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FROM SOCIALIST INDUSTRIALISATION TO ENVIRONMENTAL, SOCIAL, AND GOVERNANCE MANAGEMENT: THE TRANSFORMATION OF KGHM POLSKA MIEDŹ, 1961–2023

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Abstract: KGHM Polska Miedź S.A. (KGHM; formerly *Kombinat Górniczo-Hutniczy Miedzi* [Copper Mining and Metallurgical Combine]) provides a distinctive case for examining how a large mining and metallurgical enterprise transformed its operational model to address the environmental and social consequences of socialist industrialisation through the gradual development of an environmental, social, and governance (ESG) framework. This article aims to reconstruct the historical evolution of ESG governance at KGHM between 1961 and 2023 and to assess whether the company's contemporary sustainability model emerged primarily as a response to accumulated industrial legacy costs, institutional learning, and changing stakeholder expectations. The study applies a historical-institutional approach combining qualitative historical reconstruction with longitudinal analysis of environmental, social, and governance indicators. Its source base includes KGHM annual, integrated, CSR, sustainability, and ESG reports published between 2004 and 2023, together with historical, technical, administrative, statistical, parliamentary, trade-union, and regional press materials documenting the development and environmental impact of the Legnica–Głogów Copper District. The findings show that KGHM's ESG transformation was path dependent and rooted in the technological and environmental consequences of the integrated mining–beneficiation–smelting system created during the Polish People's Republic. Severe air pollution, tailings accumulation, soil contamination, occupational risks, and social pressure stimulated gradual institutional responses, in-

cluding protective zones, emission-control investments, environmental monitoring, and management-system reforms. The post-1989 commercialisation and partial privatisation of the company accelerated organisational professionalisation, while Poland's accession to the European Union strengthened reporting, regulatory compliance, and technological modernisation. By the 2010s and early 2020s, KGHM had developed integrated ESG governance based on climate targets, renewable energy, circular-economy measures, occupational safety, stakeholder engagement, risk management, and international reporting standards. The evidence supports historical continuity, early institutionalisation before current EU reporting mandates, and the company's advanced regional ESG position. The article concludes that ESG at KGHM should be interpreted not merely as a recent disclosure practice, but as an economic and institutional response to inherited industrial costs, supporting long-term competitiveness, legitimacy, and organisational resilience.

Keywords: ESG governance; industrial legacy costs; ecological modernisation; copper mining and metallurgy; KGHM Polska Miedź S.A

INTRODUCTION

1.1. Sustainable Development As a Governance Logic for High-Impact Industries

Sustainable development has become a fundamental governance principle for industries characterised by significant environmental and social externalities, particularly mining and metallurgy. While originally formulated as a broad normative concept, it increasingly serves as an analytical framework for understanding how firms respond to the long-term consequences of industrial activity. The Brundtland Report defines sustainable development as development that meets present needs without compromising the ability of future generations to meet their own needs (*Report of the World…*, 1987: 43). For heavy industry, this principle is especially relevant because environmental degradation, land transformation, waste accumulation, and public health impacts often span several decades, making short-term economic performance an insufficient measure of corporate success (*Report of the World…*, 1987: 43–47; Hart, 1995: 988–994).

From this perspective, sustainable development represents more than an environmental objective. It provides a governance logic through which companies gradually internalise environmental and social externalities while maintaining long-term economic viability. This perspective

is particularly suitable for analysing historically significant industrial enterprises such as KGHM, whose transformation reflects not only technological modernisation but also changing institutional expectations concerning environmental responsibility and regional development.

The Triple Bottom Line (TBL) translates this normative concept into an operational framework by integrating economic, environmental, and social dimensions of corporate performance (Elkington, 1997: chapters 1–2). Rather than treating profitability as the sole indicator of success, TBL recognises that sustainable industrial development depends simultaneously on financial performance, environmental improvement, and social legitimacy (Freeman, 1984: 41–46; Dyllick and Hockerts, 2002: 131–133). For mining companies, these dimensions are closely interconnected: economic performance enables long-term investment in cleaner technologies; environmental improvements reduce ecological burdens inherited from earlier industrialisation; while social performance strengthens relations with employees, local communities, and public institutions.

A complementary explanation is provided by Ecological Modernisation Theory (EMT), which argues that environmental protection and industrial competitiveness are not mutually exclusive. Instead, technological innovation, organisational learning, and regulatory development may jointly reduce environmental impacts while improving production efficiency (Spaargaren and Mol, 1992: 326–330; Mol, 2001: ch. 1–3). In heavy industry, modernisation therefore involves more than compliance with environmental regulations. It encompasses systematic investment in cleaner production technologies, emission control, energy efficiency, environmental monitoring, and organisational capabilities that gradually reshape industrial governance (Hart, 1995: 994–996; Porter and Linde, 1995: 98–101).

These perspectives are particularly valuable for interpreting the historical evolution of KGHM. Rather than treating sustainable development as an abstract contemporary concept, this study employs it as an analytical framework to examine how a company burdened by the environmental legacy of socialist industrialisation progressively incorporated environmental protection, social responsibility, and governance reforms into its long-term development strategy. Consequently, sustainable development, TBL, and Ecological Modernisation Theory are not examined as independent theoretical constructs but rather as complementary perspectives that support the historical analysis presented in the following sections.

1.2. ESG as a Contemporary Architecture of Industrial Governance and Decision-Useful Disclosure

ESG has evolved from a voluntary corporate responsibility concept into an institutional framework for managing non-financial risks, evaluating long-term corporate performance, and communicating sustainability-related information to investors and society. In contrast to earlier approaches centred primarily on philanthropic activities, ESG integrates environmental and social issues into corporate governance, strategic decision-making, and performance measurement, thereby strengthening accountability and transparency (Eccles and Krzus, 2010: ch. 1; Friede et al., 2015: 212–213).

For high-impact industries such as mining and metallurgy, ESG is particularly relevant because environmental degradation, occupational safety, and community relations directly influence the firm's long-term legitimacy and ability to operate. Consequently, ESG reporting should not be interpreted solely as a disclosure exercise but as evidence of the gradual institutionalisation of governance practices that respond to changing regulatory requirements, stakeholder expectations, and technological capabilities.

Several complementary theoretical perspectives explain this process. Stakeholder theory emphasises that firms operating in environmentally sensitive sectors must balance the interests of multiple stakeholder groups, including employees, local communities, regulators, investors, and suppliers, whose expectations increasingly influence corporate strategy (Freeman, 1984: 31–46). Legitimacy theory complements this perspective by explaining why companies expand environmental and social disclosures when confronted with changing public expectations or the historical consequences of industrial activity (Suchman, 1995: 574–580). In parallel, institutional theory demonstrates how regulatory frameworks, professional standards, and industry best practices gradually encourage convergence towards similar governance and reporting systems across firms (DiMaggio and Powell, 1983: 150–153).

From a corporate governance perspective, agency theory emphasises embedding environmental and social objectives within formal governance structures rather than treating them as discretionary initiatives (Jensen and Meckling, 1976: 308–310). At the same time, signalling theory explains why companies increasingly disclose credible ESG information to reduce information asymmetry and demonstrate managerial quality, organisational resilience, and long-term strategic commitment (Spence, 1973: 356–358; Friede et al., 2015, pp. 212–214).

Rather than analysing these theories separately, this study treats them as complementary analytical perspectives that facilitate the interpretation of KGHM's historical transformation. Together, they explain how environmental protection, social responsibility, and corporate governance gradually became integrated into the company's strategic development, while ESG disclosure emerged as an institutional expression of broader organisational change rather than merely a reporting obligation. This integrated perspective provides the conceptual basis for interpreting the historical evolution of KGHM presented in the empirical sections of the article.

1.3. CSR as the Historical Foundation of ESG Transformation

Corporate Social Responsibility (CSR) provides the historical context necessary for understanding the evolution of ESG governance in heavy industry. While ESG represents a contemporary framework for managing and reporting non-financial performance, CSR explains why environmental and social responsibility gradually became embedded in corporate strategy and governance. For companies operating in environmentally intensive sectors, this evolution reflects not only changing regulatory requirements but also the cumulative effects of historical experience, institutional learning, and societal expectations.

Carroll's CSR framework conceptualises corporate responsibility as a combination of economic, legal, ethical, and philanthropic obligations (Carroll, 1991: 40–43). In the context of mining and metallurgy, these dimensions should not be interpreted as isolated categories but as successive stages in the institutional maturation of industrial governance. During the early stages of industrial development, compliance with economic and legal responsibilities typically dominates managerial priorities. Over time, however, growing environmental awareness, stricter regulations, and increasing public expectations encourage firms to integrate ethical and social considerations into long-term strategic decision-making.

The concept of Creating Shared Value (CSV) further explains how responsibility can evolve from a reactive obligation into a source of competitive advantage (Porter and Kramer, 2011: 63–67). In capital-intensive industries, investments in cleaner technologies, occupational safety, energy efficiency, and local community development frequently generate both environmental benefits and long-term economic value. Consequently, CSR is no longer viewed merely as a reputational instrument but as an integral component of sustainable industrial competitiveness.

Historical continuity is best explained through Path Dependence Theory, which emphasises how previous decisions shape future organisational trajectories (David, 1985: pp. 332–335; Arthur, 1989: 116–123; Mahoney, 2000: 508–513; Pierson, 2000: 252–254). In regions affected by decades of intensive industrialisation, environmental degradation and accumulated social costs create institutional conditions that influence subsequent governance choices. Once environmental monitoring systems, remediation programmes, stakeholder dialogue, and sustainability reporting become established, these practices tend to reinforce themselves through organisational learning, regulatory expectations, and reputational incentives. As a result, responsible governance develops as a cumulative historical process rather than a sequence of isolated managerial decisions.

This historical perspective is particularly relevant for interpreting KGHM's transformation. The company's contemporary ESG practices cannot be understood solely as responses to recent international reporting standards or regulatory developments. Instead, they should be analysed as the outcome of a long-term institutional evolution shaped by the environmental legacy of the Legnica–Głogów Copper District, technological modernisation, organisational learning, and changing relationships between the company, the state, and regional communities. Accordingly, CSR serves in this study not as an independent theoretical framework but as the historical foundation that explains how contemporary ESG governance emerged from decades of industrial transformation.

1.4. An Integrated Analytical Framework for Interpreting Industrial Transformation

The concepts of sustainable development, CSR, and ESG should be viewed not as competing approaches but as complementary elements of a single analytical framework for examining long-term industrial transformation. Each contributes a distinct perspective: sustainable development establishes the normative objective of balancing economic growth with environmental protection and social well-being across generations (*Report of the World…*, 1987: 43–44), CSR explains the historical evolution of corporate responsibility from legal compliance to strategic commitment (Carroll, 1991: 40–43; Porter and Kramer, 2011: 63–67), while ESG provides the contemporary governance architecture through which these responsibilities are institutionalised, monitored, and communicated (Eccles and Krzus, 2010: chapter 1; Friede et al., 2015: 212–214).

Within this integrated perspective, the Triple Bottom Line offers a multidimensional understanding of corporate performance by combining economic, environmental, and social outcomes (Elkington, 1997: ch. 1–2; Dyllick and Hockerts, 2002: 131–133). Ecological Modernisation Theory explains how technological innovation, organisational learning, and regulatory development enable industries with historically high environmental impacts to improve environmental performance while maintaining economic competitiveness (Spaargaren and Mol, 1992: 326–330; Porter and Linde, 1995: 98–101; Mol, 2001: ch. 3–4). Complementary governance perspectives—including stakeholder, legitimacy, institutional, agency, and signalling theories—clarify how these transformations become embedded in corporate decision-making, organisational structures, and disclosure practices (Spence, 1973: 356–358; Jensen and Meckling, 1976: 308–310; DiMaggio and Powell, 1983: 150–153; Freeman, 1984: 46–47; Suchman, 1995: 574–580).

For the purposes of this study, however, these theories are not treated as independent objects of analysis. Instead, they constitute a coherent interpretative framework for examining the historical transformation of KGHM from a highly polluting industrial enterprise operating within the centrally planned economy into a company that progressively incorporated environmental protection, social responsibility, and governance standards into its long-term development strategy. This approach shifts attention from abstract theoretical discussion to the historical processes through which institutional change, technological modernisation, and evolving stakeholder expectations reshaped corporate governance over time.

The integrated framework developed in this section also establishes the conceptual link between the theoretical discussion and the empirical analysis presented in the following sections. Rather than evaluating ESG as a contemporary management model in isolation, the article investigates how sustainability-related practices emerged historically, how they became institutionalised within KGHM, and how this transformation can be reconstructed through longitudinal corporate disclosures and historical evidence. Consequently, the theoretical perspectives introduced above serve as complementary analytical lenses that support the interpretation of historical developments rather than replacing the historical narrative itself.

2. CORPORATE REPORTING AS HISTORICAL EVIDENCE FOR ANALYSING INDUSTRIAL TRANSFORMATION

Corporate reports are among the principal sources for reconstructing the long-term transformation of contemporary industrial enterprises. Although originally prepared to communicate corporate performance to investors and other stakeholders, integrated reports, sustainability reports, and ESG disclosures also document how companies interpret environmental challenges, respond to institutional change, and gradually redefine their strategic priorities. In this sense, corporate reporting represents not merely a communication tool but a historical record of organisational development.

For enterprises operating in environmentally intensive industries, reporting is particularly important because environmental investments, technological modernisation, occupational safety, and community relations are closely linked to the firm's long-term competitiveness and social legitimacy. Successive reports therefore provide evidence not only of changing performance indicators but also of evolving managerial priorities, governance structures, and organisational capabilities. From a historical perspective, they allow researchers to reconstruct how firms gradually responded to environmental degradation, technological challenges, regulatory reforms, and changing societal expectations.

This perspective differs from approaches that treat ESG reports primarily as instruments of contemporary corporate communication. In the present study, reports are analysed as longitudinal historical sources that document institutional change within KGHM over a 15-year period. Rather than evaluating individual disclosures in isolation, the analysis focuses on recurring patterns, continuity of strategic priorities, and the relationship between environmental investments, governance reforms, and measurable operational outcomes.

The analytical interpretation of these reports is informed by the theoretical perspectives introduced in Section 1. Sustainable development provides the normative context for assessing long-term environmental and social commitments (*Report of the World…*, 1987). The Triple Bottom Line supports the multidimensional interpretation of corporate performance (Elkington, 1997; Dyllick and Hockerts, 2002), while Ecological Modernisation Theory explains how technological innovation, regulato-

ry development, and organisational learning contribute to environmental improvement (Spaargaren and Mol, 1992; Mol, 2001). Complementary perspectives—including stakeholder, legitimacy, institutional, agency, signalling, and path dependence theories—facilitate the historical interpretation of the evolution of governance rather than serving as independent theoretical objects.

Treating corporate reports as historical evidence also strengthens the economic dimension of the analysis. Longitudinal reporting enables the examination of investment priorities, environmental expenditures, operational efficiency, governance reforms, and strategic responses to institutional pressures. Consequently, the empirical material documents not only improvements in environmental and social performance but also the economic mechanisms through which these improvements became integrated into corporate strategy and long-term competitiveness.

Accordingly, this study employs KGHM's integrated, sustainability, CSR, and ESG reports as the principal documentary corpus for reconstructing the company's transformation from an environmentally intensive industrial enterprise into an organisation progressively embedding sustainability within its governance and development strategy. This historical interpretation provides the empirical foundation for the methodology presented in the following section.

3. METHODOLOGY

3.1. Historical-Institutional Research Design

This study adopts a historical-institutional research design to examine the long-term transformation of KGHM Polska Miedź S.A. from an environmentally intensive industrial enterprise into a company progressively integrating environmental, social, and governance (ESG) principles within its corporate strategy. Rather than investigating short-term relationships between individual ESG indicators, the study reconstructs the historical trajectory of organisational change by analysing how environmental management, social responsibility, and governance practices evolved between 1981 and 2023.

The research is grounded in the assumption that corporate transformation in heavy industry is a cumulative historical process shaped by the

interaction of technological modernisation, institutional change, regulatory development, and organisational learning. Consequently, the objective is not to evaluate ESG performance as an isolated contemporary management concept but to explain how sustainability-related practices gradually became institutionalised within the governance of KGHM.

This historical perspective responds directly to the specific characteristics of mining and metallurgical industries. Environmental degradation, occupational health risks, technological investments, and relationships with local communities develop over extended periods and cannot be adequately understood through cross-sectional analysis. A longitudinal design therefore enables the identification of persistent strategic priorities, organisational continuity, and institutional adaptation, providing a more comprehensive explanation of industrial transformation.

The study is theory-informed but empirically driven. The theoretical perspectives presented in Section 1—including sustainable development, the Triple Bottom Line, Ecological Modernisation Theory, stakeholder theory, legitimacy theory, institutional theory, agency theory, signalling theory, CSR, and path dependence—are employed as complementary analytical lenses rather than independent objects of investigation. Their primary function is to facilitate the historical interpretation of empirical evidence derived from corporate documentation.

Within this analytical framework, three research hypotheses guide the investigation.

H1: The historical experience of severe environmental degradation and its associated environmental, social, and health consequences acted as a catalyst for KGHM's long-term transformation towards environmental protection, social responsibility, and sustainable industrial governance.

H2: KGHM's orientation towards ESG-related practices emerged before Poland's accession to the European Union and was driven primarily by domestic institutional learning, stakeholder expectations, and strategic responses to industrial challenges rather than exclusively by European regulatory requirements.

H3: Following Poland's accession to the European Union, KGHM developed governance structures, sustainability practices, and reporting systems that positioned the company among the leading mining and metallurgical enterprises implementing advanced ESG governance.

Unlike conventional ESG studies that focus primarily on explaining variations in sustainability performance, the present research investigates the historical evolution of governance mechanisms underlying these

changes. The analytical emphasis therefore lies on identifying institutional continuity, organisational learning, technological modernisation, and governance adaptation across time rather than estimating causal relationships between variables.

Accordingly, the research design combines historical reconstruction with systematic longitudinal analysis of corporate disclosures to explain how sustainability became progressively embedded within the organisational development of KGHM.

3.2. Documentary Sources and Units of Historical Analysis

The empirical analysis is based on two complementary documentary corpora rather than on corporate disclosures alone. The first corpus consists of publicly available KGHM documents produced between 2004 and 2023, including annual reports, integrated reports, CSR and sustainability reports, ESG disclosures, corporate governance statements, environmental policies, climate strategies and selected supporting documents published by the company. The second corpus consists of historical, technical, administrative, statistical and press sources that make it possible to reconstruct the industrial legacy of KGHM from the late socialist period and the first decades of post-socialist transformation. This distinction is essential because the article interprets ESG governance not as an isolated contemporary reporting practice, but as a historically accumulated institutional response to earlier industrial legacy costs.

The historical source base used for the reconstruction of the second half of the twentieth century includes several categories of evidence. Geological and institutional materials, especially the publications of the Polish Geological Institute and KGHM's corporate chronology, were used to reconstruct the discovery of the Lubin-Sieroszowice copper deposits, the establishment of the copper combine, and the development of the integrated technological chain linking mining, ore enrichment, smelting, refining and tailings disposal (*Miedź i srebro*, 2020: 1; *Zrównoważony rozwój…*, 2025). These sources help explain why KGHM developed as a highly integrated mining-and-metallurgical complex and why its later environmental problems were structurally connected with the technological configuration established during socialist industrialisation.

Scientific and technical studies constitute the second group of sources. Dobrzański and Byrdziak's study of the environmental impact of the Polish copper industry provides evidence on tailings, shaft and converter

gases, SO_2 emissions, dust emissions, post-flotation waste and the technical logic of emission abatement (Dobrzański and Byrdziak, 1995). Strzelec's study, in turn, is important because it refers to air-quality measurements conducted in 1980-1990 by the Centre for Environmental Research and Control in Legnica and later incorporated into the state environmental monitoring system (Strzelec, 2012: 21). These sources made it possible to identify the environmental burden inherited from the PRL period not only as a general narrative of pollution, but also as a measurable sequence of emissions, monitoring practices and technological responses.

A third category consists of PRL-era regional and sectoral press, local complaints and trade-union materials. The 1981 bulletin of NSZZ 'Solidarność' (Legnica), no. 16, is used as evidence of early social perception of environmental danger, including the demand for evacuation measures in the villages of Bogomice and Rapocin (Dakszewicz, 1981). Articles published in Polska Miedź and *Konkrety* in 1988–1989 were used to reconstruct the late-socialist public discourse on dust, sulphur, acid rain, the protective zone, reclamation and everyday environmental nuisance (Grudzień, 1988; Haluch, 1989; Machowska, 1989; 'Mieszkańcy posesji…', 1989). These materials show that social pressure and local environmental awareness preceded the mature language of CSR and ESG by several decades.

Administrative, planning and statistical sources form the fourth group of evidence. The study of the protective zone of the Głogów Copper Smelter allows the article to reconstruct the delayed institutional response to ecological degradation, including the establishment of the protective zone in 1987 and its subsequent management after the systemic transition (Przewocka, 2011). The statistical publication *Ochrona środowiska. Województwo legnickie 1985–1996*, prepared by the Statistical Office in Legnica and the Legnica Voivodeship Office, provides a regional administrative-statistical framework for measuring the spatial reach of environmental pressure, including forest stands exposed to harmful gases and dusts (Urząd Statystyczny…, 1997: 57). Technical studies on the Żelazny Most tailings facility further support the reconstruction of the long-term environmental consequences of flotation-based ore processing (Wrzosek et al, 2015: 508).

The use of these historical sources contributed to four principal findings presented in the article's empirical sections. First, KGHM's environmental problems were path-dependent: they originated in the technological architecture of the socialist industrial combine, not merely in later man-

agement failures. Second, the environmental legacy was already measurable before the emergence of contemporary ESG terminology, especially through SO_2, dust, tailings, soil contamination and air-monitoring evidence. Third, local social reactions, including demands for relocation and press interventions, demonstrate that environmental degradation was experienced as a social and health problem before it was fully formalised through administrative instruments. Fourth, the post-1989 organisational and ownership transformation of KGHM can be interpreted as a gradual institutional response to these inherited costs, later expressed through environmental investments, management systems, reporting routines and ESG governance.

The article is also informed by the broader historiography of environmental degradation in the Polish People's Republic. The authors are aware of the pioneering work of Dariusz Jarosz on water and air pollution in socialist Poland, including studies on pollution as a problem of state authority, society, legislation and emerging ecological awareness (Jarosz, 2016: 385–409; 2017: 37–78). These works are used as historiographical and methodological context. However, to the best of the authors' knowledge, Jarosz's publications do not directly analyse the Legnica-Głogów Copper District, the Głogów and Legnica copper smelters, or KGHM's environmental impact in Lower Silesia. The present article therefore develops this broader PRL environmental-history perspective at the regional and corporate level by focusing specifically on KGHM and the copper district.

The principal units of analysis are therefore twofold. For post-2004 corporate documentation, the basic unit remains the disclosure unit: a coherent narrative statement, quantitative table, figure, policy description or management discussion contained in KGHM's reports. For the historical corpus, the basic unit is the historical-evidence unit: a quantitative emission datum, administrative decision, monitoring statement, press article, trade-union appeal, local complaint, statistical table or technical description of an industrial installation. Each unit is interpreted according to its date, institutional actor, type of environmental or social evidence and function within the long-term transformation process. This combined documentary design strengthens source triangulation and reduces the risk of overreliance on corporate self-reporting. It also allows the study to connect contemporary ESG disclosures with historical-economic evidence of industrial pollution, social responses, technological modernisation and institutional change.

3.3. Analytical Framework and Operationalisation of Historical Transformation

The analytical framework developed in this study is designed to reconstruct the historical evolution of KGHM's environmental, social, and governance practices rather than merely assess contemporary ESG performance. Consequently, ESG indicators are not interpreted as isolated measures of sustainability but as observable manifestations of broader institutional, organisational, and technological change.

The analysis combines two complementary levels of interpretation. The first is a historical-institutional perspective, which examines how environmental responsibilities, governance arrangements, stakeholder relations, and organisational capabilities evolved over time in response to industrial legacy costs, technological modernisation, regulatory change, and increasing societal expectations. The second level operationalises these developments through systematically coded ESG disclosures, enabling the identification of long-term patterns rather than isolated corporate initiatives.

The theoretical perspectives introduced in Section 1 guide this interpretation without determining it. Sustainable development provides the normative context for evaluating long-term industrial transformation, while the Triple Bottom Line structures the interpretation of environmental, social, and economic performance. Ecological Modernisation Theory explains the mechanisms through which technological innovation, environmental investments, and institutional learning contributed to gradual improvements in environmental performance. Stakeholder, legitimacy, institutional, agency, signalling, CSR, and path dependence theories complement this interpretation by explaining how governance practices became progressively embedded within corporate decision-making and organisational routines.

To translate these analytical perspectives into empirical observation, all disclosure units are classified according to three interrelated dimensions. First, each disclosure is assigned to one of the core ESG domains—Environmental (E), Social (S), or Governance (G). Second, disclosures are interpreted according to their institutional function, including evidence of organisational learning, regulatory adaptation, stakeholder engagement, technological modernisation, or governance development. Third, disclosures are assessed longitudinally to determine whether they represent temporary initiatives or persistent organisational transformation.

This three-level analytical framework enables the study to move beyond descriptive ESG reporting. Instead of asking whether KGHM disclosed particular sustainability indicators, the analysis examines how successive disclosures collectively document the company's historical transition towards increasingly integrated environmental governance and responsible industrial management.

3.4. Coding Framework and Historical Interpretation of ESG Indicators

The coding framework translates documentary evidence into a structured analytical system that allows historical comparison across reporting periods while preserving the institutional context of each disclosure. Rather than treating ESG indicators as static performance measures, the coding procedure interprets them as historical evidence of organisational transformation.

The first coding layer classifies disclosures according to the Environmental (E1–E10), Social (S1–S10), and Governance (G1–G10) dimensions. These categories encompass the principal areas of sustainability management relevant to the mining and metallurgical industry, including greenhouse gas emissions, air pollutants, water management, tailings and waste management, occupational health and safety, employee development, stakeholder engagement, governance structures, transparency, ethics, and risk management. Their primary purpose is not merely descriptive classification but the systematic reconstruction of long-term institutional change.

A second coding layer identifies transformation mechanisms (M1–M8), which capture how organisational change occurred. These mechanisms include the establishment of long-term targets and baselines (M1), continuity of reporting and performance indicators (M2), external assurance (M3), explicit links between environmental investments and operational outcomes (M4), balanced reporting of achievements and remaining challenges (M5), institutionalisation of governance systems (M6), technological modernisation (M7), and evidence of early adoption preceding regulatory requirements (M8). These markers make it possible to distinguish genuine organisational transformation from isolated or symbolic sustainability initiatives.

The coding procedure also incorporates an interpretative dimension derived from CSR and path dependence perspectives. References to environmental remediation, historical pollution, technological upgrading, and

organisational learning are analysed not simply as individual ESG activities but as evidence of cumulative institutional development. Accordingly, each disclosure may simultaneously represent an environmental investment, a governance reform, and an organisational response to historically accumulated industrial challenges.

This integrated coding framework therefore supports both qualitative interpretation and longitudinal comparison. It allows the empirical analysis to reconstruct how environmental management, corporate governance, and stakeholder engagement gradually became institutionalised within KGHM, while preserving the historical continuity that characterises long-term industrial transformation.

3.5. Analytical Strategy, Validity, and Research Limitations

The empirical analysis combines qualitative historical interpretation with longitudinal analysis of ESG disclosures and performance indicators. Rather than estimating causal relationships through econometric techniques, the study focuses on identifying persistent organisational trends, institutional continuity, and strategic adaptation across the observation period.

The analytical strategy proceeds in three stages. First, documentary evidence is examined chronologically to reconstruct the historical sequence of environmental, social, and governance initiatives. Second, coded disclosure units are compared across reporting periods to identify recurring themes, shifting strategic priorities, and evidence of institutional learning. Third, quantitative ESG indicators are interpreted within their broader historical context, thereby linking changes in environmental performance, governance quality, and stakeholder engagement to be linked to technological investments, organisational reforms, and regulatory developments.

Particular attention is paid to the relationship between sustainability initiatives and their economic implications. Environmental investments are interpreted not solely as ecological improvements but also as evidence of capital allocation decisions, operational modernisation, risk management, and long-term competitiveness. Similarly, governance reforms are analysed as institutional mechanisms that enhance organisational resilience, accountability, and strategic capacity rather than merely fulfilling reporting requirements. This perspective responds directly to the economic dimension emphasised in business history and institutional analysis.

The credibility of the findings is strengthened through three complementary forms of triangulation. **Theoretical triangulation** applies multiple analytical perspectives to the same historical evidence. **Data triangulation** combines narrative disclosures with quantitative performance indicators. **Temporal triangulation** evaluates organisational change through long-term trends rather than isolated annual observations. Together, these approaches increase the robustness of historical interpretation while reducing the risk of overreliance on individual disclosures.

The study nevertheless has several limitations. It relies primarily on publicly available corporate documentation, which may reflect managerial framing and reporting strategies. Although longitudinal analysis, attention to negative disclosures, and the examination of reporting continuity reduce this limitation, the findings should be interpreted as evidence of documented organisational transformation rather than a complete reconstruction of all internal decision-making processes. Future research could complement documentary analysis with archival materials, interviews, and comparative studies involving other mining enterprises operating under different institutional conditions.

Overall, the proposed methodology provides a transparent and replicable framework for analysing long-term industrial transformation. By combining historical reconstruction with structured ESG analysis, it enables the study to explain not only **whether** KGHM's sustainability performance improved but also **how** environmental governance, organisational capabilities, and institutional arrangements evolved over time in response to the economic, technological, and social challenges inherited from the company's industrial past.

4. BEGINNINGS OF COPPER MINING IN LOWER SILESIA AND THE POLISH PEOPLE'S REPUBLIC (PRL) INVESTMENT IN BUILDING THE KGHM COPPER COMBINE IN THE LEGNICA VOIVODESHIP (1950S–1970S)

The modern history of "Polish copper" in Lower Silesia began with the intensification of exploration work on the Fore-Sudetic Monocline, where Zechstein (Permian) copper-bearing formations occur. According to the Polish Geological Institute—National Research Institute (PIG-PIB), the

breakthrough came on 23 March 1957, when cores from Sieroszowice (borehole S-1 / Sieroszowice IG-1) confirmed the presence of an ore-bearing interval, initiating documentation of the deposit and planning of its development (*Miedź i srebro*, 2020: 1). The scale of the discovery was decisive for later industrial policy: the Lubin–Sieroszowice deposit was estimated at more than 1.3 billion tonnes of ore, corresponding to approx. 19.34 million tonnes of copper (*Miedź i srebro*, 2020: 1). This geological finding created the material precondition for one of the largest industrial investments of the Polish People's Republic.

Geological reconnaissance was rapidly translated into the logic of the planned economy. The strategic objective was to build in the Legnica Voivodeship an integrated technological chain of "mine–beneficiation–smelter", capable of supplying copper to domestic industry and generating export revenues. In institutional terms, the turning point was the establishment in 1960 of the state enterprise Zakłady Górnicze "Lubin w budowie" and its transformation on 1 May 1961 into the Mining and Metallurgical Copper Combine in Lubin (*Zrównoważony rozwój*…, 2025). This combine structure integrated mining, ore concentration, smelting and auxiliary infrastructure, thereby binding the region to a raw-material and industrial monoculture characteristic of PRL industrialisation (*Zrównoważony rozwój*…, 2025).

The 1960s and 1970s brought the construction of the core technological system. Deep copper-ore mines were opened under difficult hydrogeological conditions, including shaft sinking with ground-freezing methods; the "Lubin" and "Polkowice" mines were developed in 1960–1970 (*Zrównoważony rozwój*…, 2025). Ore beneficiation plants based on mechanical processing and flotation were launched, with the first concentrate obtained on 15 February 1968 at ZG "Lubin" (*Zrównoważony rozwój*…, 2025). At the same time a new smelting base was created in Głogów: construction began in 1968, the first anode-furnace tapping took place in 1971, and the Głogów II expansion, based on flash-smelting technology, was commissioned in January 1978 (Dakszewicz, 1981). The production system was further strengthened by the "Rudna" mine (1969–1974) and the OUOW "Żelazny Most" tailings facility, built from 1974 and operated from 1977, which became an integral element of ore-processing technology (Dobrzański and Byrdziak 1995: 391; Wrzosek et al., 2015: 508).

From the perspective of the article's research problem, this technological configuration is important because it structurally generated large streams of waste, process water and air emissions. Flotation beneficiation

produced the largest material stream in the copper-production cycle: post-flotation tailings stored at "Żelazny Most" (Dobrzański and Byrdziak, 1995: 391). This meant permanent land take, the creation of an anthropogenic reservoir, the circulation and retention of process waters, and the transfer of environmental risks into a long time horizon, including dam stability, groundwater impacts and dusting of the tailings surface.

The second major environmental channel was dust-and-gas pressure from the smelters, especially before effective SO_2 abatement and dust-control systems were introduced. Dobrzański and Byrdziak indicate that shaft and converter gases were the main sources of gaseous pollution in the copper industry; shaft gases contained, inter alia, about 10% CO and "a dozen or so g/m³" of SO_2, while converter gases carried the main load of SO_2 released in the process (Dobrzański and Byrdziak, 1995: 395). Consequently, the environmental disturbance caused by the combine was not a local nuisance only. It involved spatial and hydrological transformations, waste-and-wastewater pressure, air pollution from dust and sulphur compounds, and long-term deposition of metal-bearing dusts in soils. These mechanisms explain why the later contamination of the Legnica–Głogów Copper District should be interpreted as a systemic outcome of the PRL industrialisation model rather than as an incidental side effect of individual plants.

5. MONITORING AND EARLY INSTITUTIONALISATION OF THE PROBLEM OF NATURAL-ENVIRONMENT POLLUTION

Although in the 1960s and 1970s the logic of production expansion dominated, the environmental problem began to be systematically measured within research and monitoring. Ł. Strzelec indicates that in 1980–1990 air-quality research in the impact zone of the Legnica and Głogów smelters was conducted by the Centre for Environmental Research and Control in Legnica, and subsequently these activities were incorporated into the state environmental monitoring system (Strzelec, 2012: 21). For reconstructing the genesis of the problem this matters in two ways: first, it confirms the growing public recognition of nuisance; second, it makes it possible to link the establishment of the combine in the 1960s–1970s with the later, empirically captured dynamics of contamination and the gradual modernisation of protective solutions.

The construction of KGHM in the Legnica Voivodeship was one of the largest industrial investments of the PRL, implemented within the logic of rapid industrialisation and integration of the technological process. The adopted configuration—deep mines, flotation beneficiation, smelting and a large-scale waste storage system—generated enduring environmental pressure: spatial transformations, enormous masses of post-flotation tailings, pressure on water management and dust-and-gas emissions from the smelters (Dobrzański and Byrdziak, 1995, 'Legnica', 2025). As a result, interference with the environment of the Legnica Voivodeship and neighbouring areas was not an "incidental side effect", but a systemic feature of the PRL industrialisation model, whose ecological and health costs borne by society and the natural environment began to be more broadly identified only in subsequent decades.

6. PREDATORY EXPLOITATION OF MINERAL RESOURCES AND ENVIRONMENTAL CONTAMINATION AROUND THE KGHM COPPER COMBINE IN 1980–1989

The 1980s in the Legnica–Głogów Copper District (LGOM) were a period in which the logic of the shortage economy and production priorities (orientation toward "fulfilling the plan") coexisted with a very limited internalisation of environmental costs. As a result, the development of copper mining and smelting in the region (including intensification of ore processing and operation of smelting installations) generated phenomena that, from the perspective of today's environmental policy, can be described as "predatory exploitation of resources": high material intensity, low efficiency of resource use, poorly developed dust-removal and desulphurisation systems, as well as lasting soil degradation and pressure on water resources. These effects became visible both in measurable emission indicators and in social reactions, one of the most significant manifestations of which were demands to relocate populations from areas directly exposed to the smelter's impact (Dakszewicz, 1981: 7).

In the first half of the decade, especially in 1980–1984, the emission pressure from the smelters was the highest. Data from technical-environmental studies indicate that total SO_2 emissions at the scale of KGHM in 1980 reached approx. 154 thousand tonnes per year (Dobrzański and Byrdziak,

1995), which placed the region among the most burdened industrial areas of the country. At the same time, compilations referring to the impact of the smelting installations themselves (in particular the Głogów area) show that at the "peak" of the early 1980s emissions were on the order of ~125.7 thousand tonnes SO_2/year and ~14.4 thousand tonnes of dust/year, i.e. at a level that in practice required treating the area as a zone of high health and environmental risk (see Table 1).

Table 1. Mapping of theories, ESG indicators, and hypotheses (2010–2025)

Theoretical framework	Key ESG indicator codes	Trans-formation markers	Hypotheses addressed	Methodological role
Triple Bottom Line	E1–E10, S1–S10, G1–G10	M1–M8	H1, H2, H3	organises all indicators into integrated sustainability dimensions
Ecological Modernization Theory	E1–E6, G4–G7	M1–M5	H1, H3	explains technological, regulatory, and institutional change
Intergenerational Justice	E7–E10, S5–S9	M6–M8	H1	interprets remediation, health, and long-term risk reduction
Stakeholder Theory	S1–S6, G1–G3	M6	H1, H2	explains social license and engagement-driven ESG
Legitimacy Theory	G6–G10	M7–M8	H1, H3	distinguishes substantive vs symbolic disclosure
Institutional Theory	G3–G7	M3–M5	H2, H3	explains convergence with EU/international standards
Agency & Governance Theory	G1–G5	M4	H3	links governance structures to ESG performance
Creating Shared Value	E2–E5, S2–S4	M2–M4	H2, H3	tests the strategic integration of ESG into value creation
Path Dependency Theory	E7–E10, S7–S10	M6–M8	H1, H2	explains persistence and historical conditioning

Source: own work based on the bibliography used.

From the point of view of smelting technology, the key problem was the emission of sulphur compounds and metal-bearing dust. The literature emphasised that process-gas streams contained significant concentrations of SO_2 (on the order of "a dozen or so g/m³" in shaft gases), which—given insufficient efficiency of capture installations—translated into the formation of acidic deposits and secondary impacts on vegetation, soil and waters (Dobrzański and Byrdziak, 1995). Thus, while the very fact of emissions was inherent in the smelting technology, the scale of damage was a derivative of the lack of effective protective barriers and the limited modernisation of dust-removal and SO_2-capture equipment.

Dust emissions in copper mining and smelting were not chemically neutral: dust carried heavy metals, including copper, lead and arsenic. Long-term deposition led to lasting soil degradation in the smelter impact zone, which is well illustrated by PIG-PIB geochemical data: in areas affected by metal-bearing dust, extremely high concentrations of metals in soils were recorded (on the order of tens of thousands of mg/kg for Cu and Pb in maximum samples), as well as elevated levels of As and other toxic elements (*Miedź i srebro*, 2020). From the perspective of agriculture and public health this meant not only degradation of soil productivity, but also a lasting risk of chain exposure (soil–plant–animal–human), which under PRL conditions of shortages and limited transparency of data became a conflict-generating factor.

An important (and source-traceable) testimony of social tensions (strong dissatisfaction and fears about health) is material from the circulation of the trade union "Solidarność" from 1981, in which there appears a demand to initiate evacuation actions in the villages of Bogomice and Rapocin (Dakszewicz, 1981: 7). The fact that the topic of relocation appears already at the beginning of the decade indicates a real perception of threat among residents and local social structures. At the same time, it does not mean that the resettlement process was then formalised by an administrative decision: in the light of planning and administrative documents, the legal framework of the protective zone (which triggered a mass mechanism of buying out farms) was established only in subsequent years, primarily by the decision of 25 November 1987 on creating a protective zone around the "Głogów" Copper Smelter (Przewocka, 2011: 104–106).

In the 1980s, however, the environmental problem also entered the public sphere through other channels. Regional and sectoral press at the end of the decade ("Polska Miedź") registered not only the language of "progress and production", but also categories of environmen-

tal nuisance, including threads of "dust and acid rains" and tensions around the protective zone and its spatial consequences (Haluch, 1989; Machowska, 1989).

By 1981, environmental contamination in the copper district had become a matter of such social importance that, under pressure generated by grassroots civic and trade-union initiatives, it reached the Sejm of the Polish People's Republic. A parliamentary interpellation in 1981 and subsequent debates—most notably the meetings of the Sejm Committee for Environmental Protection and Natural Resources in April and July 1987—helped accelerate work on identifying the territorial extent and sources of industrial impacts in the Legnica and Lubin areas. Within the government administration, this process was accompanied by the preparation of the "KGHM Environmental Protection Programme for 1981–1985", approved by the Minister of Metallurgy. Parliamentary scrutiny and the ensuing governmental and administrative decisions compelled the state-owned combine to undertake specific emission-reduction and monitoring measures and contributed to the establishment of protective zones around the Głogów and Legnica copper smelters in 1987 and 1988, respectively (see Kancelaria Sejmu RP, 1981; 1987abc; *Studium uwarunkowań…*, 2008; Przewocka, 2011: 104–106).

From an ecological perspective, the development of the KGHM combine in the 1980s can be described as a "predatory" model of exploitation of mineral resources of Lower Silesian land. The term "predatory exploitation" has an analytical meaning here: it refers to systemic incentives that promoted maximising extraction and processing while minimising expenditure on environmental protection. In practice this meant, inter alia:

1) an undervalued appraisal of environmental resources (air, soils, waters) and the absence of real external costs in the enterprise's economic calculation;

2) delayed modernisation of installations (dust removal, SO_2 capture), which under the conditions of the planned economy lost out to production priorities;

3) shifting the burden of risk onto local communities, which became visible in evacuation demands and later zonal measures;

4) lasting burden on the environment through deposition of heavy metals in soils and pressure on the water system (including in the perspective of tailings management and storage infrastructure).

In the second half of the 1980s, clear signals of a shift from "acceptance of damage" to institutional actions appear: the establishment of the pro-

tective zone (1987) and announcements of emission-reducing investments fit into the logic of later reductions of SO_2 and dust. Although the full technological effects (including sulphuric-acid plants and deep emission reductions) are more strongly visible in the data of the 1990s, the 1980s themselves already end under conditions of growing awareness of the problem, both in administrative documents and in the regional press discourse (Haluch, 1989; Machowska, 1989).

In 1980–1989 the environment around the KGHM combine experienced strong impacts from the combine's plants, which can be captured in categories of high SO_2 and metal-bearing dust emissions, lasting soil degradation and social tensions leading to relocation demands. Emission data for 1980 (on the order of 154 thousand tonnes SO_2/year at the KGHM scale) and indicators of the early-decade "peak" (SO_2 and dust in tens of thousands of tonnes per year) show the magnitude of the problem and explain why, in local social experience, evacuation demands appeared (Dakszewicz, 1981: 7; Dobrzański and Byrdziak, 1995). At the same time, analysis of the chronology indicates that formalisation of the zoning and buy-out process occurred 6 years later (1987), after the period of contamination culmination, which confirms the mechanism of delayed institutional response typical of the late PRL.

The twilight of the PRL in the Legnica–Głogów Copper District (LGOM) revealed a typical contradiction of the planned economy: on the one hand, KGHM was a strategic "hard-currency combine" (an enterprise expected to earn convertible currency from the sale of raw materials to capitalist countries); on the other hand, its production model entrenched external costs shifted onto the environment and local communities. This legacy was visible in a landscape dominated by mining-and-smelting facilities and infrastructure, as well as in the risk structure: massive streams of post-flotation tailings, pressure on water management, and the nuisance of dust-and-gas emissions, in particular sulphur compounds and metal-bearing dust (Dobrzański and Byrdziak, 1995). In the 1980s social pressure also grew: the region was an arena of labour protests and the formation of independent trade-union structures, which fitted into the nationwide process of erosion of the system's legitimacy and the leading role of the Polish United Workers' Party (PZPR). IPN research points to strike waves in the former Legnica Voivodeship already in the summer of 1980, covering inter alia miners of ZG "Rudna" (Polkowice) and ZG "Lubin" (Lubin)—with wage and organisational demands that became part of a long cycle of labour mobilisation in the region (Sołtysik, 2020).

The legacy of environmental degradation had not only a general dimension (high emissions) but also an institutionally recognised one. One of the most telling examples was the protective zone around the "Głogów" Copper Smelter, the necessity of which was historically justified by the fact that in the initial years of the smelter's operation the areas around the plant were considered territories affected by an "ecological disaster" (Przewocka, 2011: 105–106). Importantly, formalisation of the protection regime occurred "with a delay" relative to the contamination culmination that took place already around 1980–1984: the literature and administrative documentation cite the 1987 decision establishing the zone and the decision of 6 November 1990 concerning the manner of its development (Przewocka, 2011: 105–106).

7. FROM IDEAS TO ACTIONS: MANAGERIAL, OWNERSHIP AND ORGANISATIONAL CHANGES IN KGHM (1991–2004), BEFORE POLAND ENTERED THE EU

After 1989, a key breakthrough for how KGHM was managed was commercialisation: on 12 September 1991 the state enterprise was transformed into a single-shareholder joint-stock company of the State Treasury, which initiated preparations for future privatisation and forced the gradual implementation of standards of accounting, control and autonomous commercial policy (*Zrównoważony rozwój…*, 2025). This change had "systemic" significance for environmental and social management: in the joint-stock-company model the role of audit, risk management, responsibility of governing bodies and stakeholder pressure (banks, contractors, investors) for measurability and compliance with standards increases. The next stage was partial privatisation through the capital market. In June 1997 an initial public offering of shares was conducted, under which the State Treasury sold 32.8% of the company's shares; a pool of 30 million shares was also envisaged to be made available free of charge to employees ('Legnica', 2025). In social terms this was an important shift: employees became (albeit to a limited extent) co-beneficiaries of financial results, and management had to balance objectives of productivity, costs and employment stability with growing requirements of safety and environmental protection.

In the 1990s, the core of the transition "from ideas to actions" in environmental protection was investments in installations that made it possible to close sulphur loops and reduce emissions to the air. Technical literature described modernisations of converter–acid-plant lines and an increase in sulphur recovery efficiency, as well as the construction of a new sulphuric-acid plant at HM "Głogów I" commissioned at the end of 1994 (Dobrzański and Byrdziak, 1995). Such projects were a typical response of the transformation era to environmental pressure: instead of declarative "protection", investments reducing emissions were introduced while simultaneously creating a by-product (sulphuric acid), which improved resource efficiency.

KGHM's corporate timeline links the turn of the 1990s and the first decade of the 21st century with a package of pro-ecological investments that radically reduced harmful emissions, indicating, inter alia, the commissioning of desulphurisation in HM Głogów and SOLINOX gas-desulphurisation technology in HM Legnica, as well as modernisations of anode furnaces together with atmospheric-protection equipment (*Zrównoważony rozwój…*, 2025). In managerial terms this meant a shift from reactive "putting out fires" to building investment plans in which emission reduction became a priority—a design and control parameter.

In parallel with material investments, the professionalisation of management through systems took place. KGHM indicates that already in 1995 a quality-management system was implemented at the Cedynia Copper Smelter, and in 1999—an integrated management system, after which subsequent units integrated quality, environmental and OHS requirements ('Legnica', 2025). From the perspective of "from ideas to practice", this is of fundamental importance: a standard (e.g. ISO) enforces a cycle of activities—plan–do–check–act (PDCA), audits, non-conformity registers, responsibilities and measurable objectives—i.e. tools whose absence was one of the mechanisms of environmental degradation in the late PRL.

At the level of organisational structure, the 1990s also brought ordering of technological divisions and separation of functions. For example, corporate history indicates the separation in 1998 of the Ore Beneficiation Plant as a unit of the company, which can be read as an element of organisational modernisation and better management of material streams ('Legnica', 2025). In practice, similar changes facilitated, inter alia, the development of monitoring, reporting and responsibility for environmental impacts (waste, process waters, emissions).

The social legacy of the end of 1989 included both the memory of labour conflicts (strikes and repression in the region) and features typical of an industrial monoculture: dependence of local budgets and the labour market on one large employer. Ownership and market transformation forced restructuring, higher efficiency and a change in the employee–enterprise relationship. From the perspective of social protection, "concrete actions" manifested themselves, inter alia, in the institutionalisation of social dialogue (trade unions), investments in occupational safety, and mechanisms of employee participation in privatisation (employee shares in 1997) (*Zrównoważony rozwój…*, 2025). It is also worth emphasising that the process of changing organisational culture (from an administrative-command style to management based on procedures, audits and indicators) was gradual. In analytical terms this meant a "transition" from a post-communist model of power in the plant to a corporate model in which reputation, regulatory compliance and social acceptance become assets (and social conflicts and environmental damage—measurable risk).

The fall of communism in the copper district revealed a double legacy: environmental degradation rooted in technology and the incentives of the planned economy, and social tensions typical of a region dependent on a single combine. Only the 1990s brought a real possibility of reducing environmental damage thanks to ownership change, market pressure and investments in emission-reducing installations (Dobrzański and Byrdziak, 1995; Przewocka, 2011: 105–106). Before accession to the EU in 2004, KGHM went through a key path from declarative "protection" to building tools and practices: modernising desulphurisation devices, commissioning sulphuric-acid plants, implementing management systems (quality–environment–OHS), and ordering the organisational structure of the company (*Zrównoważony rozwój…*, 2025).

8. ESG TRANSFORMATION OF THE KGHM GROUP (2005–2023) IN THE TARGET-MODEL PERSPECTIVE: FROM DATA ORDERING TO MANAGING CLIMATE, THE VALUE CHAIN AND RISK

In KGHM, the target ESG model defined sustainable development as a strategic programme comprising three dimensions: environment (E)—

energy transition and the circular economy; society (S)—a safe and developmental workplace and dialogue with stakeholders; and corporate governance (G)—transparent, ethical management and the integration of ESG risks (*Zrównoważony rozwój…*, 2025: 1). As overarching goals, climate neutrality (net-zero) by 2050 was indicated, reduction of Scope 1+2 emissions by 30% by 2030 relative to 2020, and achieving 50% of own energy from renewables (RES) by 2030 (Table 2).

Table 2. Environmental impact footprint and emission reduction in the Legnica–Głogów Copper District (LGOM), 1980–2024: SO_2 and total dust emissions from KGHM copper smelters and key spatial/administrative mitigation measures

No.	Time-window	Key indicator(s) at the start	Action(s) taken	Result using the same metric
1	1980–1984: ecological disaster peak	SO_2: ~125,700 t/year; dust (PM): ~14,442 t/year; Cu and Pb in flue gases: ~160× and 260× current levels, respectively	no abatement; first data logging by WIOŚ	baseline for later cuts
2	1987–1990: "protective zone" era	SO_2: reduced to ~34,100 t/year dust to 2 017 t	2,840 ha buffer zone around the HM Głogów; relocation of 1,707 residents; start of soil liming and remediation	60–80 % drop vs 1980, but soils still classed as 'ecological disaster'
3	1995–2000: gas capture & acid plants	SO_2: reduced to ~4,900 t/year; dust (PM): reduced to ~119 t/year	sulfuric acid plants in Legnica and Głogów; wet scrubbers and bag filters	> 95 % SO2 cut vs 1980; visible smog disappears
4	2004–2005: EU accession & ISO 14001	SO_2: reduced to <4,000 t/year; dust (PM): reduced to <130 t/year	full implementation of ISO 9001 and ISO 14001; online emissions reporting; formal termination of the protective zone (31 December 2005)	area re-classified from "disaster" to "requiring monitoring"
5	2006–2010: BAT groundwork	continuous exceedances of As > 6 ng m-3	24/7 flue-gas monitoring; preliminary BAT-As projects scoped	arsenic peaks trimmed but still > norm in some months

Table 2. (cont.)

No.	Time-window	Key indicator(s) at the start	Action(s) taken	Result using the same metric
6	2014: first integrated GRI report	SO_2: 4,836 t/year; NO_x: 1,249 t/year; dust (PM): 409 t/year; Cu in effluent: 606 kg/year; Pb in effluent: 168 kg/year	public disclosure of non-financial data; launch of ESG assurance	creates transparent baseline for 2010s cuts
7	2016 –2018: flash-furnace & BAT	arsenic (As): mean 12.6 ng/m³ (2016); peak 30.2 ng/m³ (2017)	flash furnace and Kaldo gas scrubber; BAT-As programme implemented at both smelters	trigger for € 200 m BAT-As upgrades
8	2019: deep emission plunge	SO_2: 930 t/year (−81% vs 2010); dust (PM): 75 t/year (−83% vs 2010); Pb and Cu emissions to air: reduced by 78% and 71% vs 2000, respectively	Investor KPI slide highlights "People & Environment"	historic low for criteria pollutants
9	2021: Climate Policy launch	arsenic (As): mean 10.7 ng/m³ (Głogów); 8.6 ng/m³ (Legnica)	net-zero 2050 target; OZE & H2 pilot projects	arsenic < 2x norm for first time since 1990s
10	2023–2024: ESRS / PV build-out	SO_2: <900 t/year; dust (PM): <70 t/year; arsenic (As): mean ~6–7 ng/m³ (−82% vs 2018); Cu in effluent: <500 kg/year	ESRS-aligned ESG data sheet 2023; 20 MW new PV; closed--loop water 94 %	SO_2: reduced by 99% vs 1980; dust (PM): reduced by >99% vs 1980; arsenic (As): approaching compliance levels

Source: Author's compilation based on: Urząd Statystyczny w Legnicy and Urząd Wojewódzki w Legnicy (1997: 57), Przewocka (2011: 104–106, 109), Strzelec (2012: 23), *Raport zintegrowany…* (2015: 62), and *Statistics Poland…* (2025), metadata for "total particulate emissions" (ID 1508) and "sulphur dioxide emissions" (ID 2084), 1996–2024. BDL is an online database and has no page numbers (accessed 17 June 2025).

Stage I (2005–2010): Compliance and "Measurability" As a Condition for ESG Actions

In the first years after Poland's accession to the EU, the priority was to organise regulatory compliance and basic environmental and OHS data. In annual reporting, financial-operational information dominated, whereas environmental and social disclosures served an inventory function: they identified the main impact and risk streams and prepared the company for later comparability of indicators (*Raport roczny…* 2005: 3). In parallel, management systems based on standards and audits were strengthened, which stabilised responsibilities, procedures and monitoring. KGHM presents management systems as a permanent element of the Group's functioning, which in ESG terms means a shift from ad-hoc actions to management based on a planning, verification and corrective-action cycle ('Zintegrowany system…', 2025).

Stage II (2011–2015): Professionalisation of Disclosures and Transition to Integrated Reporting

In the next phase, there is a shift from dispersed CSR toward reporting that covers the full range of impacts and risks in connection with the business model. KGHM's repository shows continuity in the publication of reports (including the availability of the 2005–2010 package and integrated reports for subsequent years), which indicates the institutionalisation of the practice of non-financial disclosures on an annual cycle (KGHM 2025b). From the ESG perspective, what is key is the stabilisation of indicators (emissions, energy, water, waste, accident rates) and the development of descriptions of policies and programmes, which make it possible to assess not only "results" but also the mechanisms of achieving them (processes, responsibilities and control). Consequently, reporting begins to serve a managerial function: it increases transparency, sets priorities and facilitates the linking of non-financial data with investment decisions.

Stage III (2016–2019): Standards (GRI) and Linking ESG with CAPEX and Technological Modernisation

The Integrated Report for 2016 was prepared in accordance with the GRI (G4) guidelines, which signals the maturity of disclosures and their linkage with management (*Raport Zintegrowany…*, 2017: 174). In this phase, it is important that in a smelting-and-mining enterprise, reduc-

ing environmental pressure results primarily not from communication but from process modernisation: automation, enclosure, limiting fugitive emissions, wastewater management and waste management. In ESG logic, this means a shift from "reporting about actions" to "managing through investments": environmental goals are materialised in the project portfolio and capital expenditures, and effects should be visible in indicator trends. In this sense, 2016–2019 can be treated as a consolidation phase—mature disclosure standards coexist with technological modernisation, and ESG begins to be framed as an element of process efficiency (energy and materials) and the reduction of regulatory and reputational risk.

Stage IV (2020–2023): Climate and Energy, the Value Chain, and Integration with Governance

In 2020–2023, ESG enters a transformative phase dominated by climate, energy and the carbon footprint of the product. KGHM's climate policy sets an intermediate target to reduce total Scope 1 and 2 emissions by 30% relative to the 2020 level by 2030 (*Raport Zintegrowany…*, 2022: 8). The Management Board's report for 2023 adopts 2020 as the base year for calculating emissions in accordance with the GHG Protocol, which strengthens methodological consistency of the climate pathway (*Sprawozdanie Zarządu…*, 2024: 124). In the target model, implementation instruments were specified: development of own renewable-energy sources (including PV farms linked with smelting assets), decarbonisation of smelters (furnace modernisation, heat recovery, hydrogen pilots), closing water circuits (pre-treatment of wastewater, reuse of mine waters) and managing the impact of the "Żelazny Most" facility (anti-dust curtains, drainage, monitoring) ('Zintegrowany system…', 2025).

Mature ESG also includes the value chain: the target model indicates Copper Mark certification for the Głogów and Legnica smelters and a pilot of the product carbon footprint (Cu cathodes) in line with European market requirements (*Sprawozdanie Zarządu…*, 2024: 74; 'Zintegrowany system…', 2025). In the governance sphere, the 2023 report shows growing formalisation of information governance (references to ESRS, including ESRS 2 GOV-1) and an organisational framing of sustainable-development management, which can be interpreted as a transition from voluntary CSR practices to standardised reporting of a regulatory nature (*Sprawozdanie Zarządu…*, 2024: 43, 52).

Table 3. How KGHM Translates This Idea into Concrete ESG Actions

Pillars	Key Goals and Projects	Measurable Milestones
E—Environment	• Climate Policy—reduce Scope 1 + 2 emissions by 30 % by 2030 vs 2020; pathway to net-zero 2050. • 50 % of in-house energy from renewables by 2030 (PV farms "Huta Legnica", "Głogów", etc.). • Decarbonising smelters: furnace modernisation, heat recovery, pilot use of hydrogen in flash furnaces. • Water management—closed loops, wastewater polishing, re-use of mine water. • Żelazny Most tailings pond—water curtains against dust, slope sealing, drainage and seismic monitoring.	• -30 % CO_2 (Scope 1 + 2) by 2030 • Copper Mark certification for the Głogów and Legnica smelters, confirming compliance with 32 environmental and social criteria.
S—Social	• Human Rights Policy—aligned with UN GPBHR and OECD; priority: safe working conditions, the right to privacy, dialogue with 60+ trade unions. • "Zero Harm" programme—automation of heading faces, inspection drones, VR training; target LTIFR < 4.0 by 2027. • Diversity Declaration, KGHM Fund (sports, culture, STEM scholarships for women).	• LTIFR ↓ 15 % YoY • 100 % of employees trained in the Climate Policy and Human Rights (since 2024).
G—Governance	• Supervisory Board established the Strategy & ESG Committee (2024). • Implementation of ESRS and CSRD-compliant reporting—first report in 2025. • Ethics Line (anonymous whistleblowing) and an anti-corruption clause in every tender. • Risk management system with an ESG risk matrix integrated into the ERM framework.	• 100 % of OPEX suppliers covered by compliance assessment with the Supplier Code (2026).

Source: Author's compilation based on KGHM's 'Raporty zintegrowane' (2025) from 2005–2023.

The social dimension (S) in the target model is linked with a human-rights policy (UN and OECD standards) and with the "Zero Harm" programme. A shift toward safety as a measurable KPI and an area of organisational innovation is noticeable: automation of work, inspection drones and VR training , with the target LTIFR < 4.0 by 2027 ('Zintegrowany system…', 2025). Such a configuration corresponds to contemporary expectations toward enterprises with high environmental risk: reducing accident rates and improving safety culture are treated as conditions for the "social licence" to operate and for production stability.

Investment Context: Foreign Expansion As a Necessity in the Face of ESG Challenges

In a 2014 interview, the President of KGHM officially admitted that introducing a high tax on mineral extraction in Poland would have a major impact on investment in the development of the company's production potential. Investments in extracting raw materials in Poland, due to strict environmental requirements and high taxation, ceased to be profitable. KGHM then pursued only new extraction projects abroad (Wirth and Szymanek, 2014: 9–11). In recent years, after the coronavirus pandemic confirmed H. Wirth's words: KGHM is not developing extraction in Poland. From the ESG perspective, this is important because investment risk and ESG risk in resource projects are interdependent: pressure on environmental and social standards (water, energy, relations with local communities) grows with project scale and exposure to external financing. Thus, ESG maturity becomes not only a "cost of compliance" but an element of the capability to implement a development strategy under conditions of growing stakeholder expectations.

In 2005–2023, KGHM's ESG transformation proceeded in stages: from building measurability and compliance, through professionalisation of integrated reporting and standards (GRI), to a phase in which climate, energy and the value chain became the core of the strategy. The target ESG model synthesises this trajectory, translating it into measurable goals (Scope 1+2, RES, LTIFR) and a catalogue of technological and governance projects. As a result, ESG can be interpreted as a mechanism of industrial modernisation: reducing environmental pressure, stabilising occupational safety, and increasing transparency and organisational resilience under conditions of growing European regulation and global competition for capital.

9. ESG PERFORMANCE INDICATORS: FORMAL HYPOTHESIS TESTS, RESULTS, INTERPRETATION, AND CONCLUSIONS

9.1. Overview of Longitudinal ESG Performance (2010–2025)

The longitudinal analysis of ESG indicators for KGHM Polska Miedź S.A. over the period 2010–2025 reveals a clear evolution from early-stage CSR-style disclosure toward a mature, governance-integrated ESG perfor-

mance architecture. Consistent with the methodological assumptions outlined in Section 3, the results are interpreted not as isolated annual outcomes but as persistent trajectories, allowing assessment of structural change, institutional learning, and modernisation processes predicted by sustainable development and ESG theories (*Report of the World…*, 1987: 51; Elkington, 1997: ch. 1–2; Mol, 2001: ch. 2).

Across all three ESG pillars, the evidence shows increasing indicator continuity, methodological sophistication, and strategic integration, particularly after the mid-2010s. Environmental indicators evolved from aggregate inventories to scope-based and intensity-linked measures; social indicators, especially occupational safety, exhibit one of the strongest long-term improvement trends; and governance indicators demonstrate progressive alignment with international reporting and risk-management standards. This pattern provides the empirical foundation for formal hypothesis testing.

9.2. Formal Hypothesis Test: H1

It is worth noting that hypothesis (H1) states that historical environmental degradation and its social and health consequences served as "a critical catalyst for KGHM's long-term transformation toward environmental remediation, social responsibility, and intergenerational risk reduction." H1, therefore, concerns legacy environmental and social impacts as a catalyst for transformation.

The empirical evidence supports H1, as evidenced by a convergent pattern across environmental, social, and governance indicators. First, environmental performance data demonstrate sustained investment in pollution control, particularly in smelting operations, including large-scale BAT-oriented projects targeting SO_2, arsenic, and mercury emissions. These investments are not episodic but recur over multiple reporting cycles, indicating institutionalised modernisation rather than symbolic compliance (Porter and Linde, 1995: 100–103; Mol, 2001: ch. 2–3; European Commission, 2016).

Second, social indicators—most notably LTIFR and TRIR—show a pronounced long-term decline. LTIFR decreased from 18.6 in 2010 to approximately 5.0 by the early 2020s, representing a reduction of more than 70%. Such a trajectory is characteristic of deep organisational learning and systematic safety governance rather than short-term CSR initiatives (Friede et al., 2015: 212–214; ICMM, 2021).

Third, qualitative disclosures explicitly reference community health and environmental-risk prevention programs targeted at residents of historically affected areas, including former protective zones. Although these disclosures are not always accompanied by quantified health outcomes, their persistence across reporting periods aligns with Path Dependency Theory, which holds that historical shocks generate long-lasting institutional responses (Arthur, 1989: 119–123; Pierson, 2000: 251–254).

From a theoretical perspective, H1 is best explained by the combined logic of Intergenerational Justice, Legitimacy Theory, and Ecological Modernisation Theory. The data indicate that KGHM's ESG trajectory reflects not merely regulatory adaptation but a broader legitimacy-repair and responsibility-reconstruction process shaped by historical environmental and social burdens (*Report of the World…*, 1987: 43–44; Suchman, 1995: 574–578; Mol, 2001: ch. 1–3). This supports the view that legacy impacts can function as critical junctures, reorienting corporate strategy toward long-term risk reduction and stakeholder trust.

H1 is supported with moderate-to-strong evidence. While the causal narrative would be further strengthened by explicit retrospective accounts of historical environmental crises, the observed persistence, scale, and integration of environmental and social investments are fully consistent with the hypothesised mechanism.

9.3. Formal Hypothesis Test: H2

It should be noted that hypothesis (H2) states that KGHM's ESG orientation emerged before "binding EU sustainability reporting requirements and was driven primarily by local materiality, stakeholder pressure, and internal learning rather than external regulatory coercion". H2 thus points to an early ESG orientation beyond regulatory compulsion.

The analysis of early CSR reports (2010–2012) provides clear evidence of structured, quantitative disclosure of GHG emissions, energy consumption, and water withdrawal well before the introduction of the EU's current sustainability reporting regime (CSRD/ESRS). These disclosures follow GRI-style logic and display internal consistency across years, indicating early development of non-financial measurement capacity.

However, the dataset begins after Poland's EU accession, which limits the ability to empirically verify whether ESG orientation predated EU membership. It can be demonstrated that ESG practices were already institutionalised in the early 2010s, prior to the acceleration of EU-level ESG regulation and capital-market pressure.

The findings align with Stakeholder Theory and Institutional Theory, suggesting that ESG orientation at KGHM was shaped by the materiality of mining and smelting impacts on local communities and environments, as well as by organisational learning processes (DiMaggio & Powell, 1983: 150–154; Freeman, 1984: 25-31). The results are consistent with prior research on Polish heavy industry, which highlights early CSR adoption driven by environmental and social risk exposure rather than formal regulatory mandates (Woźniak, 2018: 6–8).

H2 is partially supported. The evidence confirms early ESG institutionalisation but does not allow definitive verification of a pre-EU accession origin. The hypothesis is therefore supported in its substantive logic but not in its strongest historical formulation.

9.4. Formal Hypothesis Test: H3

It is worth mentioning that hypothesis (H3) states that "KGHM acted as a precursor within the mining and smelting sector in adopting advanced ESG governance models, international standards, and integrated reporting practices". As shown in H3, KGHM has acted as a precursor in advanced ESG governance. In this area, KGHM has played a pioneering role in the mining and metallurgical sector.

H3 receives the strongest empirical support. Governance disclosures demonstrate early and progressive adoption of integrated reporting principles, a structured materiality assessment, and alignment with international frameworks such as GRI, the GHG Protocol, and, later, TCFD-oriented climate-risk governance. The introduction of Scope 3 emissions accounting and category breakdown further places KGHM among higher-maturity ESG adopters in the mining sector (Eccles and Krzus, 2010: ch. 4–6; Friede et al., 2015: 228–229).

Environmental and social indicators reinforce this conclusion by showing not only disclosure sophistication but also measurable performance improvements, particularly in safety and selected emissions categories. This combination of governance architecture and performance outcomes is consistent with Signalling Theory, which holds that credible, high-quality disclosure reflects substantive organisational capability rather than symbolic compliance (Spence, 1973: 358–360; Suchman, 1995: 586–588).

H3 is strongly supported. The evidence clearly positions KGHM as an advanced ESG adopter relative to regulatory timelines and sector norms, particularly within the Central and Eastern European mining context.

9.5. Synthesis of Results

Taken together, the results confirm that KGHM's ESG trajectory between 2010 and 2025 reflects a structural transformation rather than incremental compliance. The company's performance aligns with the theoretical expectations of the Triple Bottom Line, Ecological Modernisation Theory, and CSR/ESG governance frameworks, providing a coherent explanation of how heavy industry can reconcile environmental responsibility, social safety, and long-term operational viability (Freeman, 1984: 34; Elkington, 1997: ch. 1–2; Mol, 2001: ch. 1–3).

10. ESG PERFORMANCE INDICATORS: DISCUSSION, RECOMMENDATIONS, POLICY AND MANAGERIAL IMPLICATIONS

10.1. Discussion in the Context of Prior Mining and Copper-Sector ESG Research

The findings are consistent with international research on ESG in mining and metals, which emphasises that environmental modernisation in this sector is typically driven by regulatory frameworks (IED/BAT), technology investment cycles, and institutional learning rather than rapid decarbonization alone (Mol, 2001: ch. 2–3; European Commission, 2016). KGHM's gradual shift toward scope-based climate accounting and BAT-oriented abatement mirrors patterns observed among leading EU mining and metallurgical firms.

Social performance results, particularly the long-run decline in LTIFR, align closely with global mining benchmarks published by the ICMM, which identify occupational safety as the most standardised and comparable ESG dimension across the sector (Friede et al., 2015: 212–214; ICMM, 2021). Compared with international peers, KGHM's safety trajectory is consistent with an "upper-quartile improvement path" rather than laggard behaviour.

In governance terms, the transition from CSR reporting to integrated ESG governance reflects a broader convergence trend documented in global ESG scholarship, where reporting quality increasingly serves as a proxy for organisational ESG capability (Eccles and Krzus, 2010: ch. 4–6; Friede et al., 2015: 228–229).

10.2. Policy Implications for Poland and the European Union

From a policy perspective, the KGHM case underscores the importance of sector-specific ESG benchmarks for the mining and smelting sectors. Generic ESG indicators risk obscuring material risks, including tailings management, metal pollutants, and occupational hazards. Polish and EU regulators should therefore further integrate IED/BAT compliance data with CSRD/ESRS reporting, thereby improving both performance assessment and the usability of research (European Parliament and Council, 2010; European Parliament and Council, 2022).

At the EU level, the findings support the case for explicit alignment between sustainability reporting and industrial regulation, particularly in the non-ferrous metals sector. Enhanced guidance on tailings governance disclosure, consistent with the Global Industry Standard on Tailings Management, would significantly strengthen ESG comparability and risk governance (Global Tailings Review, 2020).

10.3. Managerial Implications for Mining and Smelting Companies

For corporate managers, the results highlight that governance maturity is a leading indicator of ESG performance. Investments in reporting systems, risk management, and KPI continuity precede and enable improvements in environmental and social outcomes (Jensen and Meckling, 1976: 310; Eccles and Krzus, 2010: ch. 6). The KGHM case demonstrates that early adoption of structured ESG governance can reduce long-term regulatory and reputational risk while enhancing strategic flexibility.

Additionally, the growing prominence of Scope 3 emissions suggests that future competitiveness in the copper value chain will depend increasingly on supplier engagement and value-chain governance, rather than on operational efficiency alone (Spence, 1973: 360; Freeman, 1984: 34).

10.4. Final Conclusions

This study demonstrates that long-term ESG transformation in heavy industry is both empirically observable and theoretically explainable when analysed through an integrated framework linking sustainable development theory, ESG governance, and longitudinal indicator analysis. The KGHM case provides robust evidence that mining and smelting compa-

nies can evolve toward higher ESG maturity through a combination of historical learning, regulatory modernisation, and strategic governance integration.

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