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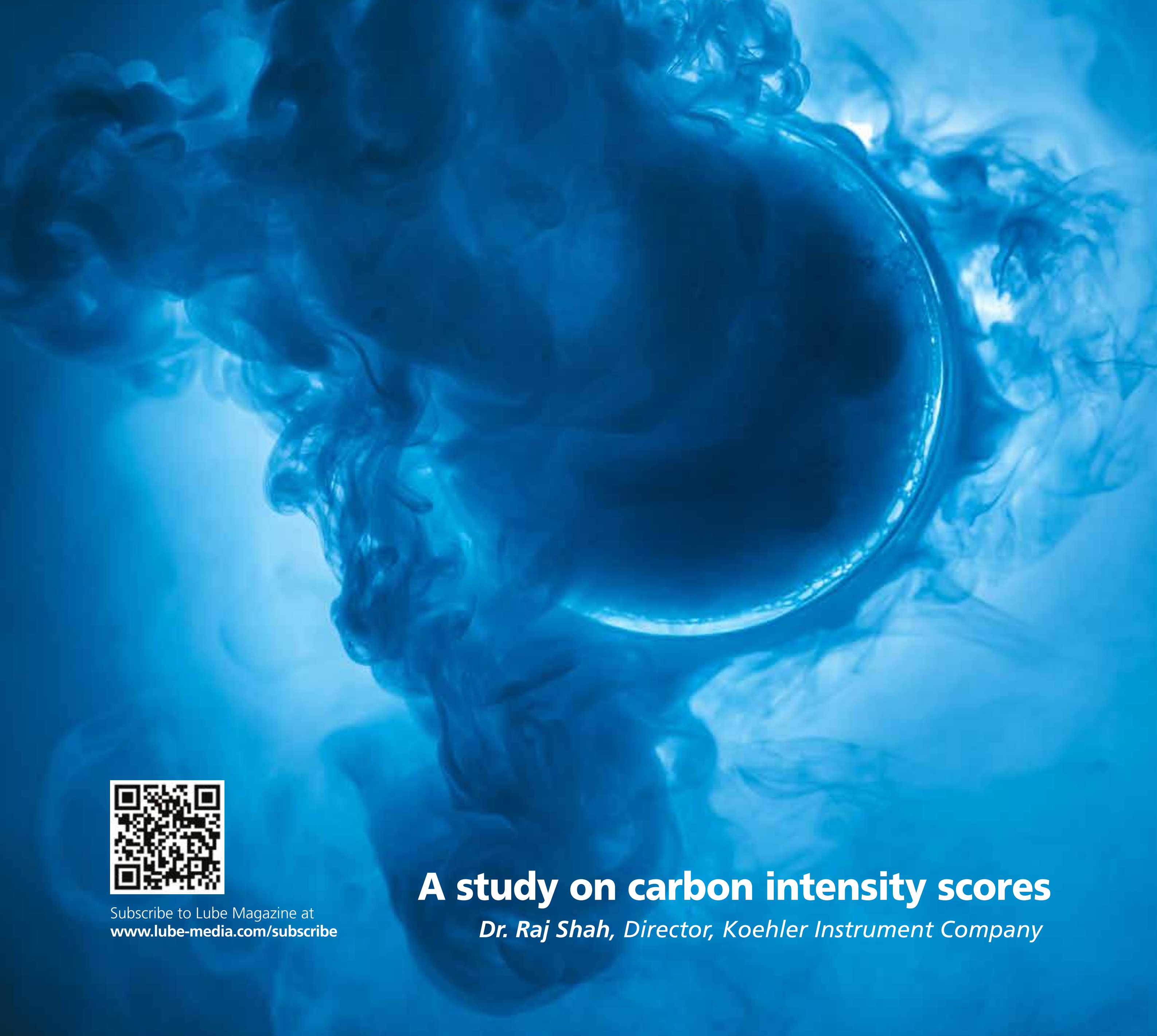

A study on carbon intensity scores

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A sweeping study on Carbon Intensity scores

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Introduction

Carbon intensity scores are pivotal for quantifying the climate-related activities of companies. These scores, established by entities such as the Department of Energy, measure the amount of carbon dioxide equivalents (CO_2e) emitted per unit of output or activity [1]. For instance, in the biofuels sector, the energy used to produce the grain feedstocks is assessed. This provides a clear metric to compare the efficiency of different companies and industries in managing their carbon emissions [1]. Carbon intensity scores are crucial not only for meeting regulatory compliance and enhancing sustainability reporting but also for influencing investment decisions and consumer behaviour. By offering a transparent view of a company's efforts to minimise its environmental footprint, these scores play a critical role in steering economic, climate-related disclosures, advertising, and environmental sustainability. While environmental protection and the prefix "bio" indicate eco-toxicological requirements, these should not be confused with sustainable development or climate protection, even though eco-toxicological criteria are now a "subset" of the United Nations' Sustainable Development Goals (see SDGs #3 and #6).

Background and context

Historical development of carbon Intensity metrics

The concept of carbon intensity metrics has evolved significantly since it first emerged, driven by increasing global industrial activity and the corresponding rise in greenhouse gas (GHG) emissions awareness. This trend heightened global concerns about climate change, underscoring the need for standardised measures to quantify environmental impact. The term "carbon intensity" gained initial visibility in a 1999 BBC vegetarian magazine and was later popularised by a 2005 advertising campaign developed by Ogilvy for BP (2). These developments highlighted the urgency of establishing reliable metrics that could effectively gauge the environmental efficiency of various economic sectors.

Over time, carbon intensity scores have become essential tools in environmental policy-making and corporate strategy, reflecting their critical role in managing and mitigating the ecological impacts of industrial operations. Carbon intensity measures greenhouse gas emissions against something meaningful to a business or per unit of activity. It refers to how many grams of carbon dioxide equivalent (CO_2e) are emitted to produce kWh of electricity (gCO_2e/kWh) or megajoules of energy (gCO_2e/MJ) or per cargo-carrying capacity and nautical mile.

Environmental and economic sgnificance

Carbon intensity scores serve as a crucial metric in bridging the gap between industrial activities and their environmental and climate repercussions, specifically by quantifying emissions such as CO2 and other greenhouse gases. These metrics are vital tools in the global fight against climate change, providing stakeholders with a transparent indicator of how efficiently industries manage their environmental impact relative to their output. In particular, the California Air Resources Board (CARB) is at forefront and employs these scores as part of the AB 32 Climate Change Scoping Plan, which is a comprehensive, multi-year initiative designed to significantly reduce greenhouse gas emissions across the state [3].

Within the framework of this plan, carbon intensity scores are not merely numerical values; they are actionable insights that guide policy and regulation. They help assess the effectiveness of various measures aimed at reducing emissions and transitioning towards more sustainable industrial practices [4]. For example, under the California´s Low Carbon Fuel Standard (LCFS), which is a critical component of the AB 32 plan, the scores are used to monitor the reduction in carbon intensity of transportation fuels [4]. By setting increasingly stringent benchmarks for fuel producers, the LCFS encourages the adoption of cleaner, lower-carbon fuels, thereby directly contributing to the reduction of greenhouse gas emissions.

Economically, carbon intensity scores play a significant role in shaping policy decisions. The implementation of carbon taxes and cap-and-trade systems are prime examples of policies designed to incentivise reductions in greenhouse gas emissions, as depicted in Figure 1 demonstrating the U.S.´s efforts to decrease carbon emissions relative to GDP growth. Furthermore, these scores influence investment strategies, with an increasing number of investors seeking to support companies that maintain lower carbon footprints, thereby fostering a more sustainable and environmentally conscious business environment.

Figure 1: *Carbon intensity: Historic evolution of CO_2 emissions per dollar of GDP [5]*

Policy and regulatory frameworks

The regulatory landscape around carbon emissions reporting and reduction is continually evolving. The Paris Agreement is the corner stone and countries have set ambitious targets for reducing GHG emissions, which they translate into Nationally Determined Contributions (NDCs) and national regulations affecting industry operations. These frameworks often mandate the calculation and reporting of carbon intensity scores, which serve as benchmarks for compliance with environmental standards [6]. As such, these scores play a pivotal role in shaping the regulatory obligations and sustainable practices of companies worldwide.

Understanding this background provides a crucial foundation for discussing how carbon intensity scores are calculated, their applications, and the challenges and future directions in utilising these important environmental metrics.

Methodologies for calculating carbon intensity

Life cycle assessment methods

Life Cycle Assessment (LCA) is a comprehensive methodology used to evaluate the environmental impacts associated with all stages of a product's life, from raw material extraction through to disposal or recycling. This approach is particularly valuable in calculating carbon intensity as it quantifies the total emissions of CO_2 and other greenhouse gases emitted throughout the product's lifecycle. By examining each phase of the production process, LCA helps to identify major sources of emissions and opportunities for reducing environmental impact. This detailed analysis is crucial for formulating strategies to minimise carbon footprints, especially within complex supply chains.

Figure 2: *The holistic approach of life cycle assessment accounts for environmental impacts associated over the entire life cycle with all stages of product's life cycle (circle in the middle) [7].*

The development of LCA guidelines, as per ISO 14060 family, has been underpinned by a robust body of literature and collaborative expert insights, as outlined in various standards and guidelines from reputable sources, like the European Committee for Standardisation (CEN) and the World Resources Institute [7]. These guidelines have evolved through rigorous peer-reviewed methodologies and extensive discussions across multiple workshops involving experts from industry, academia, and policy sectors. Such comprehensive development processes ensure that LCAs adhere to high standards of accuracy and relevance, addressing specific needs like the assessment of carbon capture and utilisation (CCU) technologies [7]. These guidelines emphasise the 'shall,' 'should,' and 'may' rules, which dictate the minimum requirements, recommended practices, and optional detailed analyses for conducting LCAs, respectively. An example of this can be seen in Figure 2 as it shows the holistic approach for environmental impacts based on certain environmental factors. This structured approach facilitates the use of LCA as a critical tool in various fields, ranging from product design to policymaking, by providing a holistic view of environmental impacts throughout a product's lifecycle.

Sector-specific calculation methods

Sector-specific calculation methods are essential due to the distinct operational processes and environmental impacts that characterise each industry. For example, in the energy sector, carbon intensity is measured in emissions per megawatt-hour (MWh) of electricity generated, considering the types of fuel used and the efficiency of energy conversion technologies [8]. This approach is vividly illustrated in Figure 3 for an index from researchers at Carnegie Mellon University's Scott Institute for Energy Innovation, which highlights a significant reduction in CO2 emissions intensity in the US power sector since 2005. Similarly, in the manufacturing sector, carbon intensity is calculated per unit of product or economic output [9]. This calculation incorporates critical factors such as energy consumption and process emissions. These specialised measurement techniques enable industries to conduct precise evaluations of their environmental performance, facilitating compliance with regulatory standards and aiding in the pursuit of sustainability objectives.

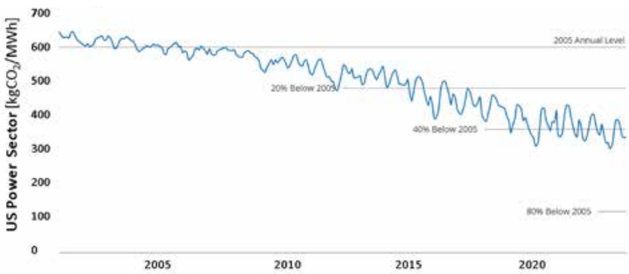

Figure 3: *US Power Sector CO_2 Emissions Intensity [8]*

Challenges and limitations in measurement

The process of calculating carbon intensity scores presents several challenges, primarily due to issues with data availability and accuracy. Reliable emissions and energy use data are often scarce, particularly in less regulated markets or among smaller companies, leading to significant discrepancies in calculated scores. This is further complicated by the complexity of global supply chains, making comprehensive carbon footprint assessments across various regulatory environments difficult. Additionally, life cycle assessments and other detailed evaluations are resource-intensive, which may be prohibitive for smaller entities. Current methodologies also might not fully account for indirect emissions or the impacts of emerging technologies like carbon capture, potentially skewing the real carbon intensities.

Building on this understanding, the article "Carbon accounting for sustainability and management" published in the Journal of Cleaner Production highlights the rapidly evolving field of carbon accounting as a crucial area of sustainability management [10]. It underscores the need for holistic approaches to mitigate climate change impacts, urging the development of new accounting methods that enhance transparency, accountability, and decision-making across various sectors including governments, corporations, academia, and non-profits [10]. Different types of carbon accounts — scientific, political, economic, and corporate — are evolving, but remain insufficiently interconnected in policy or strategy.

On a corporate level, carbon accounting supports management by delineating between accounts for unsustainability and those aimed at sustainability improvements. These approaches increasingly influence corporate functions such as production, distribution, procurement, supply chain management, innovation, communication, and marketing. The environmental management accounting framework aids corporate decision-makers by providing a structured overview of methods, distinguishing between physical and monetary approaches to carbon accounting [10]. As carbon accounting practices expand to include supply chains and product life cycles, researchers face the challenge of developing new methods, such as input–output assisted hybrid accounting, to keep pace with these advancements.

Thus, while the methodologies for measuring carbon intensity are indispensable for understanding and mitigating emissions, their continuous refinement and adaptation are necessary to ensure their effectiveness in a dynamically evolving global context.

Applications of carbon intensity scores in corporate sustainability reporting

Carbon intensity scores are increasingly utilised in corporate sustainability reporting as a vital means of demonstrating a company's environmental performance. By measuring and disclosing the amount of greenhouse gases emitted per unit of production or activity, companies provide transparent information to stakeholders about their efforts to reduce their carbon footprint. This transparency not only helps build trust with consumers, investors, and regulatory bodies but also enhances the company's reputation in the marketplace. A notable example of institutionalising this practice is the European Corporate Sustainability Reporting Directive (CSRD), effective from January 5, 2023 [11]. The CSRD mandates comprehensive reporting requirements for companies, ensuring alignment with sustainability goals like the European Green Deal and the Paris Agreement, which aims to limit global warming to +1.5°C [11]. Furthermore, these scores drive internal decisions toward more sustainable practices, aligning business operations with global sustainability objectives. The CSRD represents a significant step towards better data transparency in financial markets [11]. It extends the scope of reporting to include not only environmental impacts but also social and governance factors, with the inclusion of forward-looking and retrospective information across short, medium, and long-term horizons [11]. This comprehensive approach under the CSRD ensures that companies not only report on their current sustainability performance but also on their strategic planning and risk management related to sustainability, enhancing overall corporate accountability in environmental matters.

Simultaneously, the U.S. Securities and Exchange Commission (SEC) is adopting rules that will require information about climate-related risks that have materially impacted or are reasonably likely to have a material impact on a company's business strategy, results of operations, or financial condition. The initial proposal sparked discussions on whether GHG targets should be absolute or intensity based. In the final rule, the SEC does not require the disclosure of GHG emissions in terms of intensity—just absolute values.

On the other hand, the Task Force on Climate-related Financial Disclosures (TCFD) recommends disclosing key climate-related targets, whether they are absolute or intensity-based [13]. The Partnership for Carbon Accounting Financials (PCAF) recommends sector-specific emissions per unit of activity data, such as $kgCO_2e/m^2$ for real estate, gCO_2e/kWh for power utilities, and tCO_2e/t for cement or steel [14].

For regulatory compliance and carbon taxation

Carbon intensity scores are pivotal in regulatory compliance and the implementation of carbon taxation schemes. These scores serve as benchmarks for determining whether industries meet legally mandated environmental standards or require additional measures to comply. For example, under carbon taxation systems, businesses with higher carbon intensity may incur greater taxes, motivating them to innovate and reduce emissions. This regulatory application underscores the role of carbon intensity scores in promoting environmental accountability and encouraging industries to adopt cleaner technologies.

However, an interesting dynamic emerges from a study conducted by researchers from Shanghai University of Finance and Economics and Zhongnan University of Economics and Law, which investigated the effects of carbon emissions trading policy in China [5. Their findings suggest that while environmental regulations like carbon trading are designed to encourage environmental responsibility, they may inadvertently lead to increased corporate tax avoidance, especially among non-state-owned firms, firms with severe financing constraints, and those in highly competitive industries [15]. This behaviour is primarily driven by the reduction in cash flow caused by the costs associated with complying with such policies.

The study highlights that when firms face stricter environmental regulations, they may resort to tax avoidance strategies to offset the financial burdens imposed by these policies. This suggests a complex interplay between environmental regulations and corporate financial strategies where the direct costs of environmental compliance could push firms towards minimising their tax liabilities. To address these unintended consequences, the researchers recommend strengthening cooperation between environmental protection and tax authorities to enhance enforcement and curb unreasonable tax avoidance [15]. Additionally, they advocate for government interventions such as increased subsidies and tax incentives for R&D in green technologies, which could help mitigate the financial impact on firms and encourage sustained environmental investments.

In consumer information and product labeling
Climate neutrality is the current advertising gold and labeling as "climate neutral" is an environmental advertising claim that needs to be quantified. Green marketing claims are voluntary disclosures. Although labellings with "climate-related disclosures" are voluntary advertising claims and one has to be careful not to violate the principles of greenwashing when formulating them as per U.S. Federal Trade Commission´s Green Guide (October 2012, under review) or future European directive on Greenwashing (COM(2022) 143 final).

Carbon intensity scores play an essential role in consumer information and product labeling, offering crucial data about the carbon footprint of products. This allows consumers to make more informed decisions based on the environmental impact of their purchases. Labels that display lower carbon intensities can significantly influence consumer behaviour, steering preferences toward products that are less damaging to the environment. Such a market-driven approach encourages companies to reduce their emissions to remain competitive, furthering the overall push towards a more sustainable economy.

The potential of carbon labeling in the green economy is substantial, as discussed in the article "The potential role of carbon labeling in a green economy". While carbon footprint product labeling is still developing, there is a clear theoretical foundation: without information on the greenhouse gas implications of their choices, consumers cannot make environmentally informed decisions [16]. However, effective carbon labeling also depends on credible third-party certification to ensure that such a market is meaningful and trustworthy. Moreover, because climate change is a global issue and international trade contributes significantly to carbon emissions, a universally accepted methodology for calculating life-cycle emissions and labeling products is crucial [16].

The potential impact of carbon labeling on consumer and firm behaviour is significant yet underexplored. Some product segments could see large reductions in carbon emissions, and as more consumers become aware of these issues, their interest and demand for labeled products are likely to increase. This growth in consumer awareness can also increase pressure on manufacturers and retailers to reduce the carbon footprints of the products they offer. Ultimately, the successful implementation of carbon labeling can contribute significantly to reducing carbon emissions in a cost-effective manner, aligning with international trade standards, and promoting environmental sustainability on a global scale [16]. Each of these facets plays a vital role in the collective effort to mitigate climate change and enhance environmental sustainability through better consumer information and product choices.

Case Studies
Companies and their carbon intensity score improvements
The research article "Exploring the determinants and long-term performance outcomes of corporate carbon strategies" introduces a comprehensive framework for analyzing corporate responses to environmental challenges, particularly focusing on the steel, cement, and automotive sectors [17]. An example of this framework can be seen in figure 4. This detailed study evaluates data from 45 leading global enterprises and illustrates how institutional pressures and stakeholder demands significantly influence companies' carbon reduction initiatives. Specifically, the automotive sector demonstrates remarkable efforts in adopting sustainable practices and technologies to reduce carbon emissions, driven largely by increased regulatory standards and heightened consumer awareness of environmental issues [17].

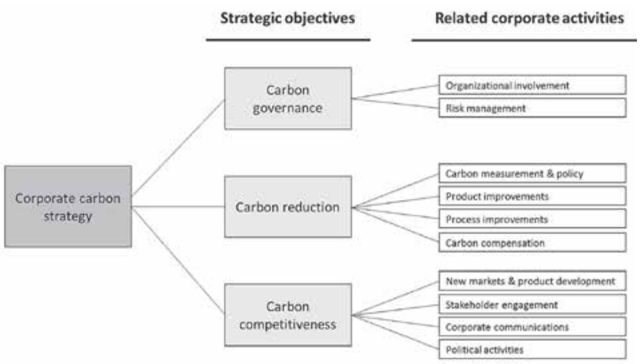

Figure 4: *Corporate carbon strategy framework [14]*

The study reveals that while automotive companies are making strides in reducing immediate carbon emissions through innovations such as electric vehicles and energy-efficient manufac¬turing processes, the long-term impact on overall carbon performance is varied [17]. This variation often stems from challenges in completely overhauling existing systems and the gradual improvement curve associated with new technologies becoming fully efficient. However, despite these complexities, the initiatives for reducing emissions have been shown to concurrently generate financial gains for companies. These gains arise from enhanced operational efficiency, reduced energy costs, and an improved corporate image that can attract new customers and markets.

The automotive examples from the study underscore the intricate relationship between implementing short-term carbon reduction measures and achieving long-term sustainability goals. They highlight the role of regulatory and stakeholder pressures in shaping corporate strategies that not only aim to mitigate environmental impact but also enhance profitability. The insights from this research provide a valuable perspective on the dynamics of corporate environmental strategies and their effectiveness in contributing to global sustainability efforts.

National carbon intensity trends and Their Global Implications

The increasing atmospheric concentration of greenhouse gases (GHGs) poses a significant global issue, as highlighted in "A Preliminary Assessment of Global CO_2: Spatial Patterns, Temporal Trends, and Policy Implications" by Ahmed M. El Kenawy et al. This study underscores that most of the increase in GHG emissions can be traced back to human activities, particularly the combustion of fossil fuels for economic development, industrial emissions, changes in land use, and technological advancements [18]. Notably, fossil fuels have been the primary source of anthropogenic emissions since 1950, with their share escalating rapidly. On the other hand, 33% of the 57.1 gigatons of CO_2e were non-fossil greenhouse gas emissions in 2022 and could be minimise by optimisations in industrial processes [19].

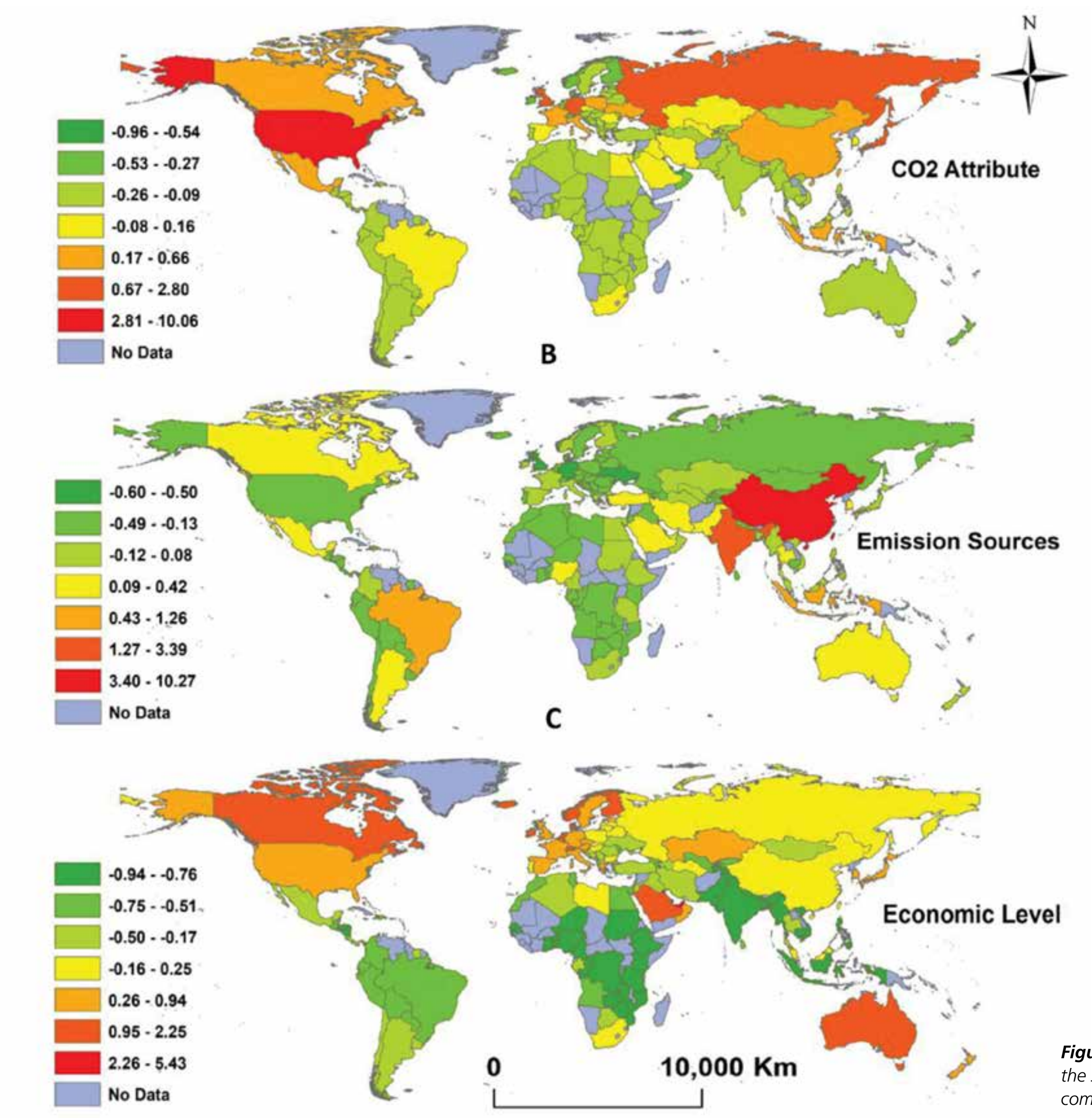

Figure 5: *Spatial distribution of the scores of the three different components. [18]*

The research emphasises the global nature of CO2 emissions, compounded by the fact that emissions in one country can affect the entire globe due to atmospheric mixing [18]. This global interconnectivity leads to inequities between nations that are major contributors to GHG emissions and those that bear the brunt of the adverse effects, such as climate change. This is shown in figure 5, in which it shows the effects of such inequalities. While developed countries are advancing in clean energy, developing nations are still catching up, contributing dispropor¬tionately to emissions from soil and agriculture.

Empirical studies across various global regions link CO2 emissions to multiple socioeconomic factors, including economic growth and energy use. For example, negative correlations between energy conservation policies and economic growth in the Middle East and North Africa highlight the complex interplay between economic policies and environmental outcomes [18]. In contrast, in Sub-Saharan Africa, the nexus between energy consumption, economic growth, and pollution underscores the significant impact of economic activities on CO2 levels, neces¬sitating nuanced energy policies that harmonise economic and environmental considerations [18].

This complex backdrop of CO_2 emissions shaped by a myriad of economic, technological, and institutional factors calls for a coordinated global response. Addressing these emissions effecti¬vely requires integrating diverse economic statuses and environmental policies across countries to formulate comprehensive strategies that mitigate environmental impacts while promoting sustainable economic growth.

Comparative Analysis of Industries by Carbon Intensity Scores

Exploring the dynamics between energy efficiency, carbon emissions, and industrial competitiveness is increasingly vital in a world focused on environmental sustainability and stringent carbon regulations. The research conducted by Andrius Zuoza and Vaida Pilinkienė in "Energy Efficiency and Carbon Emission Impact on Competitiveness in the European Energy Intensive Industries" offers a comprehensive analysis of how carbon intensity affects the performance and strategic positioning of industries across the European Union (EU).

The study highlights how sectors with high carbon intensity, such as basic metals and chemicals—which are pivotal to the EU's economic structure—face substantial challenges due to their significant CO2 emissions resulting from energy-intensive operations. For instance, the basic metals sector is deeply influenced by the European Union Emission Trading System (ETS), which directly affects its cost structures through carbon pricing mechanisms. This necessitates a strategic pivot towards more sustainable practices and advanced technologies to remain economically viable and compliant with regulations [20]. In contrast, sectors like information technology and services enjoy the benefits of lower carbon intensities, facing reduced regulatory costs and, potentially, gaining competitive advantages in the marketplace.

This research introduces a sophisticated industry competitiveness measure index that incorpo¬rates carbon emissions, providing a nuanced view of industry performance that balances both economic and environmental factors. This index is structured around three core sub-indexes: export performance, energy, and environmental factors, each weighted equally to reflect the complex nature of industry competitiveness [20]. The empirical results of this study, particularly demonstrated through the ANOVA results shown in Table 1, reveal a pronounced correlation between environmental efficiency and competitiveness. Industries that proactively reduce their energy consumption and carbon emissions tend to achieve higher scores on competitiveness indices, underscoring the dual benefits of sustainability efforts on both environmental and business fronts.

Predictor	Sum of Squares	df	Mean Square	F	p
(Intercept)	0.26	1	0.26	2.08	0.08
Industry	0	3	0	0	0.999
Country	35.89	16	1.99	23.28	0
Industry*Country	40.41	54	0.75	6.74	0
Error	58.6	684	0.09	-	-

Table 1: *ANOVA results using index value as the criterion. [20]*

Moreover, the analysis identifies variable influences on the competitiveness of energy-intensive industries within the EU, including factors such as energy prices and emission intensities. The detailed empirical insights emphasise the critical need for strategic investments in energy efficiency and greener technologies, essential for industries to adapt and thrive within the evolving regulatory landscapes aimed at carbon reduction.

In sum, examining carbon intensity across various industries is crucial for understanding their economic and environmental impacts comprehensively.
This exploration underscores the impe¬ra-tive for industries to adapt to regulatory climates and market demands that increasingly favor low-carbon and energy-efficient operations. Such strategic adaptations are not only pivotal for achieving global climate goals but also for ensuring the long-term sustainability and competitiveness of industries in a dynamically changing global landscape.

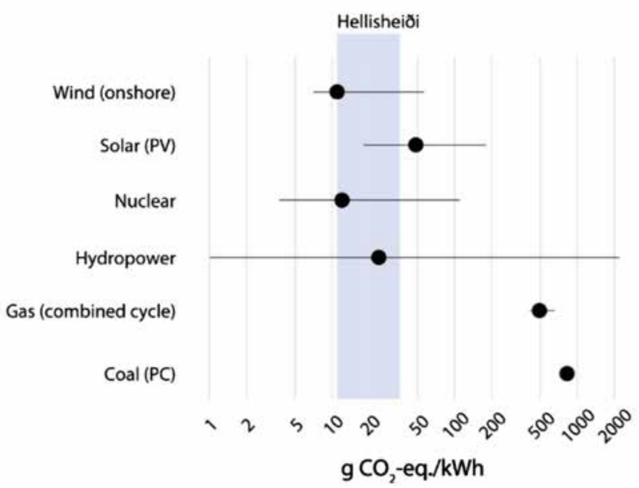

Figure 6: *Figure 6: Comparison of climate change impacts (gCO_2-eq./kWh) between Hellisheiði and other energy sources [21].*

The comparative analysis of the Hellisheiði geothermal plant in Iceland as detailed in "The environmental impacts and the carbon intensity of geothermal energy: A case study on the Hellisheiði plant" by Andrea Paulillo et al., provides a thorough Life Cycle Assessment (LCA). This study identifies significant environmental impacts primarily from the construction phase of the plant, notably involving high consumption of diesel and steel [21]. It further explores how geothermal energy, characterised by relatively low carbon intensity rates of 15-24 g CO2-eq./kWh, as seen in figure 6, is akin to other renewable sources like solar and hydropower in terms of environmental friendliness, reinforcing its viability in the sustainable decarbonisation of power generation [17]. For comparison, the average carbon intensity in 2022 was in USA 355 gCO_2e/kWh and 251 gCO_2e/kWh in Europe (EU27).

On a different front, the research titled "Digital Economy, Agricultural Technological Progress, and Agricultural Carbon Intensity: Evidence from China" by Ruoxi Zhong, Qiang He, and Yanbin Qi examines the impact of China's burgeoning digital economy on the agricultural sector's carbon intensity [22].
This study is pivotal considering China's status as the world's largest carbon emitter, where the agricultural sector represents a significant share of the nation's total emissions. The findings suggest that the digital economy does not just directly reduce agri¬cultural carbon intensity but also facilitates this reduction indirectly by enhancing agricultural technological progress. This can be seen in figure 7 as it charts China's agricultural carbon emissions, digital economy, agricultural technology progress, and the proportion of crop production value from 2011 to 2019. This dual mechanism underscores the transformative potential of digital economic strategies in promoting more efficient agricultural practices and reducing the carbon footprint [22].

Figure 7: *Figure 7. Time evolution diagram of China's agricultural carbon emissions (ACI), digital economy (DIG), agricultural technology progress (TE), and the proportion of crop production value (PI) [22].*

Both articles bring to the forefront the essential integration of technological advancement and economic activities with environmental stewardship. They illustrate the effectiveness of innovative approaches in geothermal energy exploitation and digital advancements in agricul¬ture towards achieving reduced carbon intensities. These studies collectively advocate for robust support for technological innovation and the expansion of the digital economy, aiming to optimise economic activities while minimising their environmental impacts. This aligns with broader global goals of sustainability and achieving carbon neutrality, highlighting a path forward those balances economic growth with ecological preservation.

Conclusion

The utility and implementation of carbon intensity scores as examined in diverse sectors and through various case studies underline their crucial role in enhancing environmental accountability and promoting sustainable industrial practices. The comparative analyses provided by studies such as "The environmental impacts and the carbon intensity of geothermal energy: A case study on the Hellisheiði plant" and "Digital Economy, Agricultural Technological Progress, and Agricultural Carbon Intensity: Evidence from China" demonstrate the impactful integration of technological advancements and digital economic strategies with environmental stewardship. These initiatives not only pave the way for achieving reduced carbon intensities but also contribute significantly to the broader goal of sustainable develop¬ment and carbon neutrality.

As the global community continues to face the pressing challenges of climate change, carbon intensity scores emerge as indispensable tools. They not only foster transparency and influence consumer behaviour but also guide corporate strategies and governmental policies towards more sustainable practices. The ongoing refinement of these metrics, alongside advancements in regulatory frameworks and reporting standards, is essential to their efficacy and relevance in a rapidly evolving global context. By continuing to develop and apply these metrics across sectors, stakeholders can better navigate the complexities of environmental impact, fostering a sustainable future where economic growth and environmental preservation are in alignment.

About the Authors

Dr. Raj Shah serves in the role of Director at Koehler Instrument Company in New York, boasting an impressive 30-year tenure with the organisation. Recognised as a Fellow by eminent organisations such as IChemE, CMI, STLE, AIC, NLGI, INSTMC, AOCS, Institute of Physics, The Energy Institute, and The Royal Society of Chemistry, he stands as a distinguished recipient of the ASTM Eagle award. Dr. Shah, a luminary in the field, recently coedited the highly acclaimed "Fuels and Lubricants Handbook," a bestseller that unravels industry insights. Explore the intricacies at ASTM's Long-Awaited Fuels and Lubricants Handbook 2nd Edition Now Available (https://bit.ly/3u2e6G). His academic journey includes a doctorate in Chemical Engineering from The Pennsylvania State University, complemented by the title of Fellow from The Chartered Management Institute, London. Dr. Shah holds the esteemed status of a Chartered Scientist with the Science Council, a Chartered Petroleum Engineer with the Energy Institute, and a Chartered Engineer with the Engineering Council, UK. Recently honored as "Eminent Engineer" by Tau Beta Pi, the largest engineering society in the USA, Dr. Shah serves on the Advisory Board of Directors at Farmingdale University (Mechanical Technology), Auburn University (Tribology), SUNY Farmingdale (Engineering Management), and the State University of NY, Stony Brook (Chemical Engineering/Material Science and Engineering). In tandem with his role as an Adjunct Professor at the State University of New York, Stony Brook, in the Department of Material Science and Chemical Engineering, Dr. Shah's impact spans over three decades in the energy industry, with a prolific portfolio of over 650 publications. Dive deeper into Dr. Raj Shah's journey at https://bit.ly/3QvfaLX.

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Mr. Jeff Gao part of a thriving internship program at Koehler Instrument company in Holtsville, and is a student of Chemical Engineering at Stony Brook University, Long Island, NY where Dr. Shah is the current chair of the external advisory board of directors.

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