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Nuclear Energy and Sustainable Business Models: Comparative Analysis of Corporate Reporting in the European Union

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Abstract.

Research Question: How do EU-based nuclear energy producers align their operations with the EU Taxonomy for sustainable activities, and what are the implications for their long-term sustainability strategies and financial performance?
Motivation: The integrated analysis of sustainability disclosures, financial metrics and cross-national comparisons of firms provides a lens on how nuclear energy is recast as sustainable within a new policy paradigm.
Idea: This paper compares the deployment of nuclear energy by significant producers in the European Union (EDF, Nuclearelectrica and Vattenfall) over the 2020-2024 period. While every company has a unique approach to nuclear within their energy mix and national goals, all are viewing it as a critical component to the decarbonization strategy.
Data: We analyze how these companies comply with the EU Taxonomy and how they add to the establishment of (4.26) electricity generation from nuclear, (4.27) construction of nuclear installations and (4.28) safe decommissioning of nuclear installations.
Tools: Comparative analysis, content analysis, financial analysis.
Findings: This paper also shows how the reports of selected European Union companies are different regarding the disclosure of information on nuclear activities. It additionally provides a financial framework to facilitate future analysis of the efficiency with which these firms deploy capital and operate their nuclear assets, based on fixed assets turnover.

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Contribution: In summary, the paper paints a much clearer picture of the role of nuclear energy in reaching the clean energy ambitions of Europe and the need for uniform sustainability reporting if green investment is sought.

Keywords: nuclear energy, European Union, EU Taxonomy, sustainable business models.

JEL codes: O13, P18.

1. Introduction

The EU climate and energy policy landscape is taking shape rapidly as it strives to reconcile three critical priorities: climate change mitigation by decarbonizing, net zero targets, energy security, and investor transparency (Schulte, 2024). The EU Taxonomy for sustainable activities is amongst the most prominent tools specifically developed for these goals (Regulation 2020/852). This set of norms allows investors and other stakeholders to ascertain whether the economic activities can be termed as environmentally sustainable or not.

One of these activities has received particular attention: nuclear energy generation and investments in installations. Nuclear power was included in the EU Taxonomy with the adoption of Delegated Regulation (EU) 2022/1214 in 2022. This is categorized as a transition activity. It can provide temporary emission reductions to achieve climate goals until more stringent clean energy solutions are developed. This is why the EU Taxonomy refers to nuclear power under three specific headings: power generation (4.26), new builds (4.27) and safe decommissioning of reactors (4.28). However, nuclear facilities must satisfy stringent environmental and safety requirements to qualify. This also encourages energy companies in Europe to innovate in the management and reporting of nuclear operations (Dorigoni *et al.*, 2025; Elsner, 2024; Fontanier *et al.*, 2025).

This article explores the evolution of three large EU-based companies using a case study methodology: EDF in France, Nuclearelectrica in Romania, and Vattenfall in Sweden. These firms accommodate different policies and energy systems in their respective countries but have significant dependence on nuclear power, and each firm must align their sustainability strategy and disclosures to the EU Taxonomy. The integrated analysis of financial metrics and cross-national comparisons of firms provide a lens on how nuclear energy is recast as sustainable within a new policy paradigm. In turn, this can help understand the interplay of policy, disclosure practices and adaptation of business model, as pointed out by Bocken and Geradts (2019).

This study reviews the 2024 sustainability reports of EDF, Nuclearelectrica and Vattenfall to understand how each company's narratives about nuclear energy align with the goal of carbon neutrality, how they comply with the technical requirements of the EU Taxonomy, and how they discuss ESG-related issues (e.g., nuclear waste, public trust, safety). In line with the work of Hummel and Jobst (2024) and Alessi et al. (2024), we consider corporate sustainability reports as both compliance tools and communication strategies that shape the public perception of corporations within the EU's sustainability framework. The case study methodology is employed to assess not just whether nuclear operators follow the sustainability rules, but also how convincingly these companies portray themselves as part of the EU green transition.

The results examine the three companies along four main dimensions. First, we examine the integration of nuclear power into the long-term sustainability plans of each company and national energy policies. Afterwards, we assess how well each company passes the screening criteria of the EU Taxonomy, for instance keeping lifecycle emissions low, safe management of waste, and operational transparency. Third, we analyze industry-specific issues such as public concern about nuclear power, costs of decommissioning, and stakeholder engagement. Fourth, the paper examines the financial ratio of fixed assets turnover to investigate how well these companies are utilizing their nuclear investments in terms of sustainable performance. Therefore, the research question is: *How do EU-based nuclear energy producers align their operations with the EU Taxonomy for sustainable activities, and what are the implications for their long-term sustainability strategies and financial performance?*

The structure of this article is as follows. The literature review provides a detailed exploration of the inclusion of nuclear energy in the EU Taxonomy, in line with the theory of sustainable business models. The article then presents case studies of EDF, Nuclearelectrica, and Vattenfall, examining their 2024 sustainability reports and financial disclosures from 2020 to 2024. The analysis is divided into four main dimensions: integration of nuclear power into long-term sustainability plans, compliance with EU Taxonomy criteria, industry-specific issues, and financial performance. The results section compares the operational data and Taxonomy alignment of the three companies, while the discussion highlights the differences in their strategies and national contexts. The article concludes with insights into the role of nuclear energy in the EU green transition and the importance of transparent reporting and stakeholder engagement.

2. Literature Review

The paper explores the concept of sustainable business models (SBMs) to frame the analysis (Gao and Li, 2020). When implementing SBMs, companies need to move past traditional short-term profits and integrate environmental and social

targets into their fundamental business strategies, operations, and corporate culture. According to Calvo and Villarreal (2018), sustainable firms must be reinventing their value creation process not only for shareholders but also for society, with the purpose of protecting the environment. This is especially important in industries which are highly regulated (Egres and Sarlós, 2024). Sectors such as nuclear energy production can find this particularly difficult as firms struggle to reconcile the benefits of low-carbon electricity with long-term safety and waste disposal issues, as well as the question of public trust. The nuclear industry's approach in the EU needs to reverse the logic on how it presents the business in the eyes of investors and citizens from a viewpoint of what is ecologically valuable (Euronews, 2025).

This inclusion of nuclear energy within the EU Taxonomy represents a major step in the establishment of a green finance architecture that integrates nuclear energy in second-stage environmental governance and corporate responsibility. The EU Taxonomy Delegated Regulation (EU 2022/1214) provides a classification of nuclear energy activities in sections 4.26 to 4.28 and states that nuclear energy is a base for attaining decarbonization goals. The International Atomic Energy Agency (IAEA) requires nuclear installations, construction, and safe decommissioning of nuclear installations to meet extremely high technical and environmental screening criteria.

The EU Taxonomy has also brought a compliance regime that requires higher standards of data quality, risk disclosure and lifecycle assessment in corporate sustainability reports. Schulte (2024) and Alessi et al. (2024) identified the conditional acceptance of nuclear energy as an indication that the Taxonomy represents a step towards a more expansive green finance regime. On the other hand, Hummel & Jobst (2024) proposed that this scheme generates compulsory metrics instead of voluntary ones, with additional scrutiny because investors know that companies no longer hold the claim of voluntary disclosures. Such a disruption provides opportunities in the short term but is filled with uncertainty especially for sectors dealing with intractable long-term environmental liabilities (e.g. nuclear waste) (Sierra-Garcia *et al.*, 2018).

The literature on sustainable business models offers a critical lens through which to study how firms are adapting to this new institutional context. According to Guo et al. (2022), sustainable business models are those in which ecological, economic, and social value are components of corporate strategy. This involves recalibrating the realities of operations with sustainability goals and policies in sectors where technologies are potentially harmful (Egres and Sarlós, 2024). For example, The European Union's General Court showed that nuclear energy is essential for the EU's energy transition, by proving of lifecycle emissions, nuclear waste governance and EU taxonomy compliance (World Nuclear Association, 2025). This aligns with the perspectives held by Boons and McMeekin (2019) on how, in

order to remain legitimate, firms have to continuously seek institutional alignment. According to Aagaard et al. (2021), such narrative framing reinforces ESG governance. In these examples, the sustainability disclosure of each firm becomes, in turn, a compliance tool to manage strategic positioning in a complex policy and stakeholder landscape.

Stakeholder legitimacy has quickly developed into a central theme that extends well beyond compliance and financial performance. The topic of communication around radioactive waste management and decommissioning liabilities, and long-term environmental safety has been a hot button issue in corporate documents and academic literature. According to Dorigoni et al. (2025) and Fontanier et al. (2025), this kind of disclosure is not purely informational, but rather influences the public perception of nuclear technologies. Company reports refer to lifecycle analysis, safety compliance data and verification by third parties, potentially indicating high ESG maturity. Nuclear energy companies cooperate with European and other international institutions (like IAEA) but also resort to inclusive community dialogue and cross-border cooperation to maintain public trust and communicate their ESG performance (Gitelman *et al.*, 2025). As noted by Calvo and Villarreal (2018), the completeness and granularity of ESG data across regions differ due to institutional differences. This heterogeneity captures the fluid ways that firms internalize external pressures into their own governance systems.

There are also reputational and operational implications for engagement with stakeholders. Given the market and political volatility pertaining to many energy sectors, the ESG strategy needs two related objectives: regulatory compliance and social legitimacy. Strategic communication in pollution-intensive industries is critically important (Sinansari *et al.*, 2022). As part of its low-carbon strategy, European companies integrate community engagement through stakeholder-oriented governance, as discussed in their ESG reports. To maintain support from national governments and EU institutions for large infrastructure projects, energy companies present social impact mitigation in refurbishment projects. All major energy producers are active in centralized energy markets and dependent on institutional credibility and policy alignment. ESG performance, transparency and responsiveness to stakeholders (Egres and Sarlós, 2024; Risdalen *et al.*, 2023) are linked to long-term community engagement and public approval. The purpose of the present research is to assess the credibility of business models as an indicator of the sustainability of nuclear energy production, in addition to the technical indicators.

3. Methodology

Employing a comparative research design, this study examines the role of nuclear energy in the sustainability strategies of three large European energy companies: EDF (France), Nuclearelectrica (Romania) and Vattenfall (Sweden), in connection

to the EU Taxonomy for sustainable activities. These companies justify their nuclear operations as sustainable based on the technical conditions contained in Delegated Regulation (EU) 2022/1214 sections 4.26 (nuclear electricity generation), 4.27 (construction of nuclear facilities) and 4.28 (safe decommissioning). In these sections, companies must fulfill rigid environmental, technical, and safety standards to be eligible for sustainable investment. The goal is not only to satisfy these criteria, but also to explain how nuclear power is outlined in relation to their overarching ESG and sustainability goals. The same approach is endorsed by Guo *et al.* (2022) for firms which embed sustainability into their business model and integrate their strategy, governance, and operational performance.

These companies were chosen as they reflect different regulatory and market environments, whilst also all heavily utilizing nuclear energy for national decarbonization targets. The selection was done on three criteria: (1) nuclear was a key feature of national energy strategy, (2) the company had five years of sustainability and financial disclosures, and (3) diversity in operations in terms of ownership structure and reporting maturity. While EDF is embedded in a top-down framework within a heavily state-regulated model, Nuclearelectrica activates in a country (Romania) with a very diversified energy mix, and Vattenfall operates in a more liberalized Nordic system. As Calvo and Villarreal (2018) highlighted, the success of sustainable business model transformation is frequently contingent on the adaptation of firms to their institutional and national settings.

This research is conceptually based on stakeholder theory (Stoelhorst and Vishwanathan, 2022) and sustainable business model (SBM) framework (Bocken and Geradts, 2019). Such perspectives frame corporate action towards ecological and social expectations and provide a normative approach, on which the disclosures related to nuclear energy can be evaluated. This study treats compliance with EU Taxonomy not only as regulatory compliance but also as an institutional legitimation process. For this analysis, we examined the financial reports of each company during the 2020-2024 period and the sustainability reports of 2024 (in compliance with the Corporate Sustainability Reporting Directive 2022/2464). These reports are publicly available and contain mandatory information on environmental performance, risk disclosures, sustainability targets and progress. The 2024 reports are particularly important for understanding how each company handles the existing rules of the EU Taxonomy. The EU Taxonomy analysis was operationalized by mapping disclosures in the reports to criteria under Delegated Regulation (EU) 2022/1214. For example, firms were required to provide proof of long-term disposal strategies for waste and reactor decommissioning planning (art. 4.28). Lifecycle greenhouse gas emission thresholds and safety compliance procedures were evaluated under art. 4.26. Alignment claims were determined based on this mapping.

Content analysis (Dragomir *et al.*, 2025; Guo *et al.*, 2024) was used to establish theoretical categories based on the EU Taxonomy and the SBM framework. The reports were examined to extract four general analytic dimensions: (1) the placement of nuclear energy in the larger decarbonization plan, (2) the Taxonomy criteria used in relation to nuclear activities (sections 4.26–4.28), and (3) firm-level financial performance as measured using the fixed assets turnover ratio (FAT). Themes were identified through close reading and comparison of disclosures across the five-year period for each company. Data was structured and compared in spreadsheets to make sure consistency between cases was achieved. We study the four above dimensions in a separate manner for each case, and then compare the outcomes to find trends, disparities, or similarities. This type of comparative mapping can highlight how different firms interpret and apply EU Taxonomy rules nationally and in sectors with challenging environmental and public trust issues (Alessi *et al.*, 2024; Schulte, 2024).

Financial information was collected from fifteen financial reports (five from each company, for the years of 2020–2024). To analyze financial performance on a more specific level, the fixed assets turnover (FAT) was calculated for each firm between 2020-2024. Essentially, this metric highlights how efficiently the revenue of businesses is derived from their fixed or long-term assets (e.g. nuclear plants and the infrastructure that businesses rely on). It can be obtained by dividing total revenue by net fixed assets. According to Guo et al. (2024), the metric makes it possible to assess whether capital-intensive technologies (e.g., nuclear) are efficient under sustainability limitations. The FAT ratio provides a financial performance proxy to supplement qualitative assertions regarding operational efficiency, modernization, and capital deployment. Although other financial indicators were in the scope, namely ROA and EBITDA margin, they were excluded to keep the study within the range of asset productivity.

4. Results

4.1 Analysis of production capacities and operational strategies

This section contains comparative operational data and results for EDF (Table 1), Nuclearelectrica (Table 2), and Vattenfall (Table 3). The compiled data refers to nuclear energy capacity and decarbonized electricity generation for the years 2020 to 2024, based on corporate disclosures and sustainability reports. The tables show how each company's nuclear assets and low-carbon production changed over time. Drawing on this, particular focus is placed on interpreting annual variations in installed capacity and the decarbonized energy share to demonstrate how operational strategies and external constraints influenced performance. These findings form the basis for evaluating the overall alignment of each of these

companies with the EU sustainability objectives, especially regarding how nuclear energy is framed within energy transition.

Table 1. Operational data for EDF

Year	Total Installed Capacity (GW)	Total Electricity Produced (TWh)	Nuclear installed capacity (GW)	Nuclear Installed Capacity (% of total)	Decarbonized Energy Production (% of total)	Nuclear Energy Production (% of total)
2020	120.5	501.9	71.1	59%	90%	76.50%
2021	117.3	523.7	70.38	60%	91%	78.20%
2022	116.9	431.7	67.8	58%	90%	76%
2023	117.3	467.6	68.03	58%	93%	77.70%
2024	118.8	520.3	67.71	57%	94%	77.70%

Source: authors' own study

Table 2. Operational data for Nuclearelectrica

Year	Total Installed Capacity (GW)	Total Electricity Produced (TWh)	Nuclear Installed Capacity (% of total)	Decarbonized (Nuclear) Energy Production (% of total)
2020	1.41	11.466	100%	100%
2021	1.41	11.284	100%	100%
2022	1.41	11.089	100%	100%
2023	1.41	11.191	100%	100%
2024	1.41	10.912	100%	100%

Source: authors' own study

Table 3. Operational data for Vattenfall

Year	Total Installed Capacity (GW)	Total Electricity Produced (TWh)	Decarbonized Energy Production (% of total)	Nuclear Installed Capacity (% of total)	Nuclear Electricity Generation (TWh)	Nuclear Installed Capacity (GW)
2020	15.01	109.1	45.04%	29.91%	39.3	4.49
2021	15.74	108.1	47.04%	29.29%	40.4	4.61
2022	15.6	105.7	48.58%	28.97%	39.6	4.52
2023	17.14	97.7	49.65%	24.91%	37.4	4.27
2024	14.58	95.7	52.60%	29.70%	37.9	4.33

Source: authors' own study

EDF's nuclear installed capacity (Figure 1) has a gradually declining trend over the five-year period, down from its 2020 level of 71.1 GW to 67.71 GW in 2024 level. This decline illustrates both the retirement of existing reactors, extended

maintenance and delays in new units coming online. The decline from 2020 to 2022 was mainly attributed to longer safety inspections, notably on stress corrosion problems identified in 2021 that led to the temporary or permanent offline status of some units, according to EDF's 2024 Universal Registration Document (EDF, 2025). The decline was influenced by the continued absence of significant capacity added, as no new projects were completed.

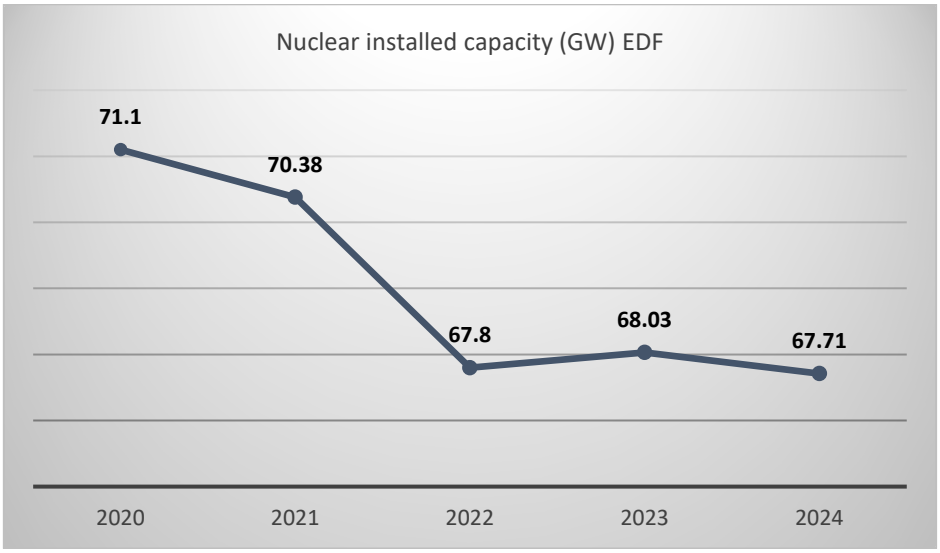

Figure 1. Trend of nuclear installed capacity of EDF (France).
Source: authors' own study

Despite the decline in nuclear capacity, EDF's decarbonized energy production (Figure 2) as percentage of total production was even higher, 90% in 2020 and 94% in 2024. This fell to the lowest level in 2022, then briefly returned to 90 percent in 2023 amidst the most extensive unplanned nuclear outages. In 2023 and 2024, the company reported greater hydropower and faster renewables deployment, with a particular focus on offshore wind. The growing amounts of decarbonized output, despite lower nuclear generation, reflect EDF's mix and hedge as an important European energy transition player. It also further demonstrates that the targets for decarbonization can be preserved despite such technical disruption in nuclear legacy assets as long other low-carbon sources are brought online in tandem.

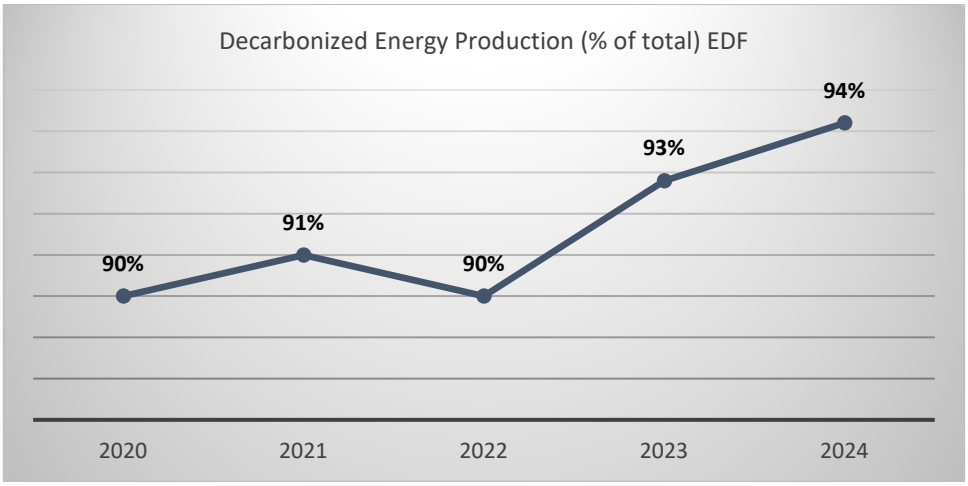

Figure 2. Trend of decarbonized energy production of EDF.
Source: authors' own study

Nuclearelectrica (Romania) kept its 1.4 GW of installed capacity unchanged between 2020 and 2024, corresponding to the operational capacity of its two CANDU 6-type reactors located at the Cernavodă Nuclear Power Plant. Despite this stable capacity level, electricity production decreased (Figure 3) slightly from 11,466 GWh in 2020 to 10,912 GWh in 2024. Such variations are attributable to operational changes, in particular preparatory work for the Unit 1 refurbishment, as detailed in the 2024 Annual Report (Nuclearelectrica, 2025). This company-specific vertically integrated model and its own nuclear fuel production through NFP Pitești ensured that output changes were not limited by fuel but rather by internal company planning.

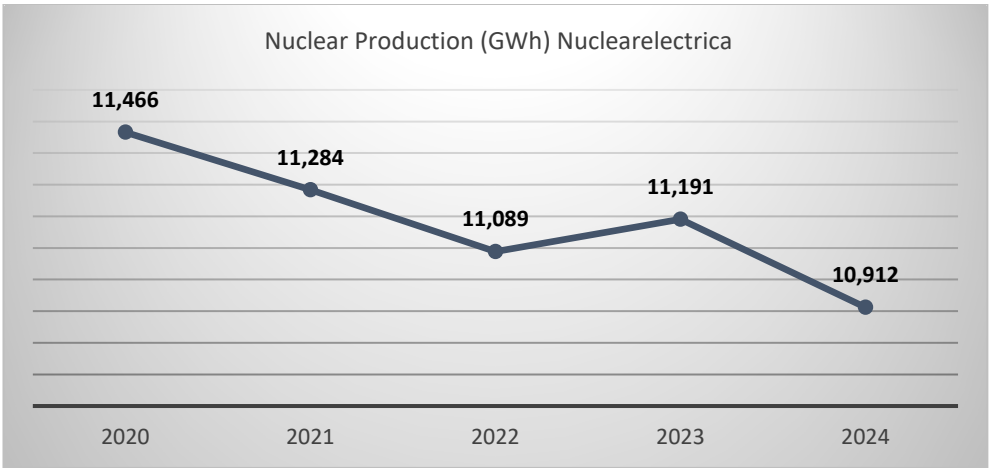

Figure 3. Trend of nuclear power production of Nuclearelectrica.
Source: authors' own study

During the five-year period, the share of decarbonized energy produced by Nuclearelectrica has maintained a value of 100%. This is in line with its 100 % nuclear-only power generation, i.e., no contributions from fossil fuels or renewables. Against the past national picture of fossil fuels still representing 71 % of energy use (Miron and Ojog, 2024), Nuclearelectrica is consistently low-carbon, and will ultimately be a key part of Romania's energy transition away from fossil fuels. Its pledges around modernization and future Small Modular Reactors (SMRs) deployment amplify its strategic fit to match national energy objectives to EU climate objectives.

Vattenfall provides a more complicated story (Vattenfall AB, 2024). As for its nuclear installed capacity (Figure 4), the figure has seen slight variations over the years, with 4.49 GW in 2020 vs 4.33 GW in 2024. The capacity reached its highest point at 4.61 GW in 2021 but has been declining gradually since then. The drop from 2022 to 2024 is not due to decommissioning but reflects a reassessment of unit categories plus temporary shutdowns for maintenance and upgrades at the Ringhals and Forsmark plants. Other than that, there are no new nuclear fleet reactors that came online during that period, and there are no immediate large-scale nuclear expansions planned. As investment has been redirected to renewables, the balance in Vattenfall's energy mix also continues to shift from nuclear. This slight drop in nuclear capacity must therefore be put in the context of the larger change the firm is undergoing in its generation portfolio.

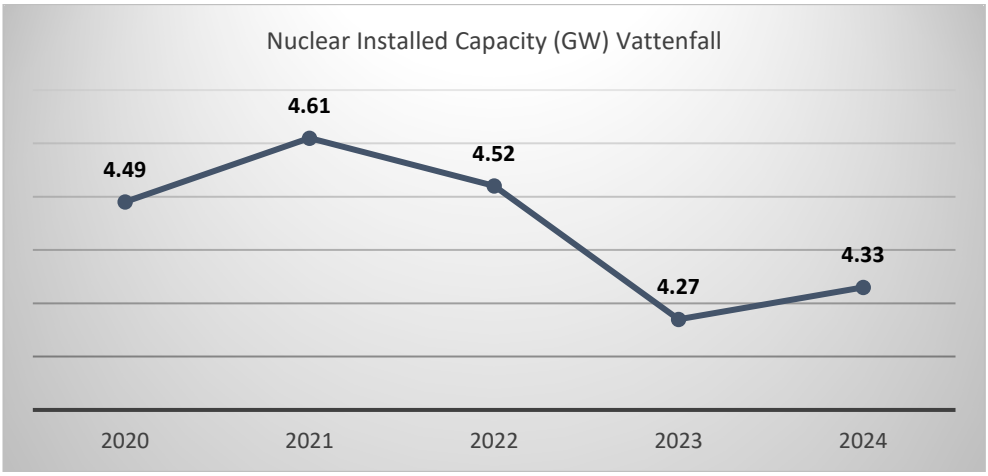

Figure 4. Trend of nuclear installed capacity for Vattenfall (Sweden).
Source: authors' own study

However, Vattenfall's share of decarbonized energy production (Figure 5) as a percentage of total production steadily increased from 45.04% in 2020 to 52.60% by 2024. It is more indicative of the expansion of renewables, not nuclear installations. In its sustainability report for 2024, the company notes new capacity

being added in 2024 from wind, especially based in the Netherlands and Sweden, as well as a greater use of hydro. Driven by both the increased upward in renewables and steady generation of nuclear power, the firm has been able to drive the overall decarbonization ratio higher. Vattenfall energy model shows a more complementary pathway whereby nuclear continues to be relevant for system reliability, but renewables assume growing importance in reaching EU climate targets.

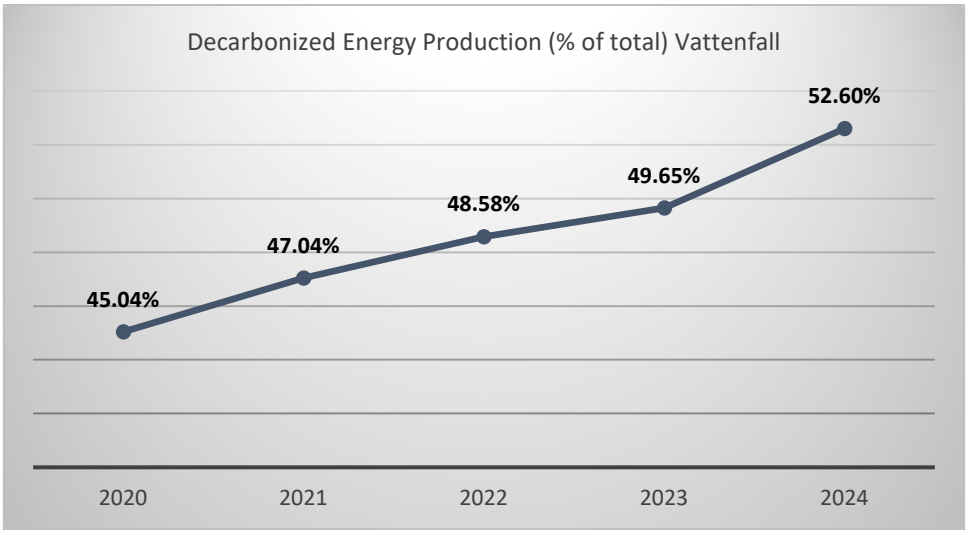

Figure 5. Trend of decarbonized energy production in Vattenfall.
Source: authors' own study

Overall, the data suggests three different strategic priorities. EDF remains reliant on nuclear power but is using renewables to counter short-term nuclear losses and is more diversified than before. Nuclearelectrica has a pure nuclear identity, despite a small fall in capacity following long-term modernization efforts. Vattenfall is deploying a hybrid strategy that reduces the proportion of nuclear power whilst deploying it as a stabilizing force in a rapidly expanding renewables portfolio. The national energy priorities as well as the maturity of power infrastructure and corporate sustainability strategies, shaped by operational constraints and policy drivers over the period 2020 to 2024, determine each corporate pathway.

4.2 Financial analysis and the EU Taxonomy

The fixed assets turnover (FAT) ratio indicates how efficiently each company was able to turn its fixed asset base into revenue over the respective five-year period. While installed capacity remained flat, the rise of EDF from 0.30 to 0.65 during 2020- 2024 indicates growing efficiency of its nuclear segment. This trend is in line with the company's focus on asset modernization with the Carénage program

and strong post-pandemic market conditions outlined in the company's 2024 Annual Report. In 2020, Nuclearelectrica had a FAT of 0.38, increased to 0.96 in 2023, and then dropped back to 0.73 in 2024. The rise through the middle part of the years befits high electricity prices and stable operations, while the fall associated with the initial refurbishment of Unit 1 at Cernavodă, forced some output offline for a short period. Vattenfall reported the highest FAT year after year for the three companies, starting at 0.59 in 2020, up to 1.08 in 2023 and down to 0.90 in 2024. Although the high ratio was supported by strong cost performance and favorable market conditions, the modest drop in 2024 reflects relatively high investment in renewables and a growing overall net asset base. In sum, these patterns can be seen in their national context and investment cycle, but evolutions are also linked to investment strategies.

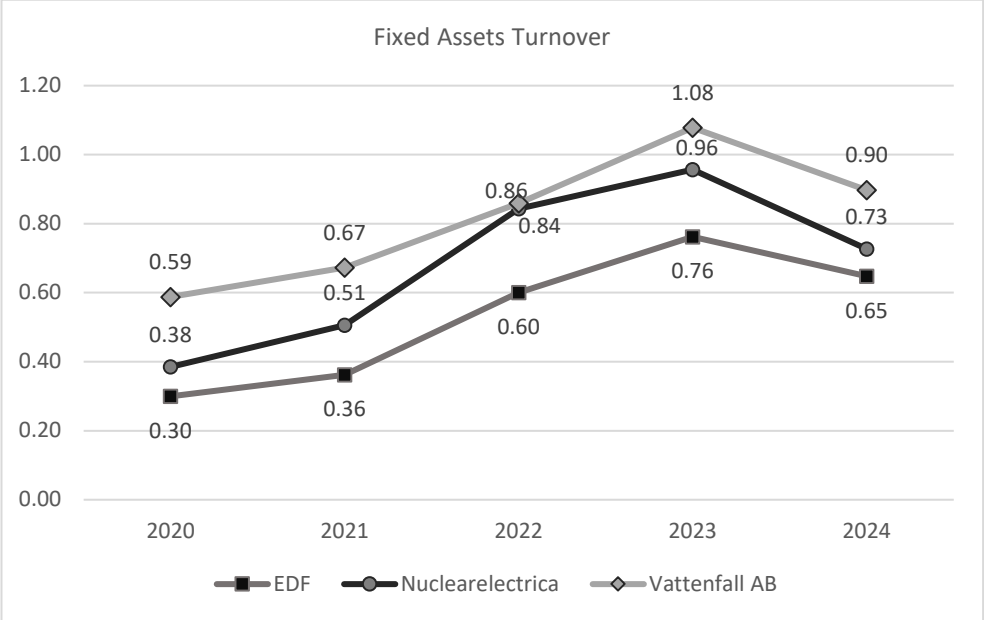

Figure 6. Trend of fixed assets turnover (FAT for the sample companies.
Source: authors' own study

According to EDF (2025) disclosure against the EU taxonomy (Table 4), 27% of its turnover, 26% of its capital expenditure, and 31% of its operational expenditure is derived from nuclear activities deemed environmentally sustainable. Most of this alignment comes from the operation of existing plants operating under section 4.28 with 27% of turnover and 28% of OpEx. EDF also records 7% of CapEx under art. 4.27 for preparatory investments in new nuclear builds. These investments are related to upgrades, annual maintenance and early work on future projects such as the Flamanville EPR, according to the 2024 sustainability report.

Table 4. EDF Taxonomy 2024

Activity (EU Code)	Taxonomy Classification	Proportion of Turnover (%)	Proportion of CapEx (%)	Proportion of OpEx (%)
4.27 – New nuclear plants	A1 – Environmentally sustainable	–	7 CCM	2 CCM + 1 CCA = 3
4.28 – Existing nuclear plants	A1 – Environmentally sustainable	27 CCM	19 CCM	28 CCM
Total eligible (A1 + A2)	-	60	62	70
Non-eligible activities (B)	-	40	38	30
Total (A + B)	-	100	100	100

Source: authors' own study

Nuclearelectrica (2025) shows a large proportion of taxonomy-eligible activity but does not fully align with the significant contribution criteria (Table 5). The company has an eligible turnover under the taxonomy of 98.83%, CapEx of 91.93% and OpEx of 94.76%, predominantly related to Cernavodă Units 1,2 and Units 3 and 4 to be built. But all relevant activities are A2, meaning they are eligible but not yet aligned because of missing compliance steps. The 2024 Annual Report confirms this status and outlines pathways towards modernization programs and regulatory alignment in particular in relation to SMR development and Unit 1 refurbishment.

Table 5. Nuclearelectrica Taxonomy 2024

Activity (EU Code)	Taxonomy Classification	Proportion of Turnover (%)	Proportion of CapEx (%)	Proportion of OpEx (%)
–	A1 – Env. sustainable nuclear activities	–	–	–
4.27 – New builds (Units 3 & 4)	A2 – Eligible but not aligned	–	7.06	–
4.28 – Existing Units 1 & 2	A2 – Eligible but not aligned	98.83	84.87	94.76
Total eligible (A1 + A2)	-	98.83	91.93	94.76
Non-eligible activities (B)	-	1.17	8.07	5.24
Total (A + B)	-	100	100	100

Source: authors' own study

The three firms have varying alignments on nuclear power, with Vattenfall disclosing the lowest (Table 6). This only relates to operations at Forsmark and Ringhals, corresponding with the fact that only 6% of turnover and CapEx, and 28% of OpEx belong to section 4.28. In its 2024 sustainability report, Vattenfall (2024) states the company's strategy is to keep its nuclear operations "safe and transparent" while emphasizing a larger role for renewables in its energy mix. The three firms are in varying degrees and depths of alignment with the Taxonomy, mostly driven by their approach to investments, and their role nuclear power in the long term decarbonization strategy.

Table 6. Vattenfall Taxonomy 2024

Activity (EU Code)	Taxonomy Classification	Proportion of Turnover (%)	Proportion of CapEx (%)	Proportion of OpEx (%)
4.28 – Forsmark & Ringhals	A1 – Environmentally sustainable	6	6	28
–	A2 – Nuclear activities eligible but not aligned	–	–	–
Total eligible (A1 + A2)	-	39	91	88
Non-eligible activities (B)	-	61	9	12
Total (A + B)	-	100	100	100

Source: authors' own study

5. Discussion

From the reports, EDF generally had a more thorough plan for matching up with the Taxonomy, using lifecycle assessments and precise safety paradigms to frame its nuclear fleet as a pillar to French climate targets. Nuclearelectrica included changes to its operations and industry-leading technology, although it aims to enhance domestic stakeholder communication. Vattenfall presented nuclear energy as a bigger effort of establishing a stable fossil-free energy system within a national perspective. While working in various national contexts, the common challenge for all these companies is to demonstrate that nuclear energy can meet the EU's sustainability requirements. This is linked to the goal to reformulate corporate identity and obtain legitimacy through the EU Taxonomy, improved reporting and policy alignment (Dragomir *et al.*, 2022).

The reframing narratives need to be grounded in the real world. Guo et al. (2024) discussed that financial performance needs to support environmental performance to determine if a company's claims about sustainability are economically viable.

The FAT ratio calculated for EDF, Nuclearelectrica, and Vattenfall for the period between 2020 and 2024 provides an operational perspective to how nuclear infrastructure generates sustainable value. The stability of EDF's turnover is a sign that its assets have matured and are being used optimally. The increase for Nuclearelectrica corresponds to its refurbishment and expansion works. The fluctuations in Vattenfall's production are due to its wider asset mix. Based on previous literature (Egres and Sarlós, 2024; Matos *et al.*, 2020), resource use efficiency can be considered as essential to justify investments in high-cost technologies such as nuclear power generation. Moreover, the combination of financial data with ESG performance embodies the accountability goals under the EU Taxonomy (Akano *et al.*, 2024).

The differences in disclosure and operational choices between companies reflect divergent national energy priorities and institutional structures. There is a distinct line of nuclear continuity in the case of Nuclearelectrica. Being already one of the least carbon-intensive countries in the EU, Romania relies on the significant contribution (around 20%) of Nuclearelectrica to its decarbonization targets. Although the company has been producing 100% of low-carbon electricity over time, this is primarily due to the operation of Cernavodă Units 1 and 2. Part of the firm's wider strategy seeks to refurbish Unit 1, build Units 3 and 4 and collaborate with foreign investors on small modular reactors. The 2024 taxonomy alignment for the firm indicated significant turnover, capital expenditure and operational expenditure associated with sustainable nuclear activities. In these three areas, the 2024 sustainability report emphasized the need for EU-level participation, regional collaboration, and lifecycle governance in several areas, including safety, decommissioning, and radioactive waste. Alongside financial indicators, the metrics for asset utilization also revealed a positive trend, with growing FAT ratio for the entire period of analysis, which indicates an efficient capital allocation through strategic investment planning and modernization works.

In contrast, EDF is responsible for the largest installed capacity of the nuclear fleet in an EU country. France has treated nuclear power as integral to energy independence and decarbonization for decades. Nuclear energy is France's approach to net-zero, providing steady, low-carbon electricity to homes and industry. Taxonomy disclosures from EDF for the latest reporting period indicate that only a quarter of the group's turnover and capital expenditure pertain to environmentally sustainable nuclear activities. A large portion of this alignment concerns with the operations driven under section 4.28 of the Taxonomy, such as maintenance, safety, and regulatory compliance. Similarly, there is some alignment with section 4.27 with respect to new nuclear construction, although new investment is quite small, affected by permitting obstacles. The safety lifecycle in EDF's 2024 Sustainability Report outlines public transparency and French energy sovereignty, maintaining and extending the service life of existing nuclear assets. While the FAT had little variance during the period, such would be a sign of

infrastructure being maintained rather than expanded. This reliability provides an underpinning for the current operational model of EDF which suggests the company is focused more on reliability and lifecycle compliance than on capacity expansion.

Vattenfall provides another model of nuclear energy's role in a diversifying portfolio with wind, hydro and bioenergy. It owns Forsmark and Ringhals, two nuclear plants that account for a sizable share of base-load production in Sweden. However, unlike Nuclearelectrica, nuclear is not the majority of its generation mix. This relative position in the company Taxonomy disclosures relates to lower turnover and capital expenditure associated with nuclear. As its 2024 sustainability report notes, the biggest alignment is activity 4.28, and there is new investment qualifying under other sections. In its report, the company focuses on stakeholder engagement and risk communication, especially regarding the safety of nuclear operations and enhancing energy system resilience. The FAT demonstrates changing tendencies for Vattenfall based on portfolio changes. The expansion of renewables aligns with high-level strategies, emphasizing the role of competing in renewables growth and electrification. Placing nuclear in this broader context strengthens Vattenfall's claim that energy categories should relate to national interest.

On a larger scale, the European discussion on nuclear energy's place in the green transition is still mixed, environmental, technological, economic and public credibility issues. Nuclear energy obtained a more viable role in sustainable finance after its inclusion in the EU Taxonomy in the form of Delegated Regulation 1214/2022. To make a significant contribution, firms must meet stringent technical and legal requirements regarding environmental protection, radioactive waste disposal, and lifecycle emissions. The policy briefing issued by the European Parliament (2023) also declared that nuclear is considered climate-aligned only if backed by strong governance for safety with geological disposal of radioactive waste, accident-tolerant reactor technology and transparency, with mechanisms providing for stakeholder engagement. This constitutes an essential regulatory framework underpinning EDF, Nuclearelectrica, and other operators seeking to meet these expectations and communicate their compliance with the EU Taxonomy.

Sustainability impact assessment means to abstain from overselling the advantages of nuclear energy. While nuclear capacities have a positive effect on reducing CO_2 emissions, it has negative effects on ecosystem mainly through land use, radioactive waste and mining for radioactive minerals (Soto and Martinez-Cobas, 2024). These results highlight the importance of full life-cycle analysis whenever companies report Taxonomy-aligned activities (Sharma *et al.*, 2024). In contrast, Schulte (2024) highlighted that economic feasibility is threatened, especially by significant long-term capital costs, long construction periods and decommissioning

timeframes. In the case of the retrofitting or the expansion of existing plants, as in EDF's Flamanville, or the Cernavodă Units 3 and 4 (Nuclearelectrica, 2023), there are always unforeseen delays and cost overruns with possible negative impacts on stakeholder expectations and investor confidence.

Nuclear energy's sustainable profile is compounded even more by social acceptance (Pampel, 2011; Sonnberger *et al.*, 2021). Egres and Sarlós (2024) noted that nuclear also does not always go hand-in-hand with pro-climate attitudes in the public domain. Indeed, high concern for climate change is frequently associated with nuclear energy rejection based on safety, radioactive consequences, and intergenerational waste risks (Portugal-Pereira *et al.*, 2024). Part of the reason for this contradiction is that decarbonization arguments cannot persuade people that nuclear energy is safe. Long-term public trust, however, has been upheld in places like France where EDF operates, through tight regulation and a prolonged positive historical experience. The recent initiation of the development of new-generation reactors in Romania under Nuclearelectrica, especially SMRs, contrasts sharply with countries that favor participatory governance, local communication, and antinuclear activism (Fox-Cardamone *et al.*, 2000).

On the other hand, Vattenfall's activity in the Swedish context is more cautiously and diversely planned. It features an energy mix that is becoming increasingly reliant on renewables such as wind and solar. Vattenfall nuclear activities are predominantly aligned with Taxonomy section 4.28 (Operation, maintenance and safety assurance) and this was confirmed in its Sustainability Report (Vattenfall AB, 2024). Euronews (2025) points out that in Sweden, for instance, nuclear power was not seen as a primary energy source, rather as an alternative that will help the entire system become more resilient. That strategy is consistent with national targets for electrification and decarbonization, where nuclear acts as a support, not a growth engine. Meanwhile, opinions in Sweden regarding nuclear power are divided (Axelsson *et al.*, 2025), which also make Vattenfall adopt a slightly more conservative investment stance. The company is not expanding but using nuclear to provide stability for its larger renewable energy agenda.

By contrast, EDF plays a much more central role in the national energy system in France (EDF, 2025). Having the largest nuclear fleet in the EU (56 reactors nationwide) and producing over 67.3% of France's electricity from nuclear sources (Euronuclear, 2025). Coinciding with this, EDF has contextualized nuclear as the first pillar of national energy sovereignty and climate resilience. As a result of this alignment between taxonomy and disclosures, we see large proportion of CaPEX and OpEX associated with green activities in 4.28 (operation) and a smaller proportion in 4.27 (new builds). However, new investment in nuclear construction is still limited partly to lengthy permitting processes as well as opposition to high-profile projects like Flamanville 3 (World Energy, 2025). Instead of newbuilds, EDF relies heavily on lifecycle safety, plant modernization and longer operational

lifespans. Nuclear energy under the EU Taxonomy can only be considered viable if it fulfills high safety standards, transparent reporting and waste disposal mechanisms (European Parliament, 2023). EDF is looking to meet these criteria by bringing its decades of technical experience in line with the expectations of EU governance. The FAT ratio indicates that, while EDF is reasonably steady in its operations, it is not actively evolving, perhaps suggesting reluctance to transformational change in favor of steady-state continuity.

Nuclearelectrica is at a different stage in nuclear development. In Romania, the company is laying the ground for a low cost, low-carbon energy, but also the next generation of technology. Nuclearelectrica, which owns the two CANDU reactors that it currently operates at the Cernavodă site, provides about 20% of Romania's electricity, 100% low-carbon. It plans for large scale upgrades for Unit 1, the construction of Units 3 and 4, and collaboration on SMRs with the U.S.A. Nuclearelectrica has Taxonomy eligible activities for operations, capital expenditure and refurbishment for future expansion. Nuclearelectrica's Sustainability Report (2025) also detailed this commitment for EU-wide collaboration, as well as commitment to lifecycle governance frameworks aligned with waste and decommissioning issues. Romania's national strategy, which has the support of both the government and international partners, enables a higher dependency on nuclear power than any other Eastern European country (Eurostat, 2025). Yet, the company also needs high levels of social legitimacy and regional stability (Ministry of Energy (Romanian Government), 2024). At the same time, the higher FAT in conjunction with sustainable activities indicates a conscious process of framing nuclear energy as a low emissions source.

Overall, the three companies exemplify the varying national models and corporate strategies linked to the EU Taxonomy. Sweden's Vattenfall conservatively integrates nuclear into a mix of renewable sources with a focus on security of supply and safety, leading in scale and technical ability. EDF's nuclear focus is central to France's national identity and energy independence. Nuclearelectrica of Romania tackles the challenges of legacy infrastructure against forward-looking innovation using the EU taxonomy as a tool for legitimacy and access to financing. These paths demonstrate that it takes more than the Taxonomy alignment because nuclear credibility in the EU depends on lifecycle sustainability, risk governance, social acceptance, and operational performance. Nuclear operators will need to move away from merely checkbox-compliance, providing genuine and measurable value across environmental, financial and governance dimensions.

6. Conclusions

In this study, we analyzed the status of nuclear energy in the sustainable finance architecture of the European Union, based on its inclusion in the EU Taxonomy.

We examined how nuclear-related activities are presented in sustainability strategies and financial disclosures of three large electricity companies: EDF (France), Nuclearelectrica (Romania), and Vattenfall (Sweden). The research, based on five years of reporting data (operational and financial information), presented the ways in which these firms link environmental processes to performance, based on the coverage of their operations under Taxonomy criteria. The results demonstrate the effect of national policy priorities, regulatory settings, and corporate strategies on the framing of nuclear energy in sustainability discourses, with similarities and differences in how firms cope with changing pressures for green investment and strict governance.

We focused on how each of these companies communicates the risk attached to their nuclear portfolios. Disclosures refer to nuclear waste, plant safety, community impacts, and long-term decommissioning. Sinansari et al. (2022) outlined criteria for the Taxonomy and whether transparency on governance aspects can inspire stakeholder trust. Vattenfall referred to stakeholder participation, and wider citizen outreach. Nuclearelectrica noted efforts towards Small Modular Reactor (SMR) development; and EDF referred to safety track records, compliance, and life cycle assessment. We examined these disclosures to explore how firms established credibility and their social license to operate, according to stakeholder theory. According to Gitelman *et al.* (2025), nuclear companies are facing the challenge of having to justify not just what they do, but also how they reduce risk and improve safety measures.

This article provides complementary angles on the role of nuclear as part of sustainable business models and the influence on reporting. Nuclearelectrica has a specialization model centered around nuclear power, operational and strategic competence. Through transparency, EDF demonstrates how legacy assets can be re-positioned, while Vattenfall illustrates how nuclear power can be incorporated within a broader sustainability strategy. In all instances, however, the EU Taxonomy serves not merely as a compliance checklist but rather a blueprint via which firms describe their position in the European energy framework. Results demonstrate that nuclear energy is getting increasingly normalized in sustainable finance, but that normalization varies in institutional settings, investment strategy and communication practices.

Despite the EU Taxonomy that seeks to harmonize different economic activities from a sustainability perspective, significant discrepancies remain at the national and firm levels in the categorization, disclosure, and justification of nuclear energy-related activities. This work could be extended in the future to examine how investors respond to disclosures from corporate executives. Taxonomy criteria and rising expectations regarding ESG performance will require energy firms to include not only operational and financial data but also the strategic vision to meet both objectives: climate neutrality and institutional accountability.

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