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RESEARCH ARTICLE

The overall sustainability index (OSI): A suitable way to measure the sustainability of electrical industry in Italy

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Abstract

The objective of this research is to develop a comprehensive and effective quantitative method to measure the overall sustainability performance of electric companies in Italy. Due to the vast diversity of the sustainability issues, many methods have been developed to measure the sustainability performance of companies, but with results that are, in our opinion, not fully satisfactory, either because they are difficult to apply or because they only cover some of the sustainability aspects. In an attempt to overcome these shortcomings, we have applied a methodology to meet the requirements of our research, on the basis of its high versatility (https://lab24.ilsole24ore.com/qualita-della-vita/). The analysis was carried out on the 12 largest Italian electricity companies, by calculating the overall sustainability index (OSI) for the years 2020 and 2021, taking into account 56 different indicators, chosen from those made available by the Global Reporting Initiative (GRI) for corporate sustainability reporting. For a more comprehensive evaluation of the sustainability performance of the electricity companies, selected indicators were chosen from all the three pillars of sustainability (economic, environmental, social). The OSI results of this research have allowed to highlight the critical points of the corporate reporting systems on sustainability providing valuable indications on the targets achieved and achievable in view of the European Commission's Green Deal 2050. This work also highlighted the strengths and weaknesses of the method.

KEYWORDS
electricity company, GRI, OSI, sustainability index, sustainability report

1 | INTRODUCTION

The 2021 'Report on the National Energy Situation'[1] prepared by the Italian Ministry of the Environment and Energy Security (MASE), shows how the country's energy sector reacted positively following the pandemic shock of 2020: primary energy demand was 153,024 thousand tons of oil equivalent (ktep), an increase of 6.2% over the previous year.

How do these changes affect the levels of sustainability achieved by Italian electricity companies? Is there a way to assess this sustainability concretely, starting from the data contained in the corporate sustainability reports published annually by electricity companies? Are the data obtained comparable with those of the previous year? All these questions form the basis of this work.

[1]https://dgsaie.mise.gov.it/pub/sen/relazioni/relazione_annuale_situazione_energetica_nazionale_dati_2021.pdf

For several years now, energy production and distribution operators in Italy have been adopting an approach aimed at decarbonisation, decentralisation and digitisation of data, while implementing solutions to support cybersecurity and sustainability. This also responds to a necessity imposed by the European Community through directive (EU) 2022/2464 concerning corporate sustainability reporting, which requires companies, as identified on the basis of the same directive, operating in the EU, to have a sustainability statement (balance sheet) reporting on economic, environmental and social sustainability aspects, starting with an appropriate materiality assessment.

The Directive was implemented through Delegated Regulation (EU) 2023/2772, which provides for mandatory sustainability reporting from the financial year 2024. Gradually, this reporting obligation will be extended to a larger group of EU companies, as indicated in Directive 2022/2464, art. 5. The companies analysed in this work, however, have already been operating in this context for several years, starting with a serious materiality assessment. It is therefore necessary to identify the right method of analysis and return of the information shared by the companies themselves.

Fortunately, Italian electricity companies have a fairly standardised method of reporting their sustainability performance, based on the use of the indicators made available by the GRI (Li et al., 2012; Singh et al., 2012), chosen by all the TBL pillars of sustainability (economic, environmental, social) (Singh et al., 2007). The indicators developed by the GRI are to be considered a guarantee/warranty in terms of choice. Thus, the fact that Italian electricity companies have chosen the GRI indicators for their sustainability reports has made it possible to consider those indicators as already standardised and ready to use for this study. Starting from the data provided in the 2021 and 2022 annual sustainability reports of the 12 largest energy producers in Italy (ENEL, Edison, Hera, A2A, AXPO, Eni, Green Network, E.ON., Iren, Acea, Duferco and Alperia) (ARERA, 2021), it was possible to calculate an overall sustainability index (OSI) of each company for the years 2020 and 2021. Each company has been assigned a progressive number, by which it will be identified from now on. The objective of this work is to describe the method and prove its effectiveness, rather than to go deep into the data, as accomplished in other publications (Carrabba & Padovani, 2022; Carrabba & Padovani, 2023).

2 | METHODS

Scientific literature proposes a number of sustainability performance measurement systems for different types of productive sectors, but a lot of difficulties are reported on various aspects (Cagno et al., 2019). For example, the need to address industrial sustainability taking into account the different pillars of the triple bottom line (TBL): environment, social, economic (Trianni et al., 2017; Wicaksono et al., 2020). The evaluation of sustainability performance requires the use of standardised indicators, adapted to the industrial sector chosen and organised into a performance measurement system (PMS) (Krajnc & Glavič, 2003). Some difficulties are related also to the size of the industries that should be comparable to each other (Ferrari et al., 2019). Nonetheless, it is important to know the current status of sustainability measurement in today's industrial practices; hence, the development of a unique single index—easy to be understood by the end users (Soler & Soler, 2008)—to measure the environmental, economic, and social dimensions of sustainability (Li et al., 2012; Parris & Kates, 2003).

The first step of this study identifies a synthetic index capable of analysing the values coming from very different variables. In the analysis of sustainability, in fact, several elements should be taken into consideration, both in terms of objectives and values, such as emissions into the atmosphere, the percentage of women employed by the company and the economic value that has been generated and distributed. Many different indices and methods are used to evaluate sustainability in numerous areas (Cagno et al., 2019; Singh et al., 2012), but none seemed suitable to provide a synthetic index truly representative of the multifactorial reality of sustainability in the Italian electricity industries.

For the analysis of corporate sustainability reports, 56 indicators were used among those made available by the Global Reporting Initiative (GRI, 2020; Singh et al., 2012), chosen by all the three pillars of sustainability (economic, environmental, social) (Singh et al., 2007; Wicaksono et al., 2020). The choice of the Italian electricity companies to use already standardised GRI indicators for their sustainability reports, allowed to use them directly (or to adapt them) for the study carried out here, without further selections. The criteria of the indicators' selection include their relevance to the purpose of the analysis of sustainability and the wider availability during the years in the corporate sustainability reports (Li et al., 2012; Singh et al., 2007). The chosen indicators, specific for the electricity companies, covered all the TBL pillars and their intersection (Cagno et al., 2019; Singh et al., 2007): 31 are environmental, 6 are economic, 19 are social indicators, in a way to obtain as much as possible an overall perspective of the sustainability of industrial activities. The quantitative distribution of the indicators in the three pillars of sustainability is in line with the scale of importance of the indicators identified by Wicaksono and Sodri (2020). The system can be applied to companies with different size, due to the way in which indicators are utilised in the construction of the index.

In the end, the most suitable method was the one developed by *Il Sole 24 ore*[2] in its annual ranking of the *Quality of Life of Italian Provinces*.[3] The method analyzes heterogeneous dimensions through the use of an easy-to-apply synthetic index.

The 56 basic indicators are divided into thematic macro-categories (governance; economic performance, energy, water and effluent, employment and so on), already established by GRI in the identification of its indicators.

The basic indicators undergo a prior transformation in order to be subsequently used to obtain the synthetic indices. The transformation is necessary because the starting data are represented by units of

[2]https://www.ilsole24ore.com/

[3]https://lab24.ilsole24ore.com/qualita-della-vita/

measurement that are mostly not comparable with each other; they also have different directions (positive or negative) with respect to the phenomenon they quantify (*Quality of Life* in the case of *Il Sole 24 Ore*; Sustainability in the case of the present work).

In the case of positive indicators (defined as 'quality' or Q), that is, when a higher value of the indicator corresponds to a higher value of sustainability, the transformation is the ratio between the figure expressed by the individual company and the maximum value expressed by the indicator among all the companies analysed, according to the equation:

$$X_{(t)}iq = (xiq/\max xq) \times 1000.$$

In the case of negative indicators (defined as "distress" or D), that is for which it is the minimum value of the indicator that expresses high sustainability, the ratio is inverted. The value assumed by the equation will then be given by the ratio of the minimum value expressed by the indicator xid among all the analysed companies to the figure expressed by the individual company, according to the equation:

$$X_{(t)}id = (\min xd/xid) \times 1000,$$

where iq stands for quality indicator; id stands for discomfort indicator.

According to each indicator, 1000 points are awarded to the company with the best value and zero points to the one with the worst value. The scores of the other companies are distributed according to their distance from the extremes (between 1000 and 0).

Subsequently, to each electric company is assigned a score for each of the thematic macro-categories, determined by the score assumed by the company indicators in comparison with the other companies, each weighted equally to the other (simple arithmetic mean). Finally, for each company, the final ranking is constructed based on the simple arithmetic mean of the 18 sector rankings (Singh et al., 2007).

Table 1 shows the indicators chosen for the calculation of the OSI.

The index described so far, applied with this paper to the area of sustainability, has been defined as the OSI.

Some indicators, whose values are difficult to be assessed in a quantitative manner, have been classified in a qualitative way, giving them a different weight from the GRI value. To be precise, for some indicators, it was chosen to attribute the value 'YES' if the hypothesis turned out to be true; the value 'NO' if the hypothesis turned out to be false.

For example, in the case of indicator 55 (Activities with significant potential and actual negative impacts on local communities), the value "YES" was assigned if the company, during the reporting period, reported company activities with possible negative impacts on local communities; the value "NO" if the company excluded that its activities had possible negative impacts on local communities.

In assigning a quantitative score to uniquely qualitative indicators, in order to be able to start comparing data, indicators with a "YES/NO" value were given the following value:

(i) indicator type Q: (yes = 1000; no = 0).

(ii) indicator type D: (yes = 0; no = 1000).

Some GRI indicators in absolute values (e.g. total fuel consumption within the organisation from non-renewable energy sources, in joules or multiples) have been transformed into percentage data (total fuel consumption within the organisation from non-renewable energy sources, as a percentage of total energy consumed) to allow for easier comparison between companies that are also very different in size.

On the other hand, in the case of indicators referring to defined parameters, where different units of measurement were used in the reporting of individual companies, the data were all standardised to one and the same unit of measurement (e.g. TJ in the case of energy; Mm3 in the case of water withdrawal, and so on).

The comparison between companies was made on a fixed time basis, that is, referring to the reporting year 2020 and the reporting year 2021, which is available for all companies considered.

At the time of writing, the data reported by the companies, referring to the 2 years under consideration, are now consolidated. However, it should be borne in mind that in sustainability reports, the data referring to a given year are to be considered provisional until the publication of the following year's sustainability report. Indeed, at the time of publication of the sustainability report, the data referring to some variables of the current year may not yet be final, and are only consolidated with the following sustainability report.

The OSI results in a definite magnitude and direction, so the index can be uniquely interpreted (Singh et al., 2007).

3 | RESULTS

The overall data obtained with the described methodology, relative to each of the 56 indicators considered, are presented in the original work published by ENEA in 2023 (Carrabba & Padovani, 2022; Carrabba & Padovani, 2023). By way of example only, in order to provide a better description of the method, the summary sheet of the scores obtained by the electricity companies in the analysis of the values indicated in the Sustainability Reports for SCOPE 1, SCOPE 2 and SCOPE 3 emissions is shown here (Table 2).

For the complete tables, please consult the published work in full.

Table 2 shows:

1. The progressive number assigned to the Company.
2. The number of the GRI indicator considered.
3. The value taken for the figure (X(t)iq/X(t)id), as reported in the Sustainability Report of the individual company in 2020 and 2021.
4. The value actually considered for the indicator in 2020 and 2021. This field was necessary because for calculation purposes, values of X less than 1 were transformed by multiplying them by appropriate multiples of 10.

TABLE 1 Indicators chosen for analysis.

N	GRI Number/ESRS	Indicators	Quality/ discomfort indicator	Value or unit of measurement considered
Governance (GRI 102)				
1	102–20/ESRS 2	Executive-level responsibility for economic, environmental, and social topics	Q	Y/N
2	102–21/ESRS 2	Consulting stakeholders on economic, environmental, and social topics	Q	Y/N
3	102–26/ESRS 2	Role of highest governance body in setting purpose, values, and strategy	Q	Y/N
4	102–42/ESRS 2-S3-S4	Identifying and selecting stakeholders	Q	Y/N
Economic performance (GRI 201)				
5	201–1/ESRS 2	Direct economic value generated and distributed	Q	%
6	204–1/ESRS 2	Proportion of spending on local suppliers	Q	%
Materials (GRI 301)				
7	301–1/ESRS E5	Materials used by weight or volume (i) non-renewable materials used	D	%
8	301–1/ESRS E5	Materials used by weight or volume (ii) renewable materials used	Q	%
9	301–2/ESRS E5	Recycled input materials used (a) percentage of recycled input materials used to manufacture the organisation's primary products and services	Q	%
Energy (GRI 302)				
10	302–1/ESRS E1-5	Energy consumption within the organisation (a) total fuel consumption within the organisation from non-renewable sources	D	%
11	302–1/ESRS E1-5	Energy consumption within the organisation (b) total fuel consumption within the organisation from renewable sources	Q	%
12	302–1/ESRS E1-5	Energy consumption within the organisation (d) total energy consumption within the organisation, in joules or multiples	D	TJ
13	302–3/ESRS E1-5	Energy intensity	D	MJ/kWh
Water and Effluents 2018 (GRI 303)				
14	303–3/ESRS E3-1	Water withdrawal (a) total water withdrawal from all areas in megaliters, and a breakdown of this total by the following sources, if applicable: (i) Surface water; (ii) groundwater; (iii) seawater; (iv) produced water; (v) third-party water	D	Mm^3
15	303–3/ESRS E3-1	Water withdrawal (b) total water withdrawal from all areas with water stress	D	Mm^3
16	303–3/ESRS E3-1	Water withdrawal (c) total water withdrawal: (i) freshwater	D	Mm^3
17	303–4/ESRS E3-4	Water discharge a. Total water discharge to all areas in megaliters	D	Mm^3
18	303–4/ESRS E3-4	Water discharge (b) a breakdown of total water discharge to all areas in megaliters by the following categories: (i) Freshwater (≤1000 mg/L Total Dissolved Solids); (ii) Other water (>1000 mg/L total dissolved solids)	D	Mm^3
19	303–4/ESRS E3-4	Water discharge (c) total water discharge to all areas with water stress in megaliters, and a breakdown of this total by the following categories: (i) freshwater (≤1000 mg/L total dissolved Solids); (ii) other water (>1000 mg/L total dissolved solids)	D	Mm^3
20	303–5/ESRS E3-4	Water consumption (a) total water consumption from all areas in megaliters	D	Mm^3

(Continues)

TABLE 1 (Continued)

N	GRI Number/ESRS	Indicators	Quality/ discomfort indicator	Value or unit of measurement considered
21	303–5/ESRS E3-4	Water consumption (b) total water consumption from all areas with water stress in megaliters	D	Mm^3
Biodiversity (GRI 304)				
22	304–1/ESRS E4-5	Operational sites owned, leased, managed in, or adjacent to, protected areas and areas of high biodiversity value outside protected areas	D	Y/N
23	304–2/ESRS E4	Significant impacts of activities, products, and services on biodiversity	D	Y/N
24	304–3/ESRS E4-2	Habitats protected or restored	Q	Y/N
25	304–4/ESRS E4	IUCN Red List species and national conservation list species with habitats in areas affected by operations	D	Y/N
Emissions (GRI 305)				
26	305–1/ESRS E1-6	Direct (Scope 1) GHG emissions	D	mln tCO_2eq
27	305–2/ESRS E1-6	Energy indirect (Scope 2) GHG emissions (a) location-based	D	mln tCO_2eq
28	305–2/ESRS E1-6	Energy indirect (Scope 2) GHG emissions (b) if applicable, gross market-based energy indirect (Scope 2)	D	mln tCO_2eq
29	305–3/ESRS E1-6	Other indirect (Scope 3) GHG emissions	D	mln tCO_2eq
30	305–6/ESRS E1-6	Emissions of ozone-depleting substances (ODS) (a) CFC-11 (trichlorofluoromethane) equivalent	D	t
31	305–7/ESRS E1-6	Nitrogen oxides (NO_X) emissions	D	t
32	305–7/ESRS E1-6	Sulphur oxides (SO_X) emissions	D	t
33	305–7/ESRS E1-6	Particulate matter (PM) emissions	D	t
Waste 2020 (GRI 306)				
34	306–3/ESRS E1-E2	Waste generated (a) total weight of waste generated in metric tons	D	mln t
35	306–4/ESRS E1-E2	Waste diverted from disposal (a) total weight of waste diverted from disposal in metric tons, and a breakdown of this total by composition of the waste	Q	mln t
Environmental compliance 2016 (GRI 307)				
36	307–1/ESRS G1	Non-compliance with environmental laws and regulations (a) significant fines and non-monetary sanctions for non-compliance with environmental laws and/or regulations	D	Y/N
Supplier environmental assessment 2016 (GRI 308)				
37	308–1	New suppliers that were screened using environmental criteria	Q	Y/N
Employment 2016 (GRI 401)				
38	401–2/ESRS S1	Benefits provided to full-time employees that are not provided to temporary or part-time employees	Q	Y/N
39	403–3/ESRS S1	Occupational health services	Q	Y/N
40	403–5/ESRS S1	Worker training on occupational health and safety	Q	Y/N
41	403–8/ESRS S1	Workers covered by an occupational health and safety management system (a) if the organisation has implemented an occupational health and safety management system based on legal requirements and/or recognised standards/ guidelines	Q	Y/N
42	403–9/ESRS S1-14	Work-related injuries (a) for all employees: (iii) The number and rate of recordable work-related injuries	D	Number of fatalities as a result of work-related injury * Number of hours worked /1,000,000

TABLE 1 (Continued)

N	GRI Number/ESRS	Indicators	Quality/ discomfort indicator	Value or unit of measurement considered
43	403–9/ESRS S2	Work-related injuries (b) for all workers who are not employees but whose work and/or workplace is controlled by the organisation: (iii) the number and rate of recordable work-related injuries	D	Number of fatalities as a result of work-related injury * Number of hours worked /1,000,000
Training and education 2016 (GRI 404)				
44	404–1/ESRS S1	Average hours of training per year per employee	Q	n
45	404–1/ESRS S1	Employees who have had access to training processes	Q	%
Diversity and Equal Opportunity 2016 (GRI 405)				
46	405–1/ESRS S1	Diversity of governance bodies and employees (a) percentage of individuals within the organisation's governance bodies in each of the following diversity categories: i. Gender (CPO)	Q	%
47	405–1/ESRS S1	Diversity of governance bodies and employees (a) percentage of individuals within the organisation's governance bodies in each of the following diversity categories: (i) gender (manager + middle manager)	Q	%
48	405–1/ESRS S1	Diversity of governance bodies and employees (b) percentage of employees per employee category in each of the following diversity categories: (i) gender	Q	%
49	405–2/ESRS S1-16	Ratio of basic salary and remuneration of women to men (a) ratio of the basic salary and remuneration of women to men for each employee category, by significant locations of operation.	Q	%
Non-discrimination 2016 (GRI 406)				
50	406–1/ESRS S1-17	Incidents of discrimination and corrective actions taken (a) total number of incidents of discrimination during the reporting period.	D	Y/N
Rights of Indigenous People 2016 (GRI 411)				
51	411–1/ESRS S1-17	Incidents of violations involving rights of indigenous peoples (a) total number of identified incidents of violations involving the rights of indigenous peoples during the reporting period	D	Y/N
Human rights assessment 2016 (GRI 412)				
52	412–1/ESRS S1-17	Operations that have been subject to human rights reviews or impact assessments (a) total number and percentage of operations that have been subject to human rights reviews or human rights impact assessments, by country	D	Y/N
53	412–2/ESRS E1	Employee training on human rights policies or procedures	Q	Y/N
Local communities 2016 (GRI 413)				
54	413–1/ESRS S3	Operations with local community engagement, impact assessments, and development programs	Q	Y/N
55	413–2/ESRS S3	Operations with significant actual and potential negative impacts on local communities	D	Y/N
Supplier social assessment 2016 (GRI 414)				
56	414–1/ESRS S2-1	New suppliers that were screened using social criteria	Q	Y/N

Note: Modified from: GRI, 2020. Consolidated Compendium of GRI Sustainability Reporting Standards (Consolidated Standards) 2019. Column (1) progressive number attributed to the indicator in this paper; column (2) reference GRI number/ESRS; column (3) indicator declaration; column (4) quality or distress indicator (Q/D); column (5) value or unit of measure with which the indicator is expressed in this paper.
Abbreviations: ESRS, European Sustainability Reporting Standards; GHG, greenhouse gas emission; GRI, global reporting initiative; mln, million; Tj, terajoule.

TABLE 2 Indicators related to SCOPE emissions.

Electricity companies	N° indicator and GRI	$X_{(t)}iq/X_{(t)}id$ 2020	X transformed 2020	Indicator value 2020	$X_{(t)}iq/X_{(t)}id$ 2021	X transformed 2021	Indicator value 2021
Emissions (GRI 305)							
1	26	45,73	45,730	0,01	51,57	515,700,00	0,008
2	26	6282	6282	0,05	5855	58,550,00	0,068
3	26	0,986	986	0,30	0,9818	9818,00	0,407
4	26	5,85	5850	0,05	7127	71,270,00	0,056
5	26	1,82	1820	0,16	0,000694	6,94	576,369
6	26	37,76	37,760	0,01	40,08	400,800,00	0,010
7	26	N.A.	0	0,00	N.A.	0	0,000
8	26	0,0003	0,3	1000,00	0,0004	4,00	1000,000
9	26	4069	4069	0,07	3978	39,780,00	0,101
10	26	0,0454	45,4	6,61	0,0508	508,00	7874
11	26	0,592	592	0,51	0,50	5000,00	0,800
12	26	0,42	42	7,14	0,4	4000,00	1000
1	27	4,06	40,600	0,02	4,31	431,000	0,009
2	27	0,07	700	1,43	0,065	6500	0,615
3	27	0,0001	1	1000,00	0,154	15,400	0,260
4	27	0,107	1070	0,93	0,108	10,800	0,370
5	27	0,47	4700	0,21	0,000108	10,8	370,370
6	27	0,73	7300	0,14	0,81	81,000	0,049
7	27	N.A.	0	0,00	N.A.	0	0,000
8	27	4,82	48,200	0,02	0,00004	4	1000,000
9	27	0,099	990	1,01	0,111	11,100	0,360
10	27	0,0348	348	2,87	0,0254	2540	1575
11	27	0,136	1360	0,74	0,162	16,200	0,247
12	27	0,38	3800	0,26	0,35	35,000	0,114
1	28	6,9	690	0,87	7,11	71,100	0,024
2	28	0,11	11	54,55	0,105	1050	1657
3	28	0,044	4,4	136,36	0,0466	466	3734
4	28	0,006	0,6	1000,00	0,0016	16	108,750
5	28	N.A.	0	0,00	0,000174	1,74	1000,000
6	28	N.A.	0	0,00	N.A.	0	0,000
7	28	N.A.	0	0,00	N.A.	0	0,000
8	28	6,06	606	0,99	N.A.	0	0,000
9	28	0,154	15,4	38,96	0,031	310	5613
10	28	0,0255	2,55	235,29	0,0218	218	7982
11	28	0,188	18,8	31,91	0,22	2200	0,791
12	28	0,27	27	22,22	0,26	2600	0,669
1	29	64,9	6490	0,35	69,15	6915	27,129
2	29	0,0228	2,28	1000,00	21,617	2161,7	86,784
3	29	11,613	1161,3	1,96	11,7235	1172,35	160,020
4	29	1464	146,4	15,57	1876	187,6	1000,000
5	29	0,76	76	30,00	N.A.	0	0,000
6	29	205,8	20,580	0,11	176	17,600	10,659
7	29	N.A.	0	0,00	N.A.	0	0,000
8	29	108,21	10,821	0,21	N.A.	0	0,000

TABLE 2 (Continued)

Electricity companies	N° indicator and GRI	$X_{(t)}$iq/ $X_{(t)}$id 2020	X transformed 2020	Indicator value 2020	$X_{(t)}$iq/ $X_{(t)}$id 2021	X transformed 2021	Indicator value 2021
9	29	4087	408,7	5,58	4538	453,8	413,398
10	29	2833	283,3	8,05	2871	287,1	653,431
11	29	N.A.	0	0,00	N.A.	0	0,000
12	29	4,87	487	4,68	5,33	533	351,970

Note: column 1: progressive number of the company; column 2: number of the GRI indicator considered (26: SCOPE 1; 27: SCOPE 2 L.b.; 28: SCOPE 2 m. b.; 29: SCOPE 3); columns 3 and 6: value assumed by the figure (X(t)iq/X(t)id), as reported in the individual company's Sustainability Reports in 2020 and 2021; columns 4 and 7: value actually considered for the indicator in 2020 and 2021; columns 5 and 8: final value assumed by the indicator in 2020 and 2021.
Abbreviation: GRI, global reporting initiative.

5. The final value assumed by the indicator in 2020 and 2021, applying the formulas given in the Section 2.

In yellow are indicated the zero values attributed to the data not available (N.A. = not available), not to be confused with the zero values corresponding to the zero data reported by the individual company. It may indeed be the case that a company declares a zero value referring to a certain indicator. In this case that indicator (highlighted in orange) will be given a score of X(t)iq equal to 1000; a value of X(t) id equal to 0.

After the construction of the overall tables, the value of the corporate OSI was extrapolated for each company from the analytical scores achieved for each indicator per year.

As an example, Table 3 shows the calculation of the OSI value for the company n°1.

The table summarising the values of the electricity company n° 1 by the indicator (Table 3) shows how the company expresses the best in organisational and formal aspects. Governance and economic performance have very high ratings. Highest values are also obtained in the ethical aspects relating to indigenous peoples and human rights. Social aspects relating to relations with personnel achieve medium-high values, with a peak of excellence related to training. The more production-related aspects, on the other hand, receive medium-low ratings in the indicators relating to energy used, use of water resources, and impacts on biodiversity. Particularly low values were obtained for indicators relating to waste and, especially, indicators relating to emissions. Company n°1 does not report on the materials used.

The value of OSI obtained by Company n°1 in the years 2020 and 2021 is almost identical, although it shows an increase in the Index of about 26 points. The difference found, however, is not statistically significant ($p \leq 0.05$).

Table 4 shows the values of the OSI calculated for each company for the 2 years under consideration.

The data, ordered in descending order according to the year 2021, range from a OSI value of 589 achieved by Company n° 4 to 47 by Company n° 7. We recall here that, due to the way the index is constructed, the OSI does not represent an absolute value, but rather a relative one, based on the comparison of the performance achieved by each company compared with the performance of the others. Taking into account that the maximum attainable value is 1000, we see how even the best performing companies from a sustainability point of view only slightly exceed the average value. Company n°4 itself, which in 2020 reaches an OSI value exceeding 600, in 2021 shows a drop of no less than 33 points. More or less marked declines are also seen for Companies n° 3, 9, 12, 10 and 5. On the other hand, Companies n°2, 1, 11 and 6 show an index improvement of varying degrees. The change in the index for Company n°8 from 119 to 337 is essentially due to the shift from a qualitative to a quantitative sustainability report. Company n°7, on the other hand, remained on a qualitative sustainability report, which does not allow the sustainability performance achieved to be assessed appropriately with this methodology.

In order to statistically assess the change in the OSI values of individual companies over the years, we applied a *t*-test for paired data to the values, where H0: x2020 = x2021. The tests performed allow us to state that the companies analysed show no significant differences between the data of 2020 and 2021 except in the case of Company n°8. The differences recorded between the years must therefore be considered as a trend only.

Figure 1 describes graphically what is shown in Table 4. The graphical representation allows even better appreciation of the comparison of the index performance per company per year. Note how all companies, except Companies n°8, 5 and 7, reach values above 300 in 2021. While the marked improvement in performance of Companies n°2 and 8 is clearly noticeable, the deterioration recorded by Company n°5 is also noticeable.

4 | DISCUSSION

The first interesting aspect of using the OSI is that of the possibility of comparing data from different reporting years, in this case 2020 and 2021, provided that the indicators analysed are the same for each year. This made it possible, on the one hand, to verify the replicability of the method over time, and on the other hand, to check its sensitivity in photographing changes, even small ones, due both to variations

TABLE 3 Company n°1: summary table of values expressed per indicator and calculated value of OSI.

Company n°1		2020		2021	
Macro-categories	Indicator	Score	Partial	Score	Partial
Governance	1	1000		1000	
	2	1000		1000	
	3	1000		1000	
	4	1000	1000	1000	1000
Economic performances	5	915,8742		941,4457	
	6	877,551	896,7126	795,9184	868,682
Materials	7	0		0	
	8	0		0	
	9	0	0	0	0
Energy	10	338,6243		368,305	
	11	80,29,412		76,308	
	12	0,005267		0,003	
	13	1000	354,7309	1000	361,1538
Water	14	33,74,757		23,995	
	15	25,08207		24,839	
	16	37,29,614		31,604	
	17	26,89,934		0,001	
	18	1000		0,001	
	19	1000		1000	
	20	83,33,333		0,178	
	21	1000	400,7948	1000	260,077
Biodiversity	22	0		0	
	23	0		0	
	24	1000		1000	
	25	0	250	0	250
Emissions	26	0,00656		0,008	
	27	0,024631		0,009	
	28	0,869,565		0,024	
	29	0,35,131		27,129	
	30	1000		55,556	
	31	0,553,661		0,597	
	32	0,043802		0,102	
	33	0,483,092	125,2916	0,673	10,512
Waste	34	90,67,797		96,66,667	
	35	456,4706	273,5743	168,1356	132,4011
Compliance	36	0	0	0	0
New suppliers	37	1000	1000	1000	1000
Employment	38	1000		1000	
	39	1000		1000	
	40	1000		1000	
	41	1000		1000	
	42	230,0319		253,165	
	43	575,1438	800,8626	90,883	724,008
Training	44	1000		1000	
	45	935	967,5	957	978,5

TABLE 3 (Continued)

Company n°1 Macro-categories	Indicator	2020 Score	2020 Partial	2021 Score	2021 Partial
Diversity	46	1000		990,991	
	47	983,2776		999,673	
	48	671,875		408,126	
	49	850	876,2881	791,220	797,503
Anti-discrimination	50	0	0	0	0
Indigenous people	51	1000	1000	1000	1000
Human rights	52	0		1000	
	23	0	0	1000	1000
Local communities	54	1000		1000	
	55	0	500	0	500
Supplier social assessment	56	1000	1000	1000	1000
OSI 2020/2021			524,7642		549,046

Abbreviation: OSI, overall sustainability index.

TABLE 4 OSI values per company, per year.

Company number	2020	2021
4	622,6497	659,332
3	584,6152	581,688
2	443,7367	578,924
1	524,7642	549,046
9	535,4231	505,812
12	519,9225	489,506
6	474,1091	483,662
11	454,4454	480,805
10	434,3626	412,162
5	406,502	352,686
8	119,6891	338,889
7	47,55,787	47,4631

Abbreviation: OSI, overall sustainability index.

in the conduct of corporate affairs and policies and to social, political and economic changes in society in general.

After a period of recession characterised by a contraction in the use of energy sources and expressed at the level of electricity companies with emissions never as low as in 2020, there is a partial reversal of the trend in 2021. Electricity companies have, in general, produced more energy to meet the increased energy demand from both industrial and civil users, resulting in a partial increase in emissions.

A general worsening trend in sustainability performance (although not supported by statistical evidence ($p \le 0.05$)) led to a lower OSI value in 2021 than in 2020 for 5 out of 12 companies (Companies n° 4, 3, 9, 12 and, 10). Another 4 companies (Companies n° 2, 1, 11 and 6) instead showed a slightly higher OSI value, and thus sustainability performance, in 2021 compared with 2020, although, even in this case, the figure was not statistically significant.

Company n°8 shows a doubled OSI value in 2021 compared with 2020. This clear improvement, which is statistically significant ($p \le 0.05$), is due to a different sustainability performance reporting policy, which in 2020 was of a qualitative type and in 2021 became of a more quantitative type, responding better to the requirements of the method used here. In 2021, Company n°8 therefore fits, on merit, into the group of companies for which the analysis was successful.

Company n°7 has not changed its way of reporting sustainability, and its OSI remains the lowest of the twelve. In both years, the company opted for a type of reporting that follows qualitative rather than quantitative logics, effectively preventing access to the data required for the methodology used in this work. The company therefore remains, essentially, outside the group of companies for which the analysis was successful.

Company n° 5 showed a clear decrease in the OSI between 2020 and 2021. The index is, in fact, almost halved, although the figure is not statistically significant ($p \le 0.05$). Over the past year, the company has evidently changed its policies concerning the drafting of the Sustainability Report.

It is interesting to consider the aspect of the percentage of data present per group of indicators in the Sustainability Reports in the two different years considered (Figure 2).

In general, all companies received very high values in reporting on governance and economic performance, which meet modern corporate policy criteria. The percentages of presence of governance data reach more than 80%. This information is very easy to find and to report on, and is also generally present in traditional company financial statements, especially with regard to economic performance aspects.

Much scarcer is the information on more purely environmental issues, information that has become important precisely in connection with the drafting of sustainability reports.

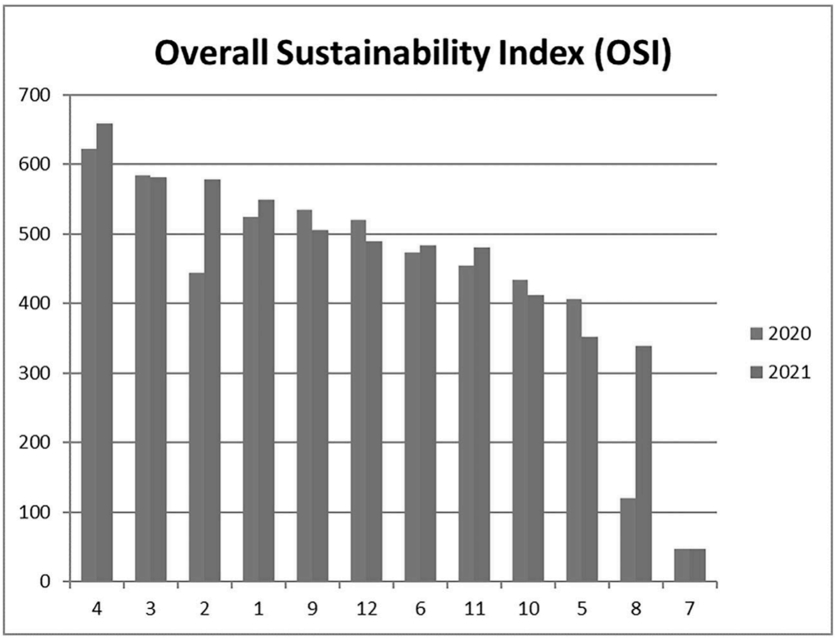

FIGURE 1 Annual development of the overall sustainability index per company per year.

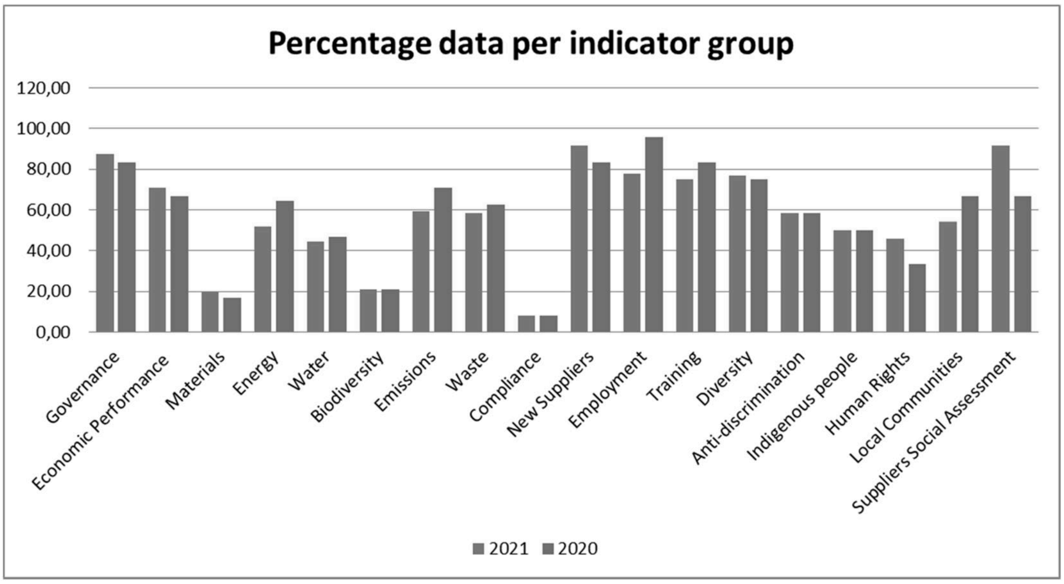

FIGURE 2 Percentage of data in sustainability reports per indicator group for the years 2020–2021.

On the materials used and their type, only a few companies respond, with very low values, apart from Company n°11, which reports satisfactorily. The percentage of data presence is less than 20% (Figure 2).

Even on energy, an indicator that is well represented in all Sustainability Reports, the companies reach very low values, with the exception of Company n°10. In fact, the companies all declare quite high levels of fuel consumption from non-renewable energy sources. Only Company n°10 declares a use of fuel from renewable sources above 65%, the rest of the companies below 20%. The figure, which was above 60% in 2020, stands at 52% in 2021 (Figure 2).

Another sore point is the reporting of water use, from withdrawals to discharges. Many companies do not report (the figure is around 45% (Figure 2)), or report only partially, reaching generally very low to low values. Only Company n°12 reports satisfactorily on this group of indicators, partly because water is fully part of its corporate commitment; however, it too reaches a fairly low value.

The group of indicators on biodiversity is scarcely taken into account (percentage of presence of the figure at 20% (Figure 2)). Companies generally either ignore this aspect or consider it as a sideline topic in relation to their sustainability objectives. The exception is Company n°11, which achieves a fairly high score in this group of indicators, indicating a sensitivity to the topic that goes beyond mere production interests.

On emissions, almost all companies respond for at least one of the 2 years considered, as this is the group of indicators centred on the focus of company activities. The percentage of data presence (Figure 2), reaches 70% in 2020, while it drops to just under 60% in 2021. The values achieved by the indicators are, however, quite low to very low. This is undoubtedly the thorniest issue in relation to sustainability performance, depending to a large extent on the technological and innovation choices made by companies, but also on the company's volume of operations. Only Company n°10 in 2021 achieves a fairly high score. The data will have to be reconfirmed by the Sustainability Report for 2022.

With regard to waste, some companies do not consider the figure at all, as if this issue were completely outside the scope of sustainability reporting, while others report only partially. Company n°4 in 2021 scores well in relation to waste management, as it declares a very high level of recycling. The same for Company n°9 in 2020 and for Company n°11 in both years. The figure is around 60% in both years (Figure 2). It must be said that this indicator can be a problem, as multifunctional companies such as Company n°12 also deal with waste collection and recycling. They therefore have to manage such quantities of waste that it is difficult to achieve very high levels of recycling. Following the evolution of these indicators over time will make it possible to monitor the company's performance in this respect.

On the compliance indicator, that is, the awarding of fines for non-compliance with environmental laws or regulations, all companies receive the lowest mark (zero), either because they state that they have received fines, or because they do not report the figure. The presence of the figure is very low, with a percentage of less than 10% (Figure 2). Only Company n°8 receives the highest score in both years, as it states that it has not received penalties on aspects of non-compliance with environmental regulations. On this aspect, therefore, there is much to be done.

On the other hand, the aspect of new suppliers assessed for compliance with environmental and social issues is very much felt by the companies, which always report the figure for at least one of the 2 years under consideration (the percentage of presence of the figure in 2021 exceeds 90% (Figure 2)). The exception is Company n° 7, which does not mention the issue. This aspect, which is one of the socio-environmental aspects of sustainability, is very good news, as it is an important lever for influencing the sustainability of the electricity market.

The issue of employment is very strongly felt and highly represented among the data provided by companies, both in its social and equality aspects and in respect for rights and combating discrimination. Scores are generally between medium-high and very high, with peaks of excellence. The exception is Company n°8, which does not include these topics except marginally in its Sustainability Reports. It must be said, however, that it is precisely thanks to the presence of these issues, which come from a long history of bargaining also with the trade unions, that a fairly high OSI score was achieved for most companies. Note the decrease in the presence of the figure between 2020 and 2021, where the percentage drops from 95 to 77%, an indication, perhaps, of some rethinking in the structure of sustainability budgets. Yet the social aspects of work are fundamental in defining the sustainability of a company.

Finally, the issues of respect for indigenous peoples and human rights are quite strongly felt, although not all companies report on the latter. The indicator on indigenous peoples was included last year in consideration of the fact that larger companies, such as Company n°1, also operate internationally in areas where the presence of indigenous peoples is an important reality to take into account when describing the levels of sustainability achieved. In view of the fact, however, that some of the companies operate only domestically and that this, therefore, may disadvantage them in the calculation of the OSI, its use in any future work should be evaluated.

Finally, as far as the indicators reporting on relations with local communities are concerned, since electricity companies experience the local area as a privileged partner, they generally score very high, although the figure varies between 66% in 2020 and 54% in 2021 (Figure 2—Percentage of data in Sustainability Reports per indicator group for the years 2020–2021).

5 | CONCLUSIONS

The possibility of relying on a standardised method to analyse the data declared by companies in their sustainability reports, gives the possibility of following the trend of changes over time due to new company policies or even to changes in the social, political, economic horizon of society. Indeed, there is no doubt that energy demand (and thus the production/emission levels of electricity companies) can change profoundly as national conditions change. Proof of this was the COVID-19 pandemic crisis, which profoundly affected industrial and social energy consumption profiles.

The OSI is therefore a useful tool for companies interested in assessing their own performance and more easily identifying areas that still need to be investigated or implemented from scratch in order to improve their reporting. Well-done reporting can in fact, also have a positive impact on company policies, indicating areas in which to invest to improve productivity and sustainability.

This contribution can also be a useful tool for all those companies that do not yet have a sustainability report but are now obliged to produce one, on the basis of Directive (EU) 2022/2464, an obligation that came into force for reports from the financial year 2024 onwards, or for those companies that already have a sustainability report, but would like to arrive at a more concise and quantitative rendering of their company data. The methodology adopted in this paper is in fact not only a tool for verifying sustainability reporting, but also for verifying the policies undertaken by the company as the boundary conditions change, again in the light of the European sustainability goals.

The data reported in this paper were provided by companies up to 2022 and are broadly comparable with the European Sustainability Reporting Standards[4] (ESRS-Delegated Regulation (EU) 2023/2772[5]), expressly required by the Directive (EU) 2022/2464, given that the development of the ESRS was largely based on the GRI standards. On these premises, in view of the next sustainability reports, both the GRI indicators and the corresponding ESRS indicators have been

[4]https://www.globalreporting.org/how-to-use-the-gri-standards/gri-standards-italian-translations/

[5]Delegated regulation-EU-2023/2772-EN-EUR-Lex (europa.eu)

reported in Table 1. With the aim of facilitating the transition from one reporting system to another and/or compare them. It is important to underline that GRI and EFRAG collaborate from the early stages by defining the ESRS to ensure the best possible interoperability between the two standards. Therefore, the OSI method, described in this work, can be also usefully utilised in the future using ESRS.

Going back to the GRI data used in this work, companies reported quite unevenly.

The results showed the need for the companies object of this study to work more concretely on the reporting of aspects such as materials, impact on biodiversity, water resource management, and waste. A further step should be taken on the emission factor, working more determinedly on the acquisition of more innovative technologies on both the production/optimisation and emission reduction sides. Starting in 2024, when Delegated Regulation (EU) 2023/2772 becomes fully applicable, it will be possible to consider which changes to make to the OSI calculation. Indeed, the method allows to change both the number of companies and the type of indicators considered, without compromising the results obtained. Of course, the comparability of the data presupposes that the indicators and the companies taken into account are the same from year to year.

With regard to the evaluation of the proposed method, it is useful to remember that the OSI is a relative and not an absolute index, therefore it is based on the comparison of balance sheets of different companies. The method cannot, therefore, be applied to assess the level of sustainability achieved objectively by an individual company.

The possibility of transforming some of the indicators from absolute to percentage values makes it possible to usefully compare even companies of significantly different sizes. For example, directly generated and distributed economic value, calculated in percentage terms on the amount of economic value generated, rather than absolute value, creates no difficulty in comparing companies operating at a multinational level with others operating at a purely national/local level.

Being a multi-factor synthetic index, the OSI undoubtedly rewards companies that report more comprehensively. Thus, companies that report even low values of an indicator achieve a higher value than those that omit the data. Nonetheless, the method allows to compare companies that have different Industrial Sustainability Performance Measurement Systems (Full, Intermediate or Core ISPMS; Cagno et al., 2019). Again, data on environmental performance, which is generally quite low, is compensated for by the higher values of data on social aspects such as employment, training, local communities.

A limitation (or a virtue) of the method is that sustainability reports, in order to be used for the construction of the OSI, must be quantitative and not qualitative. On the other hand, a qualitative balance sheet hardly allows a useful comparison even between data from the same company but referring to different years. Furthermore, since the data analysed come from the sustainability reports made available by the electricity companies themselves, the availability of indicators of the three pillars of sustainability is not always balanced as it would be desirable, in order to allow a more scientifically correct analysis (Singh et al., 2007).

A strength of the method proposed here is that there is no limit to the number of indicators and the number of companies that can be compared. The slowest step in the method is the analysis of sustainability reports, which often differs in the structure and type of indicators described. Often, there is also a difference in the unit of measurement used to describe a given parameter, which is why it is necessary to standardise the data before proceeding to the calculation of the OSI.

From what has been said so far, it emerges that there is still a long way to go towards truly comprehensive sustainability reporting, capable of representing a useful tool for companies and for the country. However, the data reported here may represent a good starting point for reflection and improvement, not only for performance reporting and the identification of corporate trends, but also for the identification of the most appropriate policies to be implemented from the corporate point of view (Trianni et al., 2017) in order to assess the effects of the adoption (Arena & Azzone, 2012; Asiaei et al., 2021) and make a real progress on the road to sustainability (Koufteros et al., 2014).

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