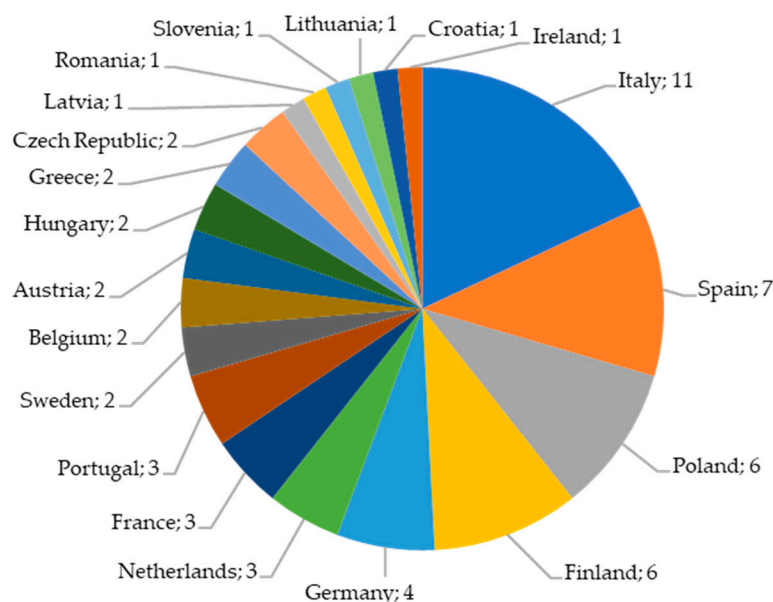
The last step in this phase was to investigate whether relevant reports were prepared based on the GRI guidelines published in 2016. For this purpose, the information presented in the SDD and CR databases, as well as information on the company's website or contained in sustainability reports, was verified again. On this basis, it was found that only 61 organizations from the energy sector in the EU publishing sustainability reports could be included in the final research sample. The quantitative data characterizing individual stages of the research sample selection are summarized in Table A2 in the Appendix A.

### 3.3. Data Collection

In the data collection phase, reports from all organizations included in the final research sample were obtained, then analyzed and assessed in accordance with established criteria. The latest available sustainability report was found for each organization from the research sample. The collection of reports took place in February and March 2020, however, in mid-April 2020, it was checked again for a newer version of the company's sustainability report (due to the fact that at the beginning of April many organizations were publishing reports for the previous year). As a result, 61 reports



were collected (in PDF format or online version available on the company's website), of which 1 was published in 2018, 34 in 2019, and 26 in 2020. The most reports in the research sample came from Italy, Spain, Finland, and Poland. However, the research sample did not include any reports from Bulgaria, Cyprus, Denmark, Estonia, Luxembourg, Malta and Slovakia. Figure 2 shows the number of reports included in the research sample, divided into individual EU countries. In addition, a list of all collected and analyzed reports with more detailed information is provided in Table A3 in Appendix A.

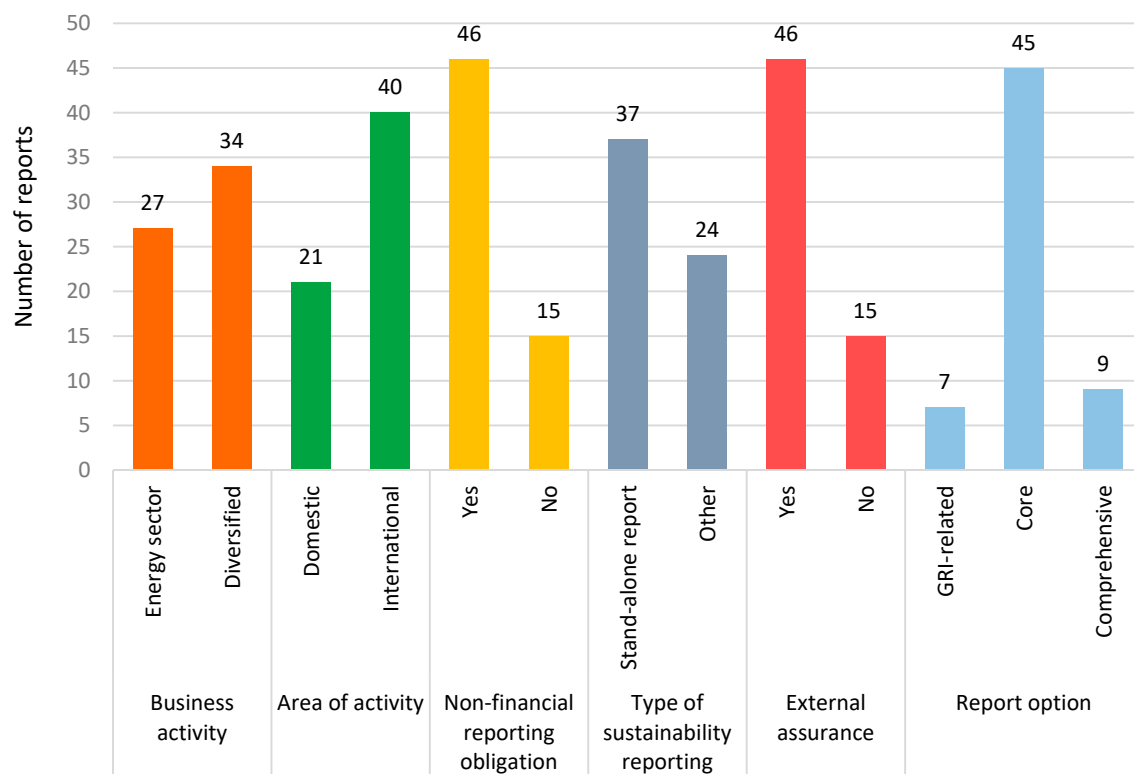


**Figure 2.** Number of sustainability reports included in the research sample (by country).

Considering the reports included in the final research sample, it can be concluded that almost 66% of reports were prepared by large multinational energy groups, which include companies operating in various countries. Of the companies we studied, 56% were those that, apart from operating in key segments of the energy market, also conduct other activities (e.g., coal mining or natural gas production, distribution, and supply). As many as 75% of the companies included in the research sample are required to report non-financial data (including data on environmental impact) in accordance with the Directive 2014/95/EU [100]. Almost 61% of the companies publish separate sustainability/CSR reports while other organizations present data on sustainability issues in annual reports with sustainability/CSR sections or in integrated reports (combining information previously presented in a separate financial statement, management commentary, activity report, or sustainability/CSR report in a coherent whole). All reports were prepared based on the GRI Standards, of which almost 74% in core option, 15% in comprehensive option, and 11% as GRI-related (i.e., reports prepared in the format recommended by GRI Standards, but without any information on which option of the report was selected). Most of the reports (75%) were verified by external units providing a limited assurance independent engagement in accordance with ISAE 3000 or the AA1000 Assurance Standard (2008) with 2018 addendum. The main characteristics of the research sample are shown in Figure 3.

In the next step, the qualitative content analysis of each of the identified reports was carried out [46,101,102]. This approach makes it possible to assess what is disclosed and how it is done by analyzing the content using and scoring specific criteria [103]. It was used in the prior research to explore sustainability reporting practices and to determine sustainability reporting quality (e.g., [44, 52,54,59,63,72,97,98,103,104]). In this study, qualitative content analysis was focused on the selected general and topic-specific disclosures included in GRI Standards identified as potentially related to GHG and CE issues. All observations for each report were classified and digitally stored together to formulate explicit conclusions and calculate relevant indices and indicators [105].





**Figure 3.** Characteristic of research sample.

The final step in this phase was the assessment of the reports. In order to assess the quality of the analyzed sustainability reports a measurement system focused on relevant reporting practices was adopted comprising criteria specific to GHG and CE issues as well as general ones. These criteria were systematically identified based on the analysis of Universal Standards and Topic-specific Standards included in the GRI Standards guidelines published in 2016 [106], to determine the possible inclusion of GHG and CE issues. The following assessment criteria were established:

- Quality of reporting GHG issues ( $QR_{GHG}$ ), comprising:
  - The occurrence of GHG issues at the strategic level ( $OSL_{GHG}$ )—defined by their occurrence in the statement from senior decision-maker (Disclosure 102-14), key impacts, risks, and opportunities (Disclosure 102-15), list of material topics (Disclosure 102-47), explanation of the material topic and its boundary and the management approach and its components (Disclosure 103-1 and 103-2).
  - The scope of information related to GHG issues ( $SI_{GHG}$ )—measured by indicators concerning direct GHG emissions (Disclosure 305-1), energy indirect GHG emissions (Disclosure 305-2), other indirect GHG emissions (Disclosure 305-3), GHG emissions intensity (Disclosure 305-4), and reduction of GHG emissions (Disclosure 305-5).
  - The accuracy of information related to GHG issues ( $A_{GHG}$ )—based on description of the specific methods used to gather, compile, and analyze information related to disclosures on emissions (Disclosure 305-1, 305-2, 305-3, 305-4 and 305-5).
- Quality of reporting CE issues ( $QR_{CE}$ ), comprising:
  - The occurrence of CE issues at the strategic level ( $OSL_{CE}$ )—described by their occurrence in the statement from senior decision-maker (Disclosure 102-14), key impacts, risks, and opportunities (Disclosure 102-15), list of material topics (Disclosure 102-47), explanation of



- the material topic and its boundary, and the management approach and its components (Disclosure 103-1 and 103-2).
- The scope of information related to CE issues ( $SI_{CE}$ )—defined by indicators concerning materials used by weight or volume (Disclosure 301-1), recycled input materials used (Disclosure 301-2), energy consumption within the organization (Disclosure 302-1), energy consumption outside of the organization (Disclosure 302-2), energy intensity (Disclosure 302-3), reduction of energy consumption (Disclosure 302-4), and waste by type and disposal method (Disclosure 306-2).
- The accuracy of information related to CE issues ( $A_{CE}$ )—based on description of the methods used to gather, compile, and analyze information related to disclosures on materials (Disclosure 301-1 and 301-1), energy (Disclosure 302-1, 302-2, 302-3 and 302-4) and waste (Disclosure 306-2).
- Clarity of reports (CLR)—based on the assessment of their content with regard to information available and required by stakeholders, the avoidance of excessive and unnecessary detail, possibilities of finding the specific information without unreasonable effort, the avoidance of technical terms or other content which may be unfamiliar to stakeholders, and the inclusion of relevant explanations.
- Comparability (CMP)—based on the assessment of the consistency of reported information and presentation of this information in a manner that empowers stakeholders to analyze changes over time, analytical comparisons on a year-to-year basis, including total numbers as well as ratios (e.g., normalized data per unit of production), and supporting analyses relative to other organizations.

Each criterion was assessed by using a 3-point scoring system similar to the scales applied in previous studies [63,71,107]. In general, depending in particular criterion the scale was as follows: 0—when relevant information for a specific disclosure topic was not mentioned or described, 1—when relevant information was partially provided or partially compliant with the disclosure requirements, and 2—when relevant information was compliant with the specific disclosure requirements. All analyzed sustainability reports were reviewed by three experts. In the case of discrepancies in the assessment results, the differences were discussed between experts and settled [74]. The applied assessment criteria and relevant scoring scales are presented in Table A4 in the Appendix A.

### 3.4. Calculation of Quality Assessment Indicators for Reporting GHG and CE Issues

The adopted research methodology makes use of aggregated indices on two quality assessment levels. The aggregation of qualitative assessment indices and indicators is an approach frequently used in the literature. It is an effective way to characterize and analyze selected quality features of sustainability reports [44,50,59,108]. Three indices (based on aggregating of selected indicators) were established on the first level and one aggregated index on the second, separately for the GHG issues and the CE issues.

The following three indices related to quality of reporting GHG issues assessment criteria were established on the first aggregation level:

- The occurrence of GHG issues at the strategic level ( $OSL_{GHG}$ ), calculated according to Equation (1);
- The scope of information related to GHG issues ( $SI_{GHG}$ ), calculated according to Equation (2);
- The accuracy of data related to GHG issues ( $A_{GHG}$ ), calculated according to Equation (3).

The aggregated index measuring quality of reporting GHG issues ( $QR_{GHG}$ ) was established on the second level. Being the arithmetic mean of the three indices mentioned above, the index was calculated according to Equation (4):

$$OSL_{GHG} = \frac{OSL_{GHG-SDM} + OSL_{GHG-IRO} + OSL_{GHG-LMT} + OSL_{GHG-BMA}}{4} \quad (1)$$



$$SI_{GHG} = \frac{SI_{GHG-DE} + SI_{GHG-IE} + SI_{GHG-OE} + SI_{GHG-EI} + SI_{GHG-RE}}{5} \quad (2)$$

$$A_{GHG} = A_{GHG-E} \quad (3)$$

$$QR_{GHG} = \frac{OSL_{GHG} + SI_{GHG} + A_{GHG}}{3} \quad (4)$$

The quality indices related to the reporting CE issues were established in the same manner. The following three indices related to quality of reporting CE issues assessment criteria were established:

- The occurrence of CE issues at the strategic level ( $OSL_{CE}$ ), calculated according to Equation (5),
- The scope of information related to CE issues ( $SI_{CE}$ ), calculated according to Equation (6),
- The accuracy of data related to CE issues ( $A_{CE}$ ), calculated according to Equation (7).

The aggregated index measuring the quality of reporting CE issues ( $QR_{CE}$ ), was calculated according to Equation (8) as the arithmetic mean of the three indices defined above.

$$OSL_{CE} = \frac{OSL_{CE-SDM} + OSL_{CE-IRO} + OSL_{CE-LMT} + OSL_{CE-BMA}}{4} \quad (5)$$

$$\frac{SI_{CE-MU} + SI_{CE-RM} + SI_{CE-ECW} + SI_{CE-ECO} + SI_{CE-EI} + SI_{CE-RE} + SI_{CE-WD}}{7} \quad (6)$$

$$A_{CE} = \frac{A_{CE-M} + A_{CE-E} + A_{CE-W}}{3} \quad (7)$$

$$QR_{CE} = \frac{OSL_{CE} + SI_{CE} + A_{CE}}{3} \quad (8)$$

In addition, two general indicators were used to assess the clarity of reports (CLR), in particular in relation to GHG and CE issues disclosed, and comparability (CMP) characterizing the presented data in terms of its consistency and possibilities of analyzing changes over time and making analytical comparisons.

### 3.5. Statistical Analysis of Collected Data

The statistical analysis of collected data was carried out in two steps. The first step was to calculate the descriptive statistics for all variables, such as mean and standard deviation values, and medians, minimum and maximum quality assessment values.

In the second step a comparative statistical analysis was conducted. A comparison was drawn at this stage of mean values of established quality indices and indicators in the determined groups of reports.

Six criteria were adopted for the division of reports into groups for comparisons. The established criteria and the groups are as follows:

- business activity—two groups: ‘energy sector’: reports of companies involved exclusively in the production, distribution, and sales of electricity, ‘diversified’—reports of companies conducting diversified business activity (including e.g., gas, petroleum or water distribution);
- non-financial reporting obligation—two groups: ‘yes’—reports of companies obliged to report non-financial information, ‘no’—reports of companies with no such obligation;
- area of activity—two groups: ‘domestic’—reports of companies operating in the territory of a single country, ‘international’—reports of companies operating in two or more countries;
- type of sustainability reporting—two groups: ‘stand-alone reports’—reports of the sustainability/CSR nature only, ‘other’—reports of a different character (e.g., integrated reports, annual reports);
- external assurance—two groups: ‘yes’—reports submitted for verification to an independent external unit, ‘no’—reports not submitted for external verification;



- report option—three groups: ‘GRI-related’—reports prepared based on the GRI Standards without stating any option, ‘core’—reports prepared in accordance with the GRI Standards core option, ‘comprehensive’—reports prepared in accordance with the GRI Standards comprehensive option.

To investigate the importance of differences between the mean values established in the groups, normality tests were performed of all analyzed indices and indicators. Due to the better power for a given statistical significance, the probability distribution of individual indices and indicators was verified using the Shapiro–Wilk tests [109]. The obtained results pointed to the lack of normality of the distributions of the variables under consideration. For this reason, nonparametric statistical tests were applied in further analyzes. In two groups the mean values were compared using the Mann–Whitney U test. Considering comparisons in three groups (i.e., based on report option) the Kruskal–Wallis one-way analysis of variance by ranks with post-hoc test was applied.

The final phase of the study included the interpretation of our results and the presentation of our main findings.

## 4. Results and Discussion

### 4.1. Descriptive Results

The first step of the analysis of the obtained results was characterization of the descriptive statistics on the quality of reporting GHG issues ( $QR_{GHG}$ ). On average, the  $QR_{GHG}$  value totaled 1.31 for all the evaluated reports, which indicates a relatively high quality of reporting in this area. It should be emphasized, however, that there are differences between the values of component indices of the  $QR_{GHG}$ . In particular, the occurrence of GHG issues at the strategic level ( $OSL_{GHG}$ ) is by far the most developed—its mean reached the highest value (1.66). Examples of statements from senior decision-maker in relation to GHG issues included in the analyzed sustainability reports are presented in Table 1.

The scope of information related to GHG issues ( $SI_{GHG}$ ) was assessed at the level of 1.19, and the mean for the accuracy of information related to GHG issues ( $A_{GHG}$ ) totaled 1.07.

With respect to  $OSL_{GHG}$  index, the highest mean (1.79) was obtained for the explanation of the material topic and its boundary and the management approach and its components ( $OSL_{GHG-BMA}$ ); the lowest mean (1.56) was found for key impacts, risks, and opportunities ( $OSL_{GHG-IRO}$ ). All indicators in this case reached relatively high values. The obtained values of standard deviation indicate that the evaluated reports are fairly homogeneous. For the  $OSL_{GHG-IRO}$  the standard deviation value is rather high (0.76), but for the other indicators the standard deviation values are included in the range of 0.45–0.59.

In the case of  $SI_{GHG}$  index, the direct GHG emissions ( $SI_{GHG-DE}$ ) won by far the highest mean of 1.62. The means obtained for the other indicators are included in the range of 0.92–1.23. The lowest mean was obtained for the reduction of GHG emissions ( $SI_{GHG-RE}$ ). It should be noted that the standard deviation values for the above-mentioned indicators are relatively high. This is due to considerable differences between the frequency of the occurrence of individual indicators included in the  $SI_{GHG}$  index in the analyzed reports and between the detail of their description. The most frequent were indicators related to direct GHG emissions ( $SI_{GHG-DE}$ ). Only 5 of the evaluated reports failed to include them. The other indirect GHG emissions ( $SI_{GHG-OE}$ ) and reduction of GHG emissions ( $SI_{GHG-RE}$ ) were the least frequent. These two indicators were not disclosed in 25 and 26 reports, respectively.

In the case of the  $A_{GHG}$ , the mean and the standard deviation values (1.07 and 0.75, respectively) are equal to the values obtained for their only component indicator: disclosure on emissions ( $A_{GHG-E}$ ).



**Table 1.** Examples of statements from senior decision-maker in relation to greenhouse gases (GHG) issues.

Company Name	Specific Statements from Senior Decision-Maker
A2A SpA	“Renewable sources, district heating and energy efficiency for the fight against climate change: ( . . . ) In 2018, we reduced CO <sub>2</sub> emissions per kilowatt hour produced by 10% compared to 2017.”
ALTEO Group	“ALTEO has reached a stage where it is able to substantially contribute to accomplishing energy and climate goals and—in respect of its activities and mission—it is able to serve as an example for other companies.”
Enel SpA	“A commitment that Enel has strengthened and expanded, revitalising the targets for reducing specific CO <sub>2</sub> emissions ( . . . ). An issue of primary importance in which Enel wants to play a leading role is undoubtedly the fight against climate change.”
ENI SpA	“The commitments we have made to continue our transformation process ( . . . ) remain intact, as our determination to fight climate change and our efforts towards a just energy transition ( . . . ) we want to be leaders in supplying decarbonized energy products, by combining economic and environmental sustainability.”
Hera Group	“Decarbonisation has become a signature part of our commercial offer ( . . . ) we are committed to reducing our impact on the climate by acquiring renewable electricity for all the Group’s main companies.”
Iren SpA	“The reduction of climate-changing emissions saw us involved in many initiatives in 2018.”
Naturgy Energy Group	“Within the context of the fight against climate change and technological transformation, our Strategic Plan is focused on renewable energies and natural gas ( . . . ). Emissions of greenhouse gases were reduced by about 11%.”
Red Eléctrica Group	“One of the greatest challenges facing humanity is that of combating climate change. Halting global warming requires urgent action worldwide to reconcile economic growth with the reduction of polluting emissions and this will only be possible through the transition to a decarbonised energy model.”
REPSOL Group	“With the technological advances of today, we envisage that we can achieve, at least, a 70% net emissions reduction by 2050, and we are committed to applying the best technologies to raise this figure ( . . . ). If this should prove not to be enough, we shall offset emissions through reforestation and other natural climate solutions to achieve net zero emissions by 2050.”
Siemens Gamesa Renewable Energy	“Siemens Gamesa is taking urgent action to combat climate change and its impacts ( . . . ). To avoid its worst effects, energy will have to be carbon-free, which is why we are committed to become carbon-neutral by 2025.”
TOTAL S.A.	“Total’s ambition is to be a leading player in energy, a player that contributes to the development of growing populations by supplying them with affordable energy, a player that helps provide answers to the climate challenge ( . . . ). Total acts on emissions, by first reducing emissions from its facilities (CO <sub>2</sub> and methane), but also by advising its customers in reducing their emissions.”
Vattenfall AB	“Driven by the need to gain control over the climate issue through lower carbon emissions, a transition is imperative ( . . . ). Vattenfall’s goal to achieve gradually lower emissions has been approved by the Science Based Targets initiative, which is proof that our goal is in line with the Paris Agreement’s CO <sub>2</sub> reduction targets going forward.”
Verbund AG	“We are planning to invest a total of around € 650m in the further expansion and maintenance of our hydropower facilities, thereby making a large contribution to mitigating climate change.”

The second step of results analysis was presentation of the descriptive statistics on the quality of reporting CE issues (QR<sub>CE</sub>). For the QR<sub>CE</sub>, the mean totaled 0.79. Considering the adopted assessment



scale, this demonstrates that the quality of reporting in this area is rather poor, especially in comparison with similar results obtained for GHG issues. The component indices of the  $QR_{CE}$  are at a different and lower level compared to the same indices adopted for GHG issues. The occurrence of CE issues at the strategic level ( $OSL_{CE}$ ) is the most developed, but the mean obtained for it is still relatively low—1.16. Examples of statements from senior decision-maker in relation to CE issues included in the analyzed sustainability reports are presented in Table 2.

**Table 2.** Examples of statements from senior decision-maker in relation to circular economy (CE) issues.

Company Name	Exemplary Statements from Senior Decision-Maker Related to CE
A2A SpA	“360° circular economy—more resources with less resources: We maximize the recovery of material and energy from waste, in full compliance with the objectives of the European Union.”
ALTEO Group	“ALTEO was actively involved in sustainability-related knowledge sharing in 2018 (...) I find the establishment of the Circular Economy Platform to be a very forward thinking initiative.”
Enel SpA	“Envisioning a sustainable and circular development model for cities means envisioning it for the entire planet ( ... ). Enel has made the circular economy a driver of its strategy, setting out a global vision and developing concrete actions for its Business Lines in various countries.”
ENI SpA	“We often talk about long-term vision, circular economy, about the need to find a new development model fit for human beings.”
Hera Group	“Hera is almost 20 years ahead of the EU’s circular economy goal and ranks at the same level as the most advanced European countries. (...) important initiatives intended to improve the “circularity” of our operating activities were introduced in 2019.
Iren SpA	“Circular economy: For Iren Group, the cornerstones include the increase in separated waste collection, the extension of the exact pricing system, the increase in material recovery and energy from non-recyclable waste.”
Naturgy Energy Group	“Naturgy has continued to introduce measures in 2018, which have enabled the business to reduce its externalities in the three company-defined strategic axes: climate and air quality, circular economy and natural capital and biodiversity.”
REPSOL Group	“The circular economy is at the heart of our strategy for both businesses.”

The scope of information related to CE issues ( $SI_{CE}$ ) was assessed at the level of 0.74, and the mean value for the accuracy of information related to CE issues ( $A_{CE}$ ) totaled 0.47.

As for the  $OSL_{CE}$  index, it can be noticed that its component indicators are assessed in the range from 0.92 for statement from a senior decision-maker ( $OSL_{CE-SDM}$ ) to 1.39 for an explanation of the material topic and its boundary and the management approach and its components ( $OSL_{CE-BMA}$ ). It can also be seen clearly that CE issues are frequently omitted in the key statements made by the senior decision-makers representing the analyzed companies. The obtained means are slightly less homogeneous compared to reports on GHG issues. The standard deviation values are included in the range from 0.53 for the  $OSL_{CE-BMA}$  to 0.80 for key impacts, risks, and opportunities ( $OSL_{CE-IRO}$ ).

In the case of the  $SI_{CE}$  index, the decidedly highest mean of 1.39 was obtained for energy consumption within the organization ( $SI_{CE-ECW}$ ). Waste by type and disposal method ( $SI_{CE-WD}$ ) came second with the mean of 1.15. The decidedly lowest mean of 0.13 was obtained for the recycled input materials used ( $SI_{CE-RM}$ ). The standard deviation values for these indicators are included in the range from 0.43 for the  $SI_{CE-RM}$  to 0.93 for energy intensity ( $SI_{CE-EI}$ ). It follows from the analysis of the reports that the most common disclosed in them was  $SI_{CE-ECW}$  and  $SI_{CE-WD}$ . They were not included only in 4 and 11 of the analyzed reports, respectively. There was very little information (if any at all) on



SI<sub>CE-RM</sub> or energy consumption outside the organization (SI<sub>CE-ECO</sub>). Information on these issues was given only in 6 and 14 reports, respectively.

In terms of the A<sub>CE</sub> index, disclosure on energy (A<sub>CE-E</sub>) won the highest mean of 0.64; the mean for disclosure on waste (A<sub>CE-W</sub>) totaled 0.49, and the lowest mean of 0.28 was obtained for disclosure on materials (A<sub>CE-M</sub>). The standard deviation values in this case are included in the range from 0.52 for the A<sub>CE-M</sub> to 0.66 for A<sub>CE-E</sub>.

Comparing the values of descriptive statistics on indices concerning the assessment of the quality of reporting GHG and CE issues, it can be noticed that the means of all indices related to GHG issues are higher than those obtained for the CE issues. The QR<sub>GHG</sub> is by 0.52 higher compared to the QR<sub>CE</sub>. In the case of component indices, the biggest difference of 0.60 is found for A<sub>GHG</sub> and A<sub>CE</sub>. For OSL<sub>GHG</sub> and OSL<sub>CE</sub>, the difference totals 0.50 and the smallest difference of 0.45 was recorded between SI<sub>GHG</sub> and SI<sub>CE</sub>.

The third step of results analysis in this phase revealed that the analyzed reports are characterized by a relatively high value of clarity (CLR)—the obtained mean totals 1.56, at a rather low level of comparability (CMP) (1.08).

The detailed descriptive statistics on the obtained results of the analysis are presented in Table 3.

**Table 3.** Descriptive statistics of the indices and indicators related to the assessment criteria.

Index/Indicator	Mean	Standard Deviation	Median	Minimum	Maximum
QR <sub>GHG</sub>	1.31	0.43	1.33	0.25	2.00
OSL <sub>GHG</sub>	1.66	0.39	1.75	0.50	2.00
OSL <sub>GHG-SDM</sub>	1.69	0.59	2.00	0.00	2.00
OSL <sub>GHG-IRO</sub>	1.56	0.76	2.00	0.00	2.00
OSL <sub>GHG-LMT</sub>	1.62	0.52	2.00	0.00	2.00
OSL <sub>GHG-BMA</sub>	1.79	0.45	2.00	0.00	2.00
SI <sub>GHG</sub>	1.19	0.63	1.20	0.00	2.00
SI <sub>GHG-DE</sub>	1.62	0.64	2.00	0.00	2.00
SI <sub>GHG-IE</sub>	1.23	0.90	2.00	0.00	2.00
SI <sub>GHG-OE</sub>	1.03	0.93	1.00	0.00	2.00
SI <sub>GHG-EI</sub>	1.16	0.92	2.00	0.00	2.00
SI <sub>GHG-RE</sub>	0.92	0.88	1.00	0.00	2.00
A <sub>GHG</sub>	1.07	0.75	1.00	0.00	2.00
A <sub>GHG-E</sub>	1.07	0.75	1.00	0.00	2.00
QR <sub>CE</sub>	0.79	0.34	0.74	0.17	1.65
OSL <sub>CE</sub>	1.16	0.44	1.25	0.25	2.00
OSL <sub>CE-SDM</sub>	0.92	0.71	1.00	0.00	2.00
OSL <sub>CE-IRO</sub>	1.03	0.80	1.00	0.00	2.00
OSL <sub>CE-LMT</sub>	1.28	0.58	1.00	0.00	2.00
OSL <sub>CE-BMA</sub>	1.39	0.53	1.00	0.00	2.00
SI <sub>CE</sub>	0.74	0.46	0.71	0.00	1.86
SI <sub>CE-MU</sub>	0.66	0.75	0.00	0.00	2.00
SI <sub>CE-RM</sub>	0.13	0.43	0.00	0.00	2.00
SI <sub>CE-ECW</sub>	1.39	0.61	1.00	0.00	2.00
SI <sub>CE-ECO</sub>	0.33	0.65	0.00	0.00	2.00
SI <sub>CE-EI</sub>	0.84	0.93	0.00	0.00	2.00
SI <sub>CE-RE</sub>	0.69	0.85	0.00	0.00	2.00
SI <sub>CE-WD</sub>	1.15	0.70	1.00	0.00	2.00



Table 3. Cont.

Index/Indicator	Mean	Standard Deviation	Median	Minimum	Maximum
A <sub>CE</sub>	0.47	0.49	0.33	0.00	2.00
A <sub>CE-M</sub>	0.28	0.52	0.00	0.00	2.00
A <sub>CE-E</sub>	0.64	0.66	1.00	0.00	2.00
A <sub>CE-W</sub>	0.49	0.60	0.00	0.00	2.00
CLR	1.56	0.53	2.00	0.00	2.00
CMP	1.08	0.42	1.00	0.00	2.00

#### 4.2. Factors Influencing the Quality of Reporting GHG and CE Issues

In order to identify potential determinants of the quality of reporting GHG and CE issues, an analysis was conducted of the significance of the differences between the means obtained for the indices and indicators distinguished in relation to: (1) business activity, (2) area of activity, (3) non-financial reporting obligation, (4) type of sustainable reporting, (5) external assurance, and (6) report option.

In the case of business activity, the mean values obtained for the quality of reporting GHG and CE issues (QR<sub>GHG</sub> and QR<sub>CE</sub>, respectively) as well as for comparability (CMP), are higher in the group of reports prepared by companies with a diversified business activity. However, it should be noted that the differences are relatively small, and it is only for CMP that they become statistically relevant ( $p = 0.009$ ). In the case of clarity (CLR) and occurrence of CE issues at the strategic level (OSL<sub>CE</sub>), a higher mean was obtained for reports from the energy sector, but the differences were of no statistical relevance. The results of the analysis indicate that business activity has an essential impact on comparability only. Interestingly, the reports of companies with a diversified business activity are more advanced compared to companies operating exclusively in the energy sector. These results suggest that diversified companies are more likely to disclose information in a manner that empowers stakeholders to analyze changes over time and to make analytical comparisons (i.e., disclosures of total and absolute numbers at least per two years, ratio per one year, or changes in ratios on a year-to-year basis). This may be the effect of operation in multiple organizational fields that makes it necessary to respond to numerous regulatory regimes and normative orders [80].

Considering the analyzed reports with respect to area of activity, the statistically significant difference occurs only for OSL<sub>GHG</sub> ( $p = 0.049$ ). Attention should be drawn to the differences concerning the SI<sub>GHG</sub>, QR<sub>CE</sub>, and CMP. However, the obtained  $p$ -values ( $p = 0.059$ ,  $p = 0.095$ , and  $p = 0.095$ , respectively) are above the 0.05 threshold. It should be added that the means obtained in the analyzed groups of reports are higher (except for the CLR) for companies operating internationally. The conducted analysis suggests that the area of activity influences sustainability reporting in terms of the occurrence of GHG issues at strategic level. This indicates that emphasizing sensitivity to climate change issues can have an impact on sustaining or improving international reputation [110]. In addition, Kolk and Fortanier (2013) claim that the internationalization of activity forces companies to balance between pressures of diverse stakeholders groups from home and host countries and this forces companies to disclose specific information [84].

With respect to the non-financial reporting obligation, the statistically significant difference ( $p = 0.025$ ) occurs for OSL<sub>GHG</sub>. As for the indicators expressed as SI<sub>GHG</sub> and OSL<sub>CE</sub>, the  $p$ -values are above the 0.05 threshold but still relatively low (0.055 and 0.079, respectively). The differences in the case of QR<sub>GHG</sub> and QR<sub>CE</sub> indices were found to be insignificant. It is worth noting, however, that except for the accuracy of data related to GHG issues (A<sub>GHG</sub>), the means obtained in the group of companies with the non-financial reporting obligation are higher compared to other companies. The prior research emphasized the role of regulation in improving the quality of disclosures [87]. However, this study indicates that non-financial information obligation inclines energy sector companies to disclose to a greater extent mostly GHG and CE issues at strategic levels.



Considering the analyzed reports in terms of the Type of sustainability reporting, the statistically significant difference occurs only for clarity (CLR) ( $p = 0.038$ ). The obtained mean is higher for stand-alone reports. No essential differences were observed for the other analyzed indices and indicators in the groups of companies distinguished based on the report type. In general, this is in line with research of Michelin et al. (2015) and Lock and Seele (2016), who found no differences between stand-alone reports and combined reports in terms of their quality and credibility [52,53]. It follows from the results that CLR of stand-alone reports is higher compared to other types of reports. It should be emphasized that combined reports (i.e., annual reports, integrated reports) are usually longer (e.g., due to inclusion of financial information) than stand-alone publications and this may influence their clarity [52].

With respect to the external assurance, statistically relevant differences were observed for the  $QR_{GHG}$  ( $p = 0.000$ ),  $OSL_{GHG}$  ( $p = 0.000$ ),  $SI_{GHG}$  ( $p = 0.001$ ),  $QR_{CE}$  ( $p = 0.002$ ),  $SI_{CE}$  ( $p = 0.004$ ),  $A_{CE}$  ( $p = 0.005$ ), CLR ( $p = 0.009$ ), and CMP ( $p = 0.004$ ). In this case, the obtained means were in each and every case higher for the companies whose reports were submitted to external assurance entities. This analysis shows that the external assurance has a wide impact on the quality of reporting GHG and CE issues as well as clarity of reports and comparability. These results confirmed evidence from prior studies on reporting quality and credibility in terms of external verification [50,92,93].

Considering the report option, statistically significant differences were found for:  $SI_{GHG}$  ( $p = 0.002$ ),  $SI_{CE}$  ( $p = 0.046$ ), CLR ( $p = 0.005$ ) and CMP ( $p = 0.017$ ). It should be noted that for the  $QR_{GHG}$  and  $QR_{CE}$  indices, the obtained  $p$ -values are above the 0.05 threshold. However, they remain at relatively low levels of 0.086 and 0.106, respectively. The Kruskal–Wallis post-hoc analysis revealed that statistically significant differences occur first and foremost between the core and comprehensive groups (for  $QR_{GHG}$ ,  $SI_{GHG}$ ,  $SI_{CE}$ ), and the relevant mean values are higher for the comprehensive group. It is only for the CLR that a statistically relevant difference occurred between the GRI-related and core reports, with the mean higher for the core group (interestingly, the core reports were characterized by higher clarity compared to reports from the comprehensive group). It is interesting that for some indices mean values are higher for the GRI-related group compared to core reports. However, it must be emphasized that only 7 GRI-related reports were assessed and therefore these results ought to be treated with utmost caution. Lock and Seele (2016) found that reports with high application levels of GRI guidelines are more credible than those without [52]. Based on the vast majority of analyzed quality indices and indicators this study confirms that sustainability reports with comprehensive option are significantly more developed than other reports. With respect to higher clarity of core reports compared to comprehensive group it may be affected by the criteria to claim a report has been prepared in accordance with the GRI Standards as the core or comprehensive option. For example, the comprehensive option means that for each identified material topic covered by a topic-specific GRI Standard, report must be in compliance with all reporting requirements for all topic-specific disclosures (while at least one topic-specific disclosure is expected for the core option) [11]. The disclosure of large amount of detailed data may affect its clarity for stakeholders. Therefore, avoidance of excessive and unnecessary detail or other content likely to be unfamiliar is of particular importance.

Detailed results of the analyses concerning the significance of differences between the investigated groups of companies are presented in Tables 4 and 5.



**Table 4.** Mann–Whitney U test results for comparison of report quality indices and indicators among the analyzed groups.

Index/Indicator	Business Activity			Area of Activity			Non-Financial Reporting Obligation			Type of Sustainability Reporting			External Assurance		
	Energy Sector	Diversified	Statistics	Domestic	Inter-National	Statistics	Yes	No	Statistics	Stand-Alone	Other	Statistics	Yes	No	Statistics
N	27	34		21	40		46	15		37	24		46	15	
QR <sub>GHG</sub>	M = 1.27 SD = 0.48	M = 1.34 SD = 0.39	Z = −0.51 p = 0.606	M = 1.17 SD = 0.51	M = 1.38 SD = 0.37	Z = 1.62 p = 0.106	M = 1.32 SD = 0.43	M = 1.25 SD = 0.44	Z = 0.56 p = 0.575	M = 1.33 SD = 0.46	M = 1.28 SD = 0.39	Z = 0.50 p = 0.616	M = 1.42 SD = 0.38	M = 0.95 SD = 0.38	Z = 3.56 *** p = 0.000
OSL <sub>GHG</sub>	M = 1.64 SD = 0.43	M = 1.68 SD = 0.36	Z = −0.30 p = 0.760	M = 1.54 SD = 0.42	M = 1.73 SD = 0.36	Z = 1.97 * p = 0.049	M = 1.72 SD = 0.34	M = 1.48 SD = 0.43	Z = 2.24 * p = 0.025	M = 1.73 SD = 0.35	M = 1.56 SD = 0.43	Z = 1.63 p = 0.104	M = 1.77 SD = 0.31	M = 1.33 SD = 0.43	Z = 3.71 *** p = 0.000
SI <sub>GHG</sub>	M = 1.10 SD = 0.65	M = 1.26 SD = 0.62	Z = −0.99 p = 0.323	M = 0.98 SD = 0.62	M = 1.30 SD = 0.62	Z = 1.89 † p = 0.059	M = 1.28 SD = 0.63	M = 0.93 SD = 0.57	Z = 0.91 p = 0.055 †	M = 1.17 SD = 0.69	M = 1.23 SD = 0.55	Z = −0.22 p = 0.829	M = 1.35 SD = 0.59	M = 0.72 SD = 0.53	Z = 3.36 *** p = 0.0005
A <sub>GHG</sub>	M = 1.07 SD = 0.83	M = 1.06 SD = 0.69	Z = 0.12 p = 0.907	M = 1.00 SD = 0.77	M = 1.10 SD = 0.74	Z = 0.48 p = 0.631	M = 0.98 SD = 0.71	M = 1.33 SD = 0.82	Z = −1.63 p = 0.104	M = 1.08 SD = 0.80	M = 1.04 SD = 0.69	Z = 0.23 p = 0.818	M = 1.15 SD = 0.73	M = 0.80 SD = 0.77	Z = 1.55 p = 0.120
QR <sub>CE</sub>	M = 0.75 SD = 0.33	M = 0.82 SD = 0.35	Z = −0.58 p = 0.556	M = 0.70 SD = 0.37	M = 0.84 SD = 0.32	Z = 1.67 † p = 0.095	M = 0.83 SD = 0.36	M = 0.66 SD = 0.22	Z = 1.27 p = 0.203	M = 0.83 SD = 0.38	M = 0.72 SD = 0.26	Z = 0.86 p = 0.392	M = 0.87 SD = 0.35	M = 0.55 SD = 0.14	Z = 3.08 ** p = 0.002
OSL <sub>CE</sub>	M = 1.08 SD = 0.43	M = 1.21 SD = 0.45	Z = −0.81 p = 0.420	M = 1.07 SD = 0.47	M = 1.20 SD = 0.43	Z = 1.03 p = 0.304	M = 1.22 SD = 0.41	M = 0.95 SD = 0.48	Z = 1.76 † p = 0.079	M = 1.18 SD = 0.45	M = 1.11 SD = 0.44	Z = 0.67 p = 0.503	M = 1.20 SD = 0.46	M = 1.02 SD = 0.36	Z = 1.08 p = 0.282
SI <sub>CE</sub>	M = 0.70 SD = 0.50	M = 0.77 SD = 0.43	Z = −0.86 p = 0.390	M = 0.63 SD = 0.42	M = 0.80 SD = 0.47	Z = 1.10 p = 0.273	M = 0.79 SD = 0.49	M = 0.60 SD = 0.32	Z = 1.15 p = 0.249	M = 0.77 SD = 0.52	M = 0.70 SD = 0.35	Z = −0.07 p = 0.941	M = 0.83 SD = 0.48	M = 0.46 SD = 0.26	Z = 2.92 ** p = 0.004
A <sub>CE</sub>	M = 0.46 SD = 0.43	M = 0.48 SD = 0.55	Z = 0.36 p = 0.717	M = 0.38 SD = 0.53	M = 0.52 SD = 0.47	Z = 1.26 p = 0.210	M = 0.49 SD = 0.52	M = 0.42 SD = 0.39	Z = 0.24 p = 0.814	M = 0.54 SD = 0.54	M = 0.36 SD = 0.39	Z = 1.18 p = 0.240	M = 0.57 SD = 0.51	M = 0.17 SD = 0.28	Z = 2.78 ** p = 0.005
CLR	M = 1.63 SD = 0.49	M = 1.50 SD = 0.56	Z = 0.85 p = 0.395	M = 1.57 SD = 0.60	M = 1.55 SD = 0.50	Z = −0.34 p = 0.731	M = 1.54 SD = 0.55	M = 1.60 SD = 0.51	Z = −0.28 p = 0.778	M = 1.68 SD = 0.47	M = 1.38 SD = 0.58	Z = 2.06 * p = 0.038	M = 1.65 SD = 0.53	M = 1.26 SD = 0.46	Z = 2.61 ** p = 0.009
CMP	M = 0.93 SD = 0.27	M = 1.21 SD = 0.48	Z = −2.61 ** p = 0.009	M = 0.95 SD = 0.50	M = 1.15 SD = 0.36	Z = 1.67 † p = 0.095	M = 1.13 SD = 0.45	M = 0.93 SD = 0.26	Z = 1.59 p = 0.112	M = 1.05 SD = 0.47	M = 1.13 SD = 0.34	Z = −0.59 p = 0.558	M = 1.17 SD = 0.38	M = 0.80 SD = 0.41	Z = 2.93 ** p = 0.004

M—mean; SD—standard deviation; Z—Mann-Whitney test value; p—probability value. †  $p < 0.1$ ; \*  $p < 0.05$ ; \*\*  $p < 0.01$ ; \*\*\*  $p < 0.001$ .



**Table 5.** Kruskal–Wallis analysis for analyzed indices and indicators among the report option groups.

Index/Indicator	Scope of the Report	M	SD	Mean Rank	Test Value	p-Value	Pairs of Groups with Statistically Significant Differences (Based on Post-Hoc Analysis)
QR <sub>GHG</sub>	GRI-related	1.30	0.43	30.65	4.90 <sup>†</sup>	0.086	Core–Comprehensive (p = 0.081)
	Core	1.25	0.42	28.65			
	Comprehensive	1.60	0.40	43.00			
OSL <sub>GHG</sub>	GRI-related	1.54	0.57	28.00	1.96	0.376	
	Core	1.66	0.35	30.04			
	Comprehensive	1.78	0.42	38.11			
SI <sub>GHG</sub>	GRI-related	1.37	0.56	35.29	12.59 <sup>**</sup>	0.002	Core–Comprehensive (p = 0.002)
	Core	1.04	0.61	26.71			
	Comprehensive	1.80	0.42	49.11			
A <sub>GHG</sub>	GRI-related	1.00	0.82	29.57	0.45	0.799	
	Core	1.04	0.77	30.56			
	Comprehensive	1.22	0.67	34.33			
QR <sub>CE</sub>	GRI-related	0.78	0.37	29.79	4.49	0.106	
	Core	0.73	0.29	28.88			
	Comprehensive	1.08	0.44	42.56			
OSL <sub>CE</sub>	GRI-related	1.14	0.64	28.64	1.90	0.386	
	Core	1.12	0.42	29.90			
	Comprehensive	1.33	0.40	38.33			
SI <sub>CE</sub>	GRI-related	0.71	0.51	28.86	6.15 <sup>*</sup>	0.046	Core–Comprehensive (p = 0.043)
	Core	0.66	0.39	28.63			
	Comprehensive	1.16	0.58	44.50			
A <sub>CE</sub>	GRI-related	0.48	0.42	33.07	2.76	0.256	
	Core	0.41	0.47	29.06			
	Comprehensive	0.74	0.62	39.11			
CLR	GRI-related	1.00	0.00	14.00	10.50 <sup>**</sup>	0.005	GRI-related–Core (p = 0.017)
	Core	1.67	0.48	34.00			
	Comprehensive	1.44	0.73	29.22			
CMP	GRI-related	1.00	0.00	28.50	8.12 <sup>**</sup>	0.017	
	Core	1.02	0.40	29.31			
	Comprehensive	1.44	0.53	41.39			

For each analysis, the degrees of freedom value is 2. <sup>†</sup>  $p < 0.1$ ; <sup>\*</sup>  $p < 0.05$ ; <sup>\*\*</sup>  $p < 0.01$ .

## 5. Conclusions

The achievement of climate neutrality and eco-economic decoupling requires explicit measures focused on GHG and CE issues. The energy sector is of particular importance in meeting these challenges because it exerts a substantial environmental impact. As indicated by the literature review, GHG issues are investigated in the context of the energy sector far more frequently than CE issues. The processes being the main source of GHG emissions are well known and so are the assumptions of the energy sector transformation needed to reduce them. What is still missing, though, is comprehensive research on the way in which the energy sector companies approach these issues. In the case of the CE concept in the energy sector, the main directions to follow to realize its assumptions in practice have already been identified. However, there are no in-depth studies on practical implementation of the solutions developed in this area. Therefore, it is extremely important to determine how essential



GHG and CE issues are for companies operating in the energy sector. This can be reflected in corporate strategies, but it can also be disclosed to the public in sustainability reports.

The results of in-depth analysis on disclosed GHG and CE issues show that the quality of sustainability reporting the former is substantially higher compared to the latter. This concerns the occurrence of the analyzed issues at the strategic level, as well as the scope of information and the accuracy of data related to them. Both for GHG and CE issues, the highest quality of the reported information occurred at the strategic level. Information on individual indicators was presented with an average quality. The quality of the information accuracy was evaluated the lowest. Moreover, the reported information ranked relatively high for clarity and relatively low for comparability. In general, the research results indicate that sustainability reports from the energy sector companies tend to focus more on GHG issues. They rarely point to actions related to CE, including actions enabling a reduction in GHG emissions, as those with a high priority. Undoubtedly, this shows that the energy sector companies should take a greater interest in CE issues. It should also be emphasized that declarations from the analyzed companies about their intentions related to GHG and CE issues at the strategic level are rather poorly reflected in the description of specific actions in this area or in demonstrating appropriate indicators at the operational level. As for the indicators included in the reports, it should be noted that the analyzed companies insufficiently describe the methods they use to gather, compile, and analyze information on the effectiveness of actions taken to address GHG and, in particular, CE issues.

As for identification of potential determinants of the quality of reporting GHG and CE issues, the results of the presented research demonstrate that external assurance has a statistically significant impact on almost all indices and indicators of the assessment of the reporting quality under analysis. In the case of reports submitted for external assurance, the mean values obtained are decidedly higher. Many statistically essential differences can be observed for the report option. Based on the vast majority of analyzed quality indices and indicators this study confirms that sustainability reports with the comprehensive option are significantly more developed than other reports. However, the higher clarity of core reports compared to comprehensive group was observed which suggests that disclosure of large amount of detailed data may affect clarity of sustainability reports. With respect to area of activity and non-financial reporting obligation, a statistically significant difference occurs for the occurrence of GHG issues at the strategic level. Nevertheless, in general, most of the analyzed indices and indicators reached higher values for companies operating internationally. Similarly, most of the analyzed means obtained in the group of companies with the non-financial reporting obligation are higher compared to other companies. According to the research results, the business activity and the type of sustainability reporting have the smallest impact on the reported information quality. However, it should be emphasized that Business activity has an essential impact on comparability and reports of companies with a diversified business activity (i.e., operating in multiple organizational fields) are more advanced compared to companies operating exclusively in the energy sector. Clarity, in turn, of stand-alone reports is higher compared to other types of reports.

It should be mentioned that according to the Directive 2014/95/EU on disclosure of non-financial information [100], a significant part of companies whose sustainability reports have been analyzed are required to disclose environmental issues that include information on GHG and CE. Most of these companies disclose only information on the overall environmental and social impact of their activities. It is worth noting that the latest guidelines of the European Commission on reporting non-financial information [111,112] recommend that companies, especially from the energy sector, also disclose information on the impact of environmental issues, including in particular the impact of climate change, on the development, results, and financial situation of the companies. This information should assess the risks associated with the transition to a low carbon and climate resilient economy, including the policy, legal, technology, market, and reputational risks [112].

The presented analysis included reports prepared in accordance with the GRI guidelines, which entered into force in 2018. It should be noted that the Global Sustainability Standards Board (GSSB) constantly reviews the standards to update them and to develop new standards. A major update to



the GRI Standards is currently underway. This applies to GRI's Universal Standards, which consist of GRI 101: Foundation 2016, GRI 102: General Disclosures 2016, and GRI 103: Management Approach, 2016. The revisions seek to improve the quality and consistency of reporting and to improve how organizations use the standards to disclose their impacts on the economy, environment, and people. This may have a positive impact on improving quality of reporting GHG and CE issues. Updated Standards are to be released in the first half of 2021.

Although considerable efforts have been made to perform this analysis in the most accurate manner, like all studies, this one is not without limitations. Nevertheless, the obtained findings offer new directions for future research. The main identified limitation concerns the sample selection. The research was focused exclusively on the energy sector. Therefore, future studies assessing GHG and CE issues in other industries may provide new results using a broader perspective. To generate an appropriate sample of sustainability reports, the two most recognized global online databases were used (i.e., GRI's Sustainability Disclosure Database and Corporate Register). However, as companies are not obliged to add reports to these databases, organizations that did not do so were omitted in the research sample. Taking account of the purpose of this study, reports based on the latest GRI Standards were selected and analyzed as the best practice in terms of sustainability reporting. The idea of acquiring information on GHG and CE issues in the future from other corporate documents and websites is worth considering. A decision was made to analyze sustainability reports published in English only. As shown by the research results, energy companies to a large extent publish sustainability reports in their native languages. Therefore, future studies may be extended to cover reports disclosed in languages other than English. However, this would mean engaging an international research team. The research could also be improved by enlarging the sample size. The presented analysis is focused on the EU member states. Further studies with a wider sample including companies from other regions would highlight new important aspects of the analyzed issues. The directions for further research may also comprise other possible factors influencing the quality of reporting GHG and CE issues, e.g., the company size or the country specificity. Unfortunately, this study was dominated by reports from large companies (i.e., the analysis covered 59 documents from large entities and 2 from medium-sized organizations), and there was a limited number of companies from the same country. Future studies with a larger sample of companies operating in different countries would make the findings more generalizable. It should also be noted that the focus of this study was on reporting and not on actual performance in terms of GHG and CE issues. In addition, the research was based on subjective evaluation, but all reports were reviewed by three experts and whenever discrepancies appeared in the assessment, the differences were discussed and settled.

Nevertheless, it should be emphasized again that efforts were made to provide as comprehensive evidence in the area under analysis as possible. Therefore, despite the above mentioned limitations, we believe that this study makes important contributions to state-of-the-art assessment of the quality of reporting GHG and CE issues in sustainability reports from the companies representing the energy sector in the EU and to exploration of specific factors influencing this quality.

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## Appendix A

**Table A1.** Overview of research on the sustainability reports assessment in the energy sector.

Authors	Method	Assessment Subject	Types of Analysis	Types of Reports	Sample
Alrazi et al. (2010) [68]	Content analysis	Environmental reporting quality	Quality	Corporate website, annual reports and a stand-alone report on sustainability issues	51 electric utilities from 19 countries (Australia, Brazil, Canada, Chile, Czech Republic, France, Germany, Italy, Japan, Korea, Hong Kong, Malaysia, New Zealand, Portugal, Russia, Spain, Thailand, UK, USA)
Alrazi et al. (2014) [77]	Content analysis	Carbon-related information	Quantity and quality	Annual reports, stand-alone sustainability reports and corporate websites	9 Malaysian companies (major power producers)
Alrazi et al. (2016) [78]	Content analysis	Quality of CO <sub>2</sub> emissions information and overall environmental information	Quality	Corporate website, annual reports and a stand-alone report on sustainability issues	205 electricity generation firms representing 35 countries.
Al-Shaer (2020) [43]	Assessment of the adoption and non-adoption of sustainability reporting practices	Quality of sustainability reporting	Quality	Any types of reports	350 UK companies (10 different industrial sectors, including energy and utilities)
Amran et al. (2014) [44]	Content analysis based on measure of sustainability reporting quality	Credibility of sustainability reports	Quality	Sustainability reports and annual reports	113 Asia-Pacific region companies from 12 countries (Australia, New Zealand, China, India, Indonesia, Korea, Malaysia, Philippines, Singapore, Taiwan, Thailand, Japan) (different sectors, including electricity generation)
Bahari et al. (2016) [79]	Content analysis using carbon disclosure index	Extent of carbon information reporting	Quality	Annual reports, stand-alone sustainability reports and corporate websites	90 Asian electricity generating companies (44 Indian, 26 Chinese, 20 Japanese)
Bakhtina and Goudriaan (2011) [69]	Content analysis	Quality of reporting employment issues as part of corporate social responsibility	Quality	CSR reports	10 large multinational energy companies
Barkemeyer et al. (2015) [56]	Content analysis	Content of corporate sustainability reports	Quality	Sustainability reports prepared in accordance with GRI G3 guidelines	933 companies from 30 countries (7 different sectors, including 188 companies from electricity sector)
Bhatia and Tuli (2018) [57]	Content analysis using sustainability disclosure index based on the GRI-G3 guidelines	Quality of sustainability disclosures	Quality	Sustainability reports	232 companies from BRIC countries, UK and USA (different sectors, including 19 companies from power sector)



Table A1. Cont.

Authors	Method	Assessment Subject	Types of Analysis	Types of Reports	Sample
Bonsón and Bednárová (2015) [45]	Content analysis using Integrated Scorecard Taxonomy Scoreboard	Extent to which Eurozone companies report on CSR indicators	Quality	Annual reports or separated sustainability reports	306 Eurozone companies from 12 countries (19 different subsectors, including utilities)
Camargos et al. (2014) [66]	Content analysis using exploratory and comparative study	Analysis of patterns of using the GRI guidelines and indicators	Quality	Sustainability reports prepared in accordance with the GRI-G3 guidelines	12 Brazilian companies (electric utilities sector)
Chang (2013) [64]	Content analysis	Analysis of environmental information disclosure	Quality	Social responsibility reports	25 Chinese electric firms
Ching et al. (2013) [46]	Content analysis based on GRI framework	Quality of information disclosed	Quality	Reports with socio-environmental information	60 Brazilian companies (4 different economic sectors, including electric utility companies)
Daub (2007) [47]	Benchmark study based on individual criteria	Quality of corporate sustainability reporting	Quality	Reports with information on economic, ecological or social performance	76 Swiss companies (different sectors, including energy supply companies)
Dyduch and Krasodomska (2017) [48]	Content analysis using disclosure weighted index	Quality of CSR disclosures	Quality	CSR disclosures in annual reports and integrated reports	60 Polish non-financial companies (different sectors, including 6 companies representing energy industry)
Fernandez-Feijoo et al. (2014) [49]	Quantitative content analysis	Transparency of the sustainability reports	Quantity	Sustainability reports from the GRI database	1047 companies from 10 countries (38 different sectors, including energy and energy utilities)
Gallego (2006) [58]	Content analysis	Analysis of economic, social and environmental information	Quality and quantity	Sustainability reports and annual reports	19 Spanish companies (different sectors, including 7 companies representing energy and water)
Hábek (2017) [50]	Content analysis using a quality indicator	Quality of CSR reports	Quality	CSR reports—GRI-based and non-GRI	44 companies from Visegrad Group (Czech Republic, Hungary, Poland, Slovakia) (different sectors, including energy and energy utilities)
Kraft (2018) [76]	Content analysis	Substantiveness of climate disclosures	Quality	Annual reports	45 electric utilities companies operating in the USA
Leitonienea and Sapkauskienė (2015) [51]	Content analysis using a quality index	Quality of CSR information	Quality	Reports of socially responsible companies	48 Lithuanian companies (different sectors, including 4 energy companies)



Table A1. Cont.

Authors	Method	Assessment Subject	Types of Analysis	Types of Reports	Sample
Lock and Seele (2016) [52]	Human and software-enhanced quantitative content analysis	Credibility of CSR reports	Quantity and quality	CSR reports—GRI-based (G3, G3.1, and G4) and non-GRI	237 European companies from 11 countries (Austria, Belgium, France, Germany, Italy, the Netherlands, Poland, Spain, Sweden, Switzerland, UK) (different sectors, including 33 companies from energy and energy utilities)
Loza Adauí (2020) [59]	Content analysis using multidimensional approach for SRQ evaluation	Quality of sustainability reporting	Quality	Sustainability reports or annual reports containing sustainability disclosures	27 Peruvian companies (different sectors, including 10 companies from energy, electricity and oil sector)
Matuszak and Róžańska (2017) [60]	Content analysis	Extent and quality of CSR reporting quantify the CSR-disclosure practices,	Quality	CSR disclosure data in annual reports, CSR reports and the websites	150 Polish companies (26 different sectors, including 6 energy companies)
Michelon et al. (2015) [53]	Content analysis based on GRI (G3) framework	Quality of CSR disclosures	Quantity and quality	CSR or sustainability reports—GRI based and non-GRI	112 UK companies (different sectors, including utility industries)
Moseñe et al. (2013) [65]	Content analysis	Comparison of the levels of compliance with GRI indicators of environmental sustainability	Quality	Sustainability reports	7 Spanish companies (wind energy sector)
Ng and Nathwani (2012) [70]	Comparative case study using sustainability performance scorecard	Assessment of sustainability performance	Quality	Annual reports	3 global companies (independent power producers)
Papoutsi and Sodhi (2020) [54]	Content analysis using scoring system	Extent to which sustainability reports indicate corporate sustainability performance	Quality	Sustainability reports obtained from the Sustainability Disclosure Database	331 companies: 117 American or Canadian and 214 European. (18 different sectors, including 35 energy and utilities companies)
Rankin et al. (2011) [61]	Content analysis	Extent and credibility of GHG disclosure	Quality	Annual reports and stand-alone environment or sustainability reports	187 Australian companies (different sectors, including 61 energy and mining companies)
Roca and Searcy (2012) [55]	Content analysis	Analysis of indicators disclosed in corporate sustainability reports	Quantity and quality	Corporate sustainability reports	94 Canadian companies (different sectors, including electricity)



Table A1. Cont.

Authors	Method	Assessment Subject	Types of Analysis	Types of Reports	Sample
Sartori et al. (2017) [67]	Data Envelopment Analysis using sustainability indicators	Assessment of sustainability performance	Quantity and quality	GRI reports	17 Brazilian companies (electricity power industry)
Slacik and Greiling (2019) [72]	Content analysis and logic and conversation theory (LCT)	The coverage and quality of documented material aspects	Quality	Sustainability reports prepared in accordance with GRI-G4 guidelines	186 English and German companies (electric utility sector)
Slacik and Greiling (2020) [73]	Quantitative content analysis	Sustainability reporting practice and coverage rates of G4-indicators	Quantity	Sustainability reports prepared in accordance with GRI-G4	186 companies from 45 countries (electric utilities sector)
Steinweg and Wilde-Ramsing (2012) [71]	Content analysis using GRI Content Index template and Checklist	Overview of the use of the GRI Guidelines	Quality	CSR/sustainability reports and associated or accompanying websites—GRI-based and non-GRI	19 European companies (electric utility sector)
Szczepankiewicz and Mućko (2016) [62]	Content analysis	Quality and variety of information disclosed	Quantity and quality	CSR and similar reports prepared in accordance with the GRI-G4 guidelines	9 Polish companies (energy and mining sector, including 6 energy companies)
Talbot and Boiral (2018) [75]	Qualitative and inductive content analysis	Quality of climate information and impression management strategies	Quality	Sustainability reports prepared in accordance with the G3 or G3.1 of GRI guidelines	21 companies from different countries (energy sector)
Traxler and Greiling (2019) [74]	Documentary analysis	Coverage of GRI indicators	Quantity	Sustainability reports prepared in accordance with GRI-G4	83 companies from 28 different countries (electric utilities sector)
Tsalis et al. (2020) [63]	Content analysis and benchmarking-scoring framework	Level of alignment of CSR practices with the scope of UN-SDGs.	Quality	Stand-alone sustainability reports	20 Greek companies (different industry sectors, including 4 energy and energy utilities companies)



**Table A2.** Summary of quantitative data from the subsequent steps of selection of research sample.

Country	Number of Organizations Included in the Databases			Total Number of Organizations after Removal of Duplicate Organizations and Subsidiary Companies of other Entities Contained in the Databases	Number of Organization Categorized as Electric Utility Company	Number of Organization Preparing Report in PDF or Online Version	Number of Organization Preparing Report in English	Number of Organization Preparing Report in Accordance with GRI Standard (Final Research Sample)
	SDD GRI Database		Corporate Register					
	Energy Sector	Energy Utilities Sector	Electricity Sector					
Austria	9	10	10	26	22	22	7	2
Belgium	2	5	5	11	5	5	4	2
Bulgaria	0	0	0	0	0	0	0	0
Croatia	2	0	1	3	1	1	1	1
Cyprus	0	0	0	0	0	0	0	0
Czech Republic	3	0	1	2	2	2	2	2
Denmark	3	1	10	13	11	11	10	0
Estonia	1	0	1	1	1	1	1	0
Finland	17	4	9	22	18	16	10	6
France	12	7	13	25	15	15	10	3
Germany	15	13	21	35	28	28	6	4
Greece	8	3	2	9	3	3	2	2
Hungary	7	4	6	14	11	11	9	2
Ireland	0	2	n.d.	2	1	1	1	1
Italy	23	12	17	44	33	33	14	11
Latvia	1	1	2	2	2	2	1	1
Lithuania	0	1	4	4	4	4	4	1
Luxemburg	1	1	0	2	1	1	1	0
Malta	0	0	0	0	0	0	0	0
Netherlands	8	5	0	13	6	6	5	3
Poland	10	7	4	13	7	7	7	6
Portugal	4	2	4	9	7	6	4	3
Romania	7	1	4	8	3	3	3	1
Slovakia	1	0	0	1	1	1	1	0
Slovenia	1	0	2	3	2	2	2	1
Spain	21	9	20	36	30	29	16	7
Sweden	14	2	16	28	14	14	2	2
Total:	170	90	152	326	228	224	123	61



**Table A3.** List of sustainability reports included in the research sample.

Company Name	Country	Report Title	Year of Publication
A2A SpA	Italy	2018 Integrated report	2019
AB Kauno Energija	Lithuania	2018 Supplement integrated report	2019
Acea SpA	Italy	Consolidated Sustainability Report in Accordance with GRI Standards 2018	2019
Aliander NV	Netherlands	Sustainability report Acea group 2018	2019
Alperia SpA	Italy	Annual Report 2018	2019
ALTEO Group	Hungary	Our commitment to the future. Sustainability Report 2018	2019
Caruna	Finland	ALTEO Group / Integrated Report 2018	2020
CEZ Group	Czech Republic	CARUNA. Positive energy. Caruna's year 2019	2020
CNTEE Transelectrica SA	Romania	The CEZ Group Sustainability Report. Energy for the future.	2019
E.ON SE	Germany	Sustainability report 2018	2019
EDF Group	France	2019 Sustainability Report. Our energy future is green.	2020
EDP	Portugal	Reference Document 2018 including the Annual Financial Report	2019
EEW Energy from Waste GmbH	Germany	EDP. Sustainability Report 2019	2020
Elawan Energy S.L.	Spain	Sustainability report 2018	2019
Elecnor Group	Spain	Sustainability Report 2018	2019
Electricity Supply Board (ESB)	Ireland	Integrated Report 2018	2019
ELES d.o.o.	Slovenia	EBS. Energy for generations. Sustainability Report 2017	2018
Elia Group	Belgium	New era of energy. Annual Report of ELES for 2018	2019
Ellevio AB	Sweden	Ready to accelerate. Sustainability report 2019	2020
Enea Group	Poland	Ellevio 2019	2020
Enel SpA	Italy	Enea Group CSR Report 2018	2019
Energa Group	Poland	Sustainability report 2018	2019
Energetický a průmyslový holding (EPH)	Czech Republic	Our responsibility 2018	2019
Enexis Holding NV	Netherlands	EPH. Sustainability Report 2018	2019
ENI SpA	Italy	Energy in a NEW REALITY. Annual report 2019	2020
ERG SpA	Italy	ENI for 2019 Sustainability performance	2020
EVN Group	Austria	Eni for 2019 A just transition	2019
Falck Renewables SpA	Italy	Sustainability report 2018	2019
Fingrid Oyj	Finland	Energy. Water. Life. EVN Full Report 2018/19	2019
Fluvius System Operator CVBA	Belgium	Sustainability at the CORE report 2019	2020
Fortum	Finland	Annual Report 2019 Fingrid	2020
Galp Energia, SGPS, S.A.	Portugal	Annual report 2018. Connecting sustainably.	2019
GASUM	Finland	Fortum. Join the change. Sustainability 2019	2020
HEP Group (Hrvatska elektroprivreda d.d.)	Croatia	Energy emotion. Galp Integrated Report 2019	2020
Hera Group	Italy	Gasum Corporate Responsibility 2018	2019
Iberdrola Group	Spain	Open way for sustainability.	2019
Iren SpA	Italy	Sustainability Report 2018	2020
Latvenergo AS	Latvia	Sustainability report 2019	2020
MVM Group	Hungary	Statement of Non-Financial Information.	2020
Naturgy Energy Group	Spain	Sustainability Report. Financial year 2019	2019
PGE Polska Grupa Energetyczna	Poland	Sustainability report 2018	2019
Polski Koncern Naftowy ORLEN (PKN ORLEN)	Poland	Integrated Report 2018 PGE Capital Group	2019
Polskie Sieci Elektroenergetyczne (PSE)	Poland	Orlen Group 2018 Integrated Report	2019
PUBLIC POWER CORPORATION (PPC)	Greece	Filling Poland with Power. PSE Impact Report 2018	2019
Red Eléctrica Group	Spain	Corporate Social Responsibility and Sustainability Report 2018	2019
REN (Redes Energéticas Nacionais)	Portugal	Sustainability report 2018	2019
REPSOL Group	Spain	REN. Driving Energy. Reports&Accounts 2019	2020
RWE AG	Germany	Integrated Management Report 2019	2020
Siemens Gamesa Renewable Energy	Spain	Our Responsibility 2019	2020
SOL SpA	Italy	Consolidated Non-Financial Statement 2019 (former Sustainability Report)	2020
SUEZ	France	Sustainability report SOL group 2018	2019
		A company for society. 2019 Integrated Report	2019



Table A3. Cont.

Company Name	Country	Report Title	Year of Publication
TAURON	Poland	Report on non-financial information of TAURON Capital Group for 2019	2020
TenneT Holding BV	Netherlands	Integrated Annual Report 2019 CSR data linked to Integrated Annual Report 2019	2020
Teollisuuden Voima Oyj (TVO)	Finland	Responsibility Report 2019	2020
TERNA ENERGY S.A.	Greece	Terna Group. Sustainable Development Report 2018	2019
Terna SpA	Italy	Sustainability report 2019	2020
TOTAL S.A.	France	Universal Registration Document 2019 including Annual Financial Report	2020
Uniper SE	Germany	Sustainability report 2019. Empower Energy Evolution.	2020
Vapo Group	Finland	Vapo Group Corporate Responsibility Report 2018. Sustainable everyday living	2019
Vattenfall AB	Sweden	Annual and Sustainability Report 2019	2020
Verbund AG	Austria	Shaping a sustainable energy future. Our drive. Our energy. Integrated Annual Report 2019	2020

Table A4. Assessment criteria and applied scoring scales.

Criterion Name	Assessment Scale
Quality of reporting GHG issues ( $QR_{GHG}$ )	
Occurrence of GHG issues at strategic level ( $OSL_{GHG}$ )	0—GHG issues not mentioned 1—GHG issues mentioned indirectly 2—GHG issues mentioned directly
Statement from senior decision-maker ( $OSL_{GHG-SDM}$ )	
Key impacts, risks, and opportunities ( $OSL_{GHG-IRO}$ )	
List of material topics ( $OSL_{GHG-LMT}$ )	
Explanation of the material topic and its boundary and the management approach and its components ( $OSL_{GHG-BMA}$ )	
Scope of information related to GHG issues ( $SI_{GHG}$ )	0—lack of relevant indicators 1—indicators partially compliant with the disclosure requirements 2—indicators compliant with the disclosure requirements
Direct GHG emissions ( $SI_{GHG-DE}$ )	
Energy indirect GHG emissions ( $SI_{GHG-IE}$ )	
Other indirect GHG emissions ( $SI_{GHG-OE}$ )	
GHG emissions intensity ( $SI_{GHG-EI}$ )	
Reduction of GHG emissions ( $SI_{GHG-RE}$ )	
Accuracy of data related to GHG issues ( $A_{GHG}$ )	0—methods not described 1—methods partially described 2—full description of relevant methods
Disclosure on emissions ( $A_{GHG-E}$ )	
Quality of reporting CE issues ( $QR_{CE}$ )	
Occurrence of CE issues at strategic level ( $OSL_{CE}$ )	0—CE issues not mentioned 1—CE issues mentioned indirectly 2—CE issues mentioned directly
Statement from senior decision-maker ( $OSL_{CE-SDM}$ )	
Key impacts, risks, and opportunities ( $OSL_{CE-IRO}$ )	
List of material topics ( $OSL_{CE-LMT}$ )	
Explanation of the material topic and its boundary and the management approach and its components ( $OSL_{CE-BMA}$ )	0—lack of relevant indicators 1—indicators partially compliant with the disclosure requirements 2—indicators compliant with the disclosure requirements
Scope of information related to CE issues ( $SI_{CE}$ )	
Materials used by weight or volume ( $SI_{CE-MU}$ )	
Recycled input materials used ( $SI_{CE-RM}$ )	
Energy consumption within the organization ( $SI_{CE-ECW}$ )	
Energy consumption outside of the organization ( $SI_{CE-ECO}$ )	
Energy intensity ( $SI_{CE-EI}$ )	
Reduction of energy consumption ( $SI_{CE-RE}$ )	
Waste by type and disposal method ( $SI_{CE-WD}$ )	
Accuracy of data related to CE issues ( $A_{CE}$ )	0—methods not described 1—methods partially described 2—full description of relevant methods
Disclosure on materials ( $A_{CE-M}$ )	
Disclosure on energy ( $A_{CE-E}$ )	
Disclosure on waste ( $A_{CE-W}$ )	



Table A4. Cont.

Criterion Name	Assessment Scale
Clarity (CLR)	0—difficult to read and to find specific information, unfamiliar content 1—relatively difficult to read and to find specific information, content relatively unfamiliar to the reader 2—easy to read and to find specific information, content familiar to the reader
Comparability (CMP)	0—indicators include only total and absolute numbers per one year 1—indicators include total and absolute numbers at least per two years or ratio per one year 2—indicators enable determination of the trend of changes in ratios on a year-to-year basis

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