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## RESEARCH ARTICLE OPEN ACCESS

# Unpacking the Renewable Pull Effect: Conditions for Green Industrial Relocation

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**Correspondence:** Sven Colen ([sven.colen@tum.de](mailto:sven.colen@tum.de))**Received:** 13 November 2024 | **Revised:** 19 March 2025 | **Accepted:** 7 April 2025**Keywords:** analytical hierarchy process | direct-reduced iron | energy-intensive industries | green ammonia | green relocation | industrial relocation | renewable pull effect | sustainable transition

## ABSTRACT

The renewable pull effect theoretically leads to the relocation of green production facilities within energy-intensive industries to regions rich in renewable energy resources. This study employs a qualitative research design, integrating the analytic hierarchy process method, by interviewing top managers and experts from globally leading steel and chemical corporations, predominantly based in Europe and Germany. The findings reveal that whereas factors associated with the renewable pull effect are most influential in green production location decisions, three critical conditions must be met for this effect to translate into actual green relocations: weaker agglomeration and demand pull effect, limited counteracting subsidies from regulatory bodies, and fulfillment of essential socio-political and environmental prerequisites. This study demonstrates that the renewable pull effect only conditionally drives green relocations, providing the first comprehensive evaluation of the key factors shaping green relocations within the ongoing academic debate. Moreover, by providing empirical insights from leading industry practitioners, the study advances the existing literature, which has been predominantly based on theoretical models and techno-economic analyses. Additionally, the study suggests several foremost avenues for future research. Finally, it delivers practical implications for energy-intensive industries' top management and policymakers in both renewable-energy-rich and scarce regions, informing strategic decision-making for sustainable transition.

## 1 | Introduction

The transition to a low-carbon economy has become a global imperative, with the industrial sector—responsible for approximately 34%<sup>1</sup> of global greenhouse gas (GHG) emissions (IPCC 2023)—facing mounting pressure to decarbonize. International policy frameworks such as the Paris Agreement, along with regional initiatives like the Inflation Reduction Act in the United States (The White House 2023) and the Green Deal Industrial Plan in the European Union (European Commission 2023), are forcing a sustainable transition by endorsing renewable energy adoption (Kabongo 2019).

For energy-intensive industries (EIIs) such as steel and chemicals, this sustainable transition presents a complex challenge

(Egerer et al. 2024). It requires the adoption of electrified production processes and the substitution of fossil fuels with low-to zero-GHG energy carriers, including green hydrogen (GH<sub>2</sub>; Eicke and De Blasio 2022; Hermundsdottir et al. 2024; Rissman et al. 2020). However, the increasing demand for renewable electricity and GH<sub>2</sub>—particularly in highly industrialized countries—combined with limited local renewable energy resources (RER) and high transportation costs of renewable energy and GH<sub>2</sub>, substantially raises production costs (Day 2022). These dynamics may create cost disadvantages for regions like Europe, North-East Asia, and parts of the United States (Neuwirth et al. 2022). Consequently, Samadi et al. (2023) introduce the “renewable pull effect” concept, proposing that countries with abundant RER could become attractive for the relocation of green production<sup>2</sup> facilities of EIIs from RER-poor countries.

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Recently, the academic literature debates whether the largely undisputed cost-saving potential of the renewable pull effect actually translates into the relocation of green production facilities—termed “green relocation” by Verpoort et al. (2024). Scholars argue that other location factors, such as labor market dynamics, supply chain infrastructure and regulatory environments, could outweigh the energy cost advantages and deter EIIs from relocating (Egerer et al. 2024; Samadi et al. 2023; Verpoort et al. 2024). Accordingly, almost all studies related to the renewable pull effect call for further research, as “a better understanding of the future relevance of the renewables pull effect requires first and foremost an analysis of the importance of energy costs in comparison to other location factors” (Samadi et al. 2023, 10). This study, therefore, aims to identify and empirically evaluate these *other location factors* by addressing the following research question: Does the renewable pull effect lead to green relocation of energy-intensive industries?

Given the prospective and dynamic nature of green production location decisions, this study employs an explorative research approach by conducting 41 semi-structured interviews with top managers and experts with direct influence on green production location decisions of global leading steel and chemical corporations, headquartered primarily in Europe and mostly in Germany. The study concentrates on direct-reduced iron (DRI) and green ammonia, as both products are highly likely to be affected by the renewable pull effect (Samadi et al. 2023). The analytical hierarchy process (AHP), a well-established methodology for multiple-criteria decision analysis (Saaty 1987), is applied to assess the relative importance of location factors, derived from literature. Additionally, thematic analysis based on Braun and Clarke (2006) and Mayring’s (2016) qualitative content analysis is applied to interpret the interview statements under which circumstances the renewable pull effect could lead to green relocation.

This study offers three central contributions to the ongoing academic discourse. Firstly, it identifies and categorizes additional location factors that influence green relocation decisions beyond renewable energy access and cost savings. Although previous research primarily present self-conceptualized factors (Verpoort et al. 2024), this study bridges the gap by deriving relevant factors through existing location decision literature, offering a broader and more grounded perspective. Secondly, by leveraging the AHP, the study not only identifies but also evaluates the importance of all factors, providing a structured assessment of the relative importance of the renewable pull effect compared to other location determinants. This addresses a crucial missing element in the ongoing debate, enhancing the understanding of the dynamics that drive or hinder green relocation (Samadi et al. 2023). Thirdly, the empirical approach taken by this study adds considerable value. Unlike prior research that predominantly relies on theoretical models and techno-economic analyses (Egerer et al. 2024; Samadi et al. 2023; Verpoort et al. 2024), this study is the first to empirically investigate the renewable pull effect. Furthermore, the rare opportunity to incorporate the perspectives of decision-makers at the highest corporate levels, adds a crucial layer of expertise to the debate. The empirical insights contribute to refining and substantiating existing studies with a more tangible basis for decision-making.

Beyond its theoretical contributions, the study delivers practical insights for both corporate leaders and policymakers. The findings equip EII decision-makers with a framework to evaluate production locations by balancing energy costs with strategic concerns. For policymakers in RER-poor regions, the study provides insights to assess their attractiveness for EIIs and suggests strategies to mitigate the risk of emigration. Conversely, regulators in RER-rich regions can use the outcomes to attract green investments from EIIs and capitalize on their competitive advantage.

The remainder of the paper is structured as follows: Section 2 reviews the location decision theory including the renewable pull effect and identifies location decision factors for green production of EIIs. Section 3 describes the applied qualitative methodology. Section 4 presents the study’s results. Section 5 answers the research question and discusses theoretical contributions, practical implications, limitations, and future research demands. Section 6 concludes.

## 2 | Literature Review: Location Decision Factors for Green Production Facilities of EIIs

The decision of production facility location has long been a focal topic in academic research (Tsai and Urmetzer 2024), evolving substantially alongside shifts in economic paradigms and, more recently, the growing emphasis on green production practices (Day 2022). This section synthesizes the current state of academic literature on location decision factors, tracing their evolution and highlighting how traditional factors are increasingly integrated with environmental considerations. Finally, we establish a comprehensive set of location factors pertinent to the green production decisions of EIIs.

### 2.1 | The Evolution of Location Decision Factors Towards Sustainable Decision-Making

Theoretical foundations for industrial location decisions date back to early models by von Thünen (1826) and Alonso (1964), which prioritize land rent and transportation costs in agricultural and industrial contexts. Later, Weber (1909) introduces a model balancing transportation, labor, and agglomeration effects (Murray et al. 2020). These traditional factors are further developed in Krugman’s (1991) *New Economic Geography*, which posits that firms select locations based on labor costs, market size, transportation expenses, and agglomeration economies. Historically, high transportation costs led industries to cluster around natural locational advantages, such as waterways, ports, and resource-rich areas (Day 2022). However, advancements in logistics and technology have diminished transportation costs, contributing to the “death of distance” perception by Glaeser and Kohlhase (2004). This shift has enabled production to relocate from resource-dependent regions to areas offering benefits like low labor costs or strong agglomeration advantages, ultimately facilitating the creation of global value chains (Mudambi 2018).

The “pollution haven hypothesis” (Levinson and Taylor 2008) highlights how firms in global value chains often prioritize

cost-effective locations, however, frequently at the expense of environmental considerations. Later research by Perez-Benitez et al. (2021) indicate that although traditional factors, including agglomeration and labor costs, remain influential, emerging criteria such as technology access, political stability, gender equality, climate conditions, and renewable energy supply are increasingly relevant. Nevertheless, environmental considerations are still viewed as secondary, signaling a need for deeper integration of sustainability in location decision models.

However, growing regulatory pressures drive industries towards sustainable practices, necessitating a broader interpretation of industrial location theory to incorporate environmental imperatives (González-Benito and González-Benito 2010). As traditional models become less adequate for explaining green production location decisions, the stakeholder approach is gaining traction, advocating for more inclusive decision-making processes. Renn et al. (1997) emphasize the importance of discursive processes among diverse stakeholders, whereas Bjartmarz and Bocken (2024) and Marcon Nora et al. (2023) argue for stakeholder and actor-network theories to better capture the dynamics of sustainability transitions in the energy sector. Furthermore, the concept of industrial symbiosis also gains prominence as an extension of agglomeration benefits for green production. Studies by Parto (2000), Doménech and Davies (2011), and Desrochers (2001) highlight the advantages of collaborative frameworks where companies exchange materials, energy, and knowledge. Vahidzadeh et al. (2021) further underscore the need to scale up such practices to maximize regional environmental benefits.

Future location decisions should place greater emphasis on sustainable decision-making perspectives (Zagonari 2024). Therefore, in addition to traditional location factors, a broader range of considerations should be incorporated into the decision-making process of green production location decisions.

## 2.2 | Renewable Pull Effect Evolving as Location Factor for Green Production Facilities of EIIs

For green production location decisions, transportation costs of renewable energy are re-emerging as a critical factor (Day 2022). Historically, declining transportation costs of fossil fuels reduced industries' dependence on proximity to natural resources. However, this trend may not hold for renewable energy sources. Saadi et al. (2018) demonstrate that electricity transmission costs can be up to 19 times higher and hydrogen transportation costs up to 17 times higher than those of fossil fuel pipelines. Day (2022) posits that, given the significantly higher transportation costs associated with renewable energy—particularly electricity and hydrogen—compared to fossil fuels, energy costs will gain substantial importance in future industrial location decisions. This discrepancy creates a competitive advantage for regions rich in RER. A renewable pull effect represented by highly relevant renewable energy access and cost factors may occur. Countries abundant in RER may attract EIIs to establish new or relocate existing green production facilities. Unlike carbon leakage, which is often

driven by the desire to evade stringent climate regulations, such green relocations are keeping environmental production standards by seeking to enhance cost-efficiency (Samadi et al. 2023).

However, the likelihood of the renewable pull effect leading to green relocations varies across industries. Samadi et al. (2023) identify specific characteristics that render certain industries, notably steel with DRI and chemistry with green ammonia, more susceptible to this effect (Armijo and Philibert 2020; Fasihi et al. 2021; Gielen et al. 2020). Traditional primary crude steel production involves processing iron ore in blast furnaces using coal coke, followed by refinement in an oxygen converter. Transitioning to green steel production requires extensive investments in new facilities, replacing blast furnaces with direct reduction processes powered by  $\text{GH}_2$  (Samadi et al. 2023). Similarly, whereas the Haber–Bosch process for ammonia synthesis remains constant, green ammonia production diverges primarily in the hydrogen production method (Egerer et al. 2024). Existing ammonia plants, optimized for steam methane reforming, must be reconfigured to utilize  $\text{GH}_2$  as a feedstock, necessitating a redesign to integrate external steam and nitrogen supplies. Samadi et al. (2023) suggest that for both DRI and green ammonia, existing conventional facilities offer limited utility for green production transitions. By 2035, energy costs—including transportation—could constitute up to 50% of total production costs for DRI and as much as 90% for green ammonia. Therefore, mentioned characteristics for DRI and green ammonia production contribute to an increased likelihood of the renewable pull effect.

Moreover, Egerer et al. (2024) calculate potential cost savings of a relocation for green steel and chemicals. The production of three energy-intensive products located in a relatively RER-poor country, in this case in Germany, are individually juxtaposed in three scenarios: The relocation to a RER-excellent site of the entire production, only primary production including  $\text{GH}_2$  production or only the  $\text{GH}_2$  production. The maximal cost savings are in steel 19%, in urea 30%, and in ethylene 25% by relocating the entire production to a RER-excellent site. Verpoort et al. (2024) pursue a similar approach and calculate potential cost savings of 18% in steel, 32% in urea, and 38% in ethylene.

Thus, the renewable pull effect potentially substantially influences the location decisions of EIIs, particularly within green steel and chemicals production sectors. However, the academic discourse continues to debate whether the cost-saving potential of the renewable pull effect opposing other factors will manifest in actual relocations of green production facilities (Egerer et al. 2024; Samadi et al. 2023). The renewable pull effect is a relatively novel concept with limited exploration and existing research predominantly focuses on such outlaid techno-economic analyses and investigations into this debate remain sparse. Only Verpoort et al. (2024) propose a broader conceptual framework for green relocations by introducing *soft* factors, categorized by perspectives from private investors, policymakers, and society. However, as these factors are conceptual and not derived empirically or from the literature, it remains uncertain whether they encompass all relevant aspects. Nevertheless, they form a valid and highly

valuable input for the objective of this study to derive a comprehensive list of pertinent factors in the subsequent section. Moreover, a deeper investigation on how these soft factors impact a green relocation decision is not pursued. Therefore, only very limited existing research discusses such soft or other factors, despite nearly all researchers in the field acknowledging their importance.

### 2.3 | Development of Comprehensive List of Factors for Green Production Location Decision of EIIs

The literature declares a wide array of valid factors potentially influencing green production location decisions of EIIs. Table 1 encapsulates the factors including the underlying primary references.<sup>3</sup>

From a financial perspective, several production costs play a critical role, including capital expenditures (CAPEX) and operational expenditures (OPEX), which encompass labor, raw materials, energy, and outbound transportation costs. Notably, inbound transportation costs for raw materials and energy—particularly the rising costs of transporting renewable energy—are integrated within the broader categories of raw material and energy costs. Given that the renewable pull effect influences only green production facilities, this analysis considers solely renewable energy sources, such as green electricity and GH<sub>2</sub>. Additional key location factors identified in the literature include carbon costs, representing the external costs of GHG emissions, available subsidies, access to capital markets for financing investments, and the implications of local customs and general taxation policies.

The availability and accessibility of assets, as well as supply and demand dynamics, are also pertinent to location decisions. Assets in this context refer to foundational prerequisites, including the facility under construction, the labor force, and critical infrastructure and logistics. New green facilities can benefit from agglomeration economies and integrated production systems, leveraging synergies in production or energy networks, the specialized technical expertise of the workforce, and shared support and maintenance functions. From a supply perspective, factors such as the geographical proximity to raw material and energy suppliers, as well as the reliable and qualified provision of these essential inputs, are substantial. Considering the current scarcity of high volumes of green energy, access to transitional bridging energy sources, such as natural gas, becomes an important consideration. From a demand perspective, the literature underscores the importance of flexible delivery capabilities, proximity to customers, and the size of the local market for final products. However, if the green production facility generates only primary products that require further processing into final products, the location decision may depend more on proximity to subsequent or potential secondary<sup>4</sup> production stages within the value chain.

Beyond financial and value chain considerations, political factors emerge as critical in the scholarly discourse. A stable legal and political environment, coupled with a generally industry-friendly political stance, plays a pivotal role in the

decision-making process. This includes the assurance of reliable property rights, transparent general regulations, and the ability of a country to support products with globally recognized quality certifications. As regional perceptions and definitions of green production vary—illustrated by the ongoing debate surrounding nuclear energy—the strictness and implementation of climate action regulations and provisions also influence location choices. Rounding out the compilation of location factors from the literature, social and environmental considerations weigh into the decision process. Certain locations may present pollution risks, environmental constraints, or a heightened potential for impacting local communities. Additionally, the quality of life, along with health and safety standards for employees, can vary extensively between potential locations.

### 3 | Methodology: Interview Study With Top Managers and Experts of EIIs

To address the research question, this study employs an empirical qualitative research design to gain in-depth insights into potential strategic management decisions of EIIs. A qualitative approach is particularly suitable due to the forward-looking, novel, and complex nature of the topic, as well as the need for a nuanced understanding of top managers' and experts' perceptions, given that green relocation decisions are heavily influenced by strategic visions and anticipated opportunities and challenges. Moreover, at present, green relocations largely remain hypothetical future scenarios, and only very limited data on actual green relocations exist, reinforcing the appropriateness of a qualitative research design (Robinson 2014).

The study's research design, depicted in Figure 1, follows a three-step sequential approach.

The **first step** involves the development of a semi-structured interview guideline and sampling of interviewees as proposed by Robinson (2014), explained in Section 3.1.

The **second step** consists of conducting 41 in-depth interviews with top managers and experts who could directly influence green production location decisions at leading global steel and chemical corporations, predominantly headquartered in Europe and Germany. Given that location decisions are inherently multi-criteria decision problems, the study incorporates an AHP to assess the importance of renewable pull effect factors, thereby enhancing the study's analytical depth. Through AHP, the interviewees rank factors via pairwise comparisons (Kangas and Kangas 2002), yielding a weighted score for each factor that reflects its relative importance (Yang and Lee 1997). As AHP is a highly detailed and time-consuming method—particularly when evaluating numerous factors—its application during interviews with high-profile managers, who have naturally limited availability, is constrained. Consequently, we gain the opportunity to conduct AHP assessments in 20 out of 41 interviews. This methodical enhancement of the qualitative study for almost half the interviews allows for an increased understanding of the relevance of the renewable pull effect factors, offering a profounder analysis of strategic



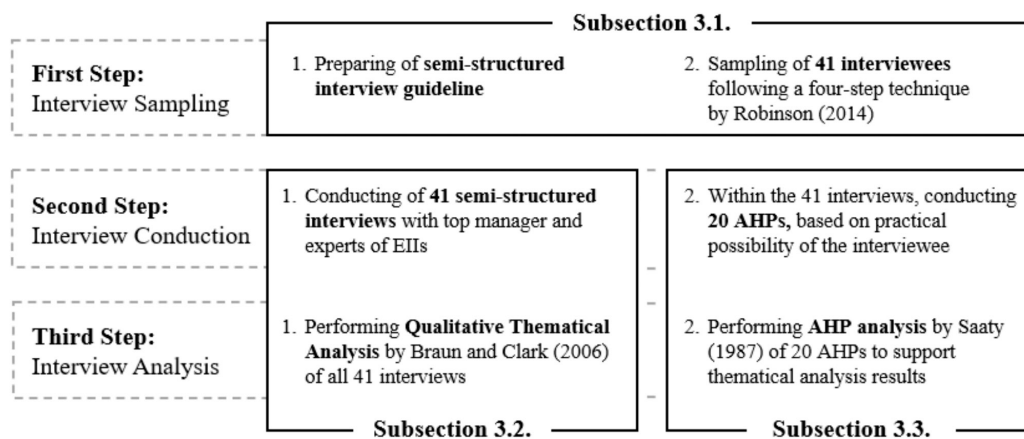
**TABLE 1** | Overview of the identified location decision factors for green production of EIIIs.

Strategic consideration	Factor	References
Production costs	CAPEX	Alberto <a href="#">2000</a> ; Greenhut <a href="#">1956</a> ; Hoover <a href="#">1948</a> ; Verpoort et al. <a href="#">2024</a>
	Labor costs	Gothwal and Saha <a href="#">2015</a> ; Schmenner <a href="#">1982</a> ; Singh et al. <a href="#">2018</a> ; Weber <a href="#">1909</a>
	Raw material costs	Day <a href="#">2022</a> ; Gothwal and Saha <a href="#">2015</a> ; Schmenner <a href="#">1982</a> ; Singh et al. <a href="#">2018</a>
	Energy costs (incl. GH <sub>2</sub> )	Day <a href="#">2022</a> ; Gielen et al. <a href="#">2020</a> ; Gothwal and Saha <a href="#">2015</a> ; Samadi et al. <a href="#">2023</a> ; Thekkethil et al. <a href="#">2024</a> ; Verpoort et al. <a href="#">2024</a> ; Zhu et al. <a href="#">2014</a>
	Outbound transportation costs	Beckmann <a href="#">1986</a> ; Samadi et al. <a href="#">2023</a> ; Verpoort et al. <a href="#">2024</a> ; Weber <a href="#">1909</a>
Regulation and financing costs	Carbon costs	Babiker <a href="#">2005</a> ; Samadi et al. <a href="#">2023</a> ; Timilsina <a href="#">2022</a> ; Wu et al. <a href="#">2017</a>
	Access to subsidies	Atthirawong and MacCarthy <a href="#">2014</a> ; Verpoort et al. <a href="#">2024</a>
	Access to capital market (incl. WACC)	Ambos et al. <a href="#">2021</a> ; Atthirawong and MacCarthy <a href="#">2014</a> ; Gothwal and Saha <a href="#">2015</a>
	Local taxation	Alberto <a href="#">2000</a> ; Atthirawong and MacCarthy <a href="#">2014</a>
Access to assets	Customs	Alberto <a href="#">2000</a> ; Atthirawong and MacCarthy <a href="#">2014</a>
	Access to green production facility	Gold <a href="#">1991</a> ; Gothwal and Saha <a href="#">2015</a> ; Walters and Wheeler <a href="#">1984</a>
	Access to labor forces	Alberto <a href="#">2000</a> ; Gothwal and Saha <a href="#">2015</a> ; Sharma <a href="#">2004</a> ; Zhu et al. <a href="#">2014</a>
	Access to infrastructure and logistics	Beckmann <a href="#">1986</a> ; McMillan <a href="#">1965</a> ; Thekkethil et al. <a href="#">2024</a> ; Verpoort et al. <a href="#">2024</a>
	Existing assets at location	Samadi et al. <a href="#">2023</a> ; Zhu et al. <a href="#">2014</a>
	Agglomeration and integration benefits	Glaeser and Kohlhase <a href="#">2004</a> ; Schneider <a href="#">2022</a> ; Smith <a href="#">1966, 1981</a> ; Weber <a href="#">1909</a>
	Proximity to raw material suppliers	Day <a href="#">2022</a> ; Gothwal and Saha <a href="#">2015</a> ; Schmenner <a href="#">1982</a> ; Wheeler and Mody <a href="#">1992</a>
Access to supply	Reliable raw material supply	Gielen et al. <a href="#">2020</a> ; Greenhut <a href="#">1956</a> ; McMillan <a href="#">1965</a> ; Verpoort et al. <a href="#">2024</a>
	Proximity to energy supplier (incl. GH <sub>2</sub> )	Alberto <a href="#">2000</a> ; Thekkethil et al. <a href="#">2024</a> ; Verpoort et al. <a href="#">2024</a> ; Zhu et al. <a href="#">2014</a>
	Reliable energy supply (incl. GH <sub>2</sub> )	Gielen et al. <a href="#">2020</a> ; Samadi et al. <a href="#">2023</a> ; Thekkethil et al. <a href="#">2024</a> ; Verpoort et al. <a href="#">2024</a>
	Access to bridging energy	Bessi et al. <a href="#">2021</a> ; Thekkethil et al. <a href="#">2024</a> ; Verdolini et al. <a href="#">2018</a>
Access to demand	Proximity to next production step	Thekkethil et al. <a href="#">2024</a> ; Verpoort et al. <a href="#">2024</a>
	Proximity to secondary production steps	Gothwal and Saha <a href="#">2015</a> ; Samadi et al. <a href="#">2023</a> ; Sharma <a href="#">2004</a>
	Proximity to customers of final products	Gothwal and Saha <a href="#">2015</a> ; Moriarty <a href="#">1980</a> ; Schmenner <a href="#">1982</a> ; Verpoort et al. <a href="#">2024</a>
	Flexible delivery of final products	Atthirawong and MacCarthy <a href="#">2014</a> ; Singh et al. <a href="#">2018</a>
	Size of local market of final products	Gothwal and Saha <a href="#">2015</a> ; Moriarty <a href="#">1980</a> ; Schmenner <a href="#">1982</a>

(Continues)

**TABLE 1** | (Continued)

Strategic consideration	Factor	References
Political environment	Stable legal and political system	Alberto <a href="#">2000</a> ; Atthirawong and MacCarthy <a href="#">2014</a>
	Industrial friendly political attitude	Atthirawong and MacCarthy <a href="#">2014</a> ; Day <a href="#">2022</a>
	Low climate action regulations	Alberto <a href="#">2000</a> ; Babiker <a href="#">2005</a> ; Huang et al. <a href="#">2021</a>
	Reliable production certification	Verpoort et al. <a href="#">2024</a>
Environmental and social risks	Pollution and environmental constraints	Coughlin et al. <a href="#">1990</a> ; Moriarty <a href="#">1980</a> ; Singh et al. <a href="#">2018</a> ; Zhu et al. <a href="#">2014</a>
	Affected communities' constraints	Gothwal and Saha <a href="#">2015</a> ; Moriarty <a href="#">1980</a>
	Quality of life for employees	Alberto <a href="#">2000</a> ; Coughlin et al. <a href="#">1990</a> ; Gothwal and Saha <a href="#">2015</a> ; Hudson <a href="#">1983</a> , <a href="#">1988</a>
	Occupational health and safety standards	Amrina and Vilsu <a href="#">2015</a> ; Singh et al. <a href="#">2018</a>



**FIGURE 1** | Overview of the study's research design.

priorities within EIIs' top management (Zambujal-Oliveira et al. [2025](#)).

The **third step** involves a comprehensive analysis of all 41 interviews using qualitative content analysis techniques based on Braun and Clarke ([2006](#)) and Mayring ([2016](#)), depicted in Section [3.2](#). This method facilitates a detailed examination of the data, systematically categorizing information into thematic groups. Additionally, we analyze the 20 AHP assessments following the classical methodology approach proposed by Saaty ([1987](#)) using these findings to enrich and validate the qualitative thematic analysis, described in Section [3.3](#).

### 3.1 | Interview Sampling

This step includes preparing a guideline for the semi-structured interview, as outlined in Appendix [A](#), and applying a four-step sampling technique based on Robinson ([2014](#)).

Firstly, we define a sample universe by establishing criteria for selecting interviewees, summarized in Table [2](#). Given the highly strategic nature of the decisions under investigation,

which are typically made at the highest management levels, we focus on top management profiles and advisors with direct influence on such decisions. All interviewees have over 10 years of experience in the steel or chemical industries and specialize in decarbonizing production processes. As DRI and ammonia are high-volume commodities and the renewable pull effect could drive further internationalization, we select individuals from large and global active corporations. Although these corporations operate worldwide, we prioritize those embedded in a regulatory environment that emphasizes decarbonization and green production transitions to ensure the relevance of the renewable pull effect. Europe, particularly Germany, serves as an ideal representative region due to its ambitious climate targets of achieving GHG neutrality by 2045 (German Government [2021](#)), high industrialization, and relatively low RER (Day [2022](#)). Consequently, our expert sampling concentrates on corporations headquartered in Europe, primarily in Germany.

Secondly, recognizing the limited availability of high-profile interviewees, we set a target sample size of 30 interviews, split evenly between AHP and non-AHP, which we ultimately exceed. Thirdly, we adopt a purposive and convenience sampling

**TABLE 2** | Overview of sampling selection criteria.

Criteria	Requirements
Decision proximity	With direct or indirect (involved in decision preparation) influence on green relocation decisions
Industrial expertise	Min. 10 years of working experience in steel or chemical industry
Functional expertise	Deep knowledge about green production processes of green steel or green chemicals
Representing corporate	Works for globally active corporate in steel or chemical industry
Regulatory embedding	Works for a corporate embedded in a regulatory environment, which prioritizes decarbonization efforts

strategy due to the specific selection criteria and the scarcity of suitable experts (Robinson 2014). Finally, sample sourcing is primarily conducted via professional networking platforms such as LinkedIn and the authors' professional contacts.

### 3.2 | Qualitative Thematic Analysis

As listed in Table 3, the study conducts 41 interviews, 20 in chemistry and 21 in steel, from August 2024 to January 2025, resulting in 1834 min and 542 pages of transcribed interview data.

We employ a qualitative thematic analysis by Braun and Clarke (2006), based on Mayring's (2016) qualitative content analysis approach. We perform two iterative rounds of structuring reduction processes of the interview data to derive meaningful insights. Our main objective is to systematically identify and categorize the key considerations influencing green production location decisions. Initially, we inductively code all statements into 10 categories using paraphrasing and generalization techniques, ensuring each code is formulated in a nominal style for clarity and consistency. We then distill the 10 categories into three overarching themes. The themes represent the main conditions of green relocation under the renewable pull effect, as posed in Table 5 in Section 4.

### 3.3 | AHP

As explained above, we conduct a multiple-criteria decision analysis using Saaty's (1987) AHP to boost the assessment of the relevance of the renewable pull effect by counteracting on potential inaccuracies inherent in qualitative research.

The AHP method is widely used for industrial location decisions in peer-reviewed research and is recognized as an

effective tool for multiple-criteria decision analysis (Boardman Liu et al. 2008; Gothwal and Saha 2015; Ho and Ma 2018; Krstić et al. 2024; Russo and Camanho 2015; Vogl et al. 2018; Zambujal-Oliveira et al. 2025). It is particularly suitable for handling numerous factors, integrating both objective and subjective judgments, and systematically prioritizing complex decision-making scenarios (Partovi 1994; Saad 2001; Singh et al. 2007; Vaidya and Kumar 2006). Previous studies also validate the AHP for sustainability-related decision-making (Brogi and Menichini 2024; Dos Santos et al. 2019; Ocampo 2019), and Pereira and Bamel (2023) specifically recommend AHP for research on *sustainable manufacturing*.

We apply the AHP<sup>5</sup> in three steps: model development, data assessment, and data synthesis. Firstly, we develop an **AHP model**, setting the study's objective and establishing strategic considerations (SCs) with associated location factors, as shown in Figure 2. We conceptualize the hierarchical decision model by reviewing relevant literature and logically grouping factors under SCs, adhering to Saaty's (2001) guidelines for AHP hierarchy construction. Through various pre-discussions with industry experts, we refine the model to include 7 SCs and 33 location factors, as detailed in Section 2.3 and Table 1. Factors related to renewable energy access or costs, including GH<sub>2</sub>, represent the renewable pull effect.

Secondly, we conduct **AHP assessments** with 20 interviewees<sup>6</sup> (10 in chemistry and 10 in steel), as listed in Table 3. During the interviews, we ask the interviewees on how they would evaluate the relative importance of location factors if they must recommend the location of a new green production facility,<sup>7</sup> as outlined in the interview guide in Appendix A. Thereby, using Saaty's (1987) classical AHP scale (Table 4), participants perform pairwise comparisons of the SCs and factors.

Their assessments generate pairwise comparison matrices, with inverse fractional values for corresponding cells. For  $n$  factor  $F_i$ , the matrix  $A$  with  $a_{ij}$  as relative importance of factor  $i$  over factor  $j$ , is as follows:

$$A = \begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ \frac{1}{a_{12}} & 1 & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \frac{1}{a_{1n}} & \frac{1}{a_{2n}} & \cdots & 1 \end{bmatrix} \quad (1)$$

Thirdly, the **AHP data synthesis** is conducted, using "AHP-OS" software (Goepel 2018). We normalize the comparison matrices and calculate the relevance rates for each SC and factor in the AHP model. Normalizing each element  $a_{ij}$  defines a normalized matrix:

$$a_{ij}^{norm} = \frac{a_{ij}}{\sum_{i=1}^n a_{ij}} \quad (2)$$

An approximation of the eigenvector can then be used to calculate the weight of each SC and factor. We categorize the relevance rates into local weight (LW), which indicate priority within the preceding hierarchical level, and global weight (GW),



**TABLE 3** | Overview of the conducted 41 semi-structured interviews.

#	Industry	AHP	Corporation	Interviewee profile	Duration [in min]
1	Chemistry	Yes	DAX-listed basic chemical producer	President, Net Zero Accelerator	48
2	Chemistry	Yes	DAX-listed basic chemical producer	Head of Global Sustainability	49
3	Chemistry	Yes	DAX-listed basic chemical producer	Director, Operations and Site Development	44
4	Chemistry	Yes	DAX-listed specialty chemical producer	Senior Vice President, Energy & Utilities	60
5	Chemistry	Yes	DAX-listed specialty chemical producer	Head of Sustainability	54
6	Chemistry	Yes	DAX-listed specialty chemical producer	Head of Sustainability Technologies	39
7	Chemistry	Yes	DAX-listed basic chemical producer	Head of Advocacy & Regulatory Affairs	53
8	Chemistry	Yes	Global leading strategy consultancy	Partner, Top management advisor for basic chemicals	53
9	Chemistry	Yes	Global leading strategy consultancy	Partner, Top management advisor for basic chemicals	50
10	Chemistry	Yes	Global leading strategy consultancy	Partner, Top management advisor for basic chemicals	54
11	Chemistry	No	DAX-listed basic chemical producer	Director, Head of Decarbonization	48
12	Chemistry	No	DAX-listed basic chemical producer	Head of Global Sustainability	36
13	Chemistry	No	DAX-listed specialty chemical producer	Senior Vice President, Public Affairs & Sustainability	44
14	Chemistry	No	DAX-listed specialty chemical producer	Global Category Lead for Energy & Utilities	54
15	Chemistry	No	DAX-listed specialty chemical producer	Sustainability & Circular Economy Manager	35
16	Chemistry	No	Leading Industrial Association	Senior Advisor for Chemicals	40
17	Chemistry	No	Leading Industrial Association	Senior Researcher Green Chemicals	36
18	Chemistry	No	DAX-listed specialty chemical producer	Vice President, Operations and Site Development	54
19	Chemistry	No	Global leading specialty chemical producer	Supply Chain Manager	38
20	Chemistry	No	German leading chemical producer	Senior Vice President, Chief Product Officer	51
21	Steel	Yes	Global leading steel producer	Head of Research & Development	52
22	Steel	Yes	Global leading steel producer	Program Manager Decarbonization	60
23	Steel	Yes	European leading steel producer	Chief Technical Officer	37
24	Steel	Yes	European leading steel producer	Chief Operations Officer	54
25	Steel	Yes	Global leading strategy consultancy	Partner, Top management advisor for steel & iron	58
26	Steel	Yes	Global leading strategy consultancy	Partner, Top management advisor for steel & iron	37
27	Steel	Yes	Global leading strategy consultancy	Partner, Top management advisor for steel & iron	41

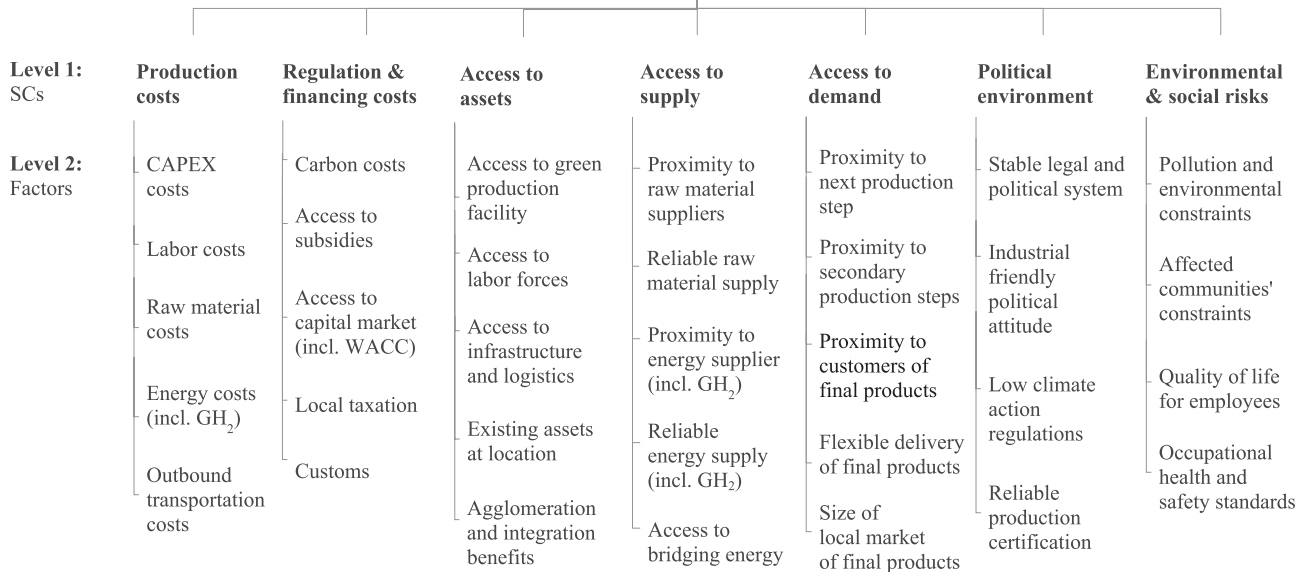
(Continues)

**TABLE 3** | (Continued)

#	Industry	AHP	Corporation	Interviewee profile	Duration [in min]
28	Steel	Yes	Global leading steel producer	Vice President, Head of Business Strategy & Sustainability	43
29	Steel	Yes	German leading steel producer	Head of Strategic Business Development	42
30	Steel	Yes	German leading steel producer	Vice President, Head of DRI Facility Development	45
31	Steel	No	Global leading steel producer	Director, Head of Global Sustainability	51
32	Steel	No	Self-employed	Senior Advisor for Steel & Iron	39
33	Steel	No	Leading Green Certification Provider	Sustainable Energy Specialist	40
34	Steel	No	Global leading strategy consultancy	Senior Advisor for GH <sub>2</sub>	40
35	Steel	No	Global Leading Energy Solutions Provider	Director of Research Institute	30
36	Steel	No	Leading Industrial Association	Head of Public Affairs & Sustainability	30
37	Steel	No	Leading Industrial Association	Chairman, Senior Expert Steel	50
38	Steel	No	Leading Industrial Association	Sustainable Energy Specialist	30
39	Steel	No	Global leading steel producer	Head of Logistic Sustainability	41
40	Steel	No	German leading steel producer	Head of Global Real Estate Management	34
41	Steel	No	European leading steel producer	Director, Global Decarbonization Program	40

Level 0:  
Objective

**Location decision for green production facilities of EIHs<sup>7</sup>**



**FIGURE 2** | AHP location decision model including the objective, 7 SCs, and 33 factors.

which reflect the overall priority concerning the AHP objective. We derive the LW and GW using Saaty's (2001) formulas:

$$LW_i = \frac{1}{n} \sum_{j=1}^n a_{ij}^{norm} \quad (3)$$

$$GW_i = \sum_{j=1}^n LW_{SC_i} \times LW_{j|SC_i} \quad (4)$$

Table 6 presents the calculated ranks, LWs, and GWs, offering a relative ranking and highlighting the most substantial SCs and location factors (Talib and Rahman 2015).

As inconsistencies often arise in expert judgments, we perform a standard consistency analysis proposed by Saaty (1987) and calculate consistency ratios (CR). First, the degree of consistency in the pairwise comparisons can be measured by an index designated by CI:

$$CI = \frac{\lambda_{max} - n}{n - 1} \tag{5}$$

This is followed by the calculation of CR, using a random index (RI(n))<sup>8</sup> (Singh 2013). According to Saaty (2001), if CR is less than a predefined threshold of 0.1, the judgments can be considered consistent. The CR describe the degree to which the pairwise comparisons are consistent:

$$CR = \frac{CI}{RI(n)} \tag{6}$$

**TABLE 4** | AHP scale for pairwise judgments (Saaty 1987).

Scale	Definition
1	<i>Equally preferred</i>
3	<i>Chosen factor is moderately preferred</i>
5	<i>Chosen factor is strongly preferred</i>
7	<i>Chosen factor is very strongly preferred</i>
9	<i>Chosen factor is extremely preferred</i>
2, 4, 6, 8	<i>Intermediate values between two adjacent judgments</i>

**TABLE 5** | Results of qualitative thematical analysis.

Conditions	Categories
The relevance of the renewable pull effect versus an agglomeration and demand pull (Section 4.1)	The renewable pull effect predominantly influences location decisions
	Raw material supply is a critical factor, with specific requirements varying between DRI and green ammonia
	Agglomeration economies and integration within production chains play a substantial role, emphasizing the importance of customer proximity
Regulatory influence on green production costs and location decisions (Section 4.2)	A strategic trade-off exists between access to renewable energy and proximity to demand centers
	Whereas high CAPEX are extensive, OPEX are the primary competitive factor
	Traditional regulatory instruments exert only a limited impact on location decisions
Prevailing prerequisites in green relocation decisions (Section 4.3)	CAPEX subsidies act as strong short-term incentives for green production site selection
	Stable legal and political environments are prerequisites rather than active decision factors
	Environmental and social risks undergo preliminary filtering, as global corporations maintain consistent governance standards
	Uncertainty surrounding climate policy remains high due to varying international climate regulations

Furthermore, as the study aggregates 20 AHP assessment, we calculate the average group consensus using arithmetic means. With an overall average group consensus of 82.0%, the study demonstrates robust theoretical saturation. The group consensus within industries is even higher, with 86.6% in chemistry and 85.5% in steel. Detailed AHP results are provided in Appendices B, C, and D.

Finally, we interpret and integrate the AHP results to validate and enrich the thematic analysis, supporting to answer the research question and forming the foundation for the results in Section 4.

#### 4 | Results: The Influence of the Renewable Pull Effect on Green Relocation Decisions

This section presents the study's results, structured according to the findings of the qualitative thematic analysis outlined in Table 5. Additionally, it includes the results of the validated and rated AHP location decision model for green production facilities in EIIs, focusing on DRI in the steel industry and green ammonia in the chemical sector. As shown in Table 6, the GWs and LWs illustrate the relative importance of the location factors identified in Section 2.3.

##### 4.1 | The Relevance of the Renewable Pull Effect Versus an Agglomeration and Demand Pull

The study's results clearly demonstrate that the location decision for green production facilities is predominantly driven by the renewable pull effect. All interviewees agree that “access

to affordable renewable energy is key.” Moreover, across both AHP hierarchy levels, SCs and location factors associated with the renewable pull effect consistently rank highest. The primary motivations for choosing a specific location are excellent supply access and low production costs. Together, these two SCs account for over half (54%) of the entire decision-making process, with energy costs (incl. GH<sub>2</sub>) and reliable energy supply (incl. GH<sub>2</sub>) holding LWs of approximately 40% each. These factors represent GWs of 10.5% and 12%, respectively, making them the most substantial determinants of location choice.

Furthermore, only four other factors surpass a 4% GW, underscoring the critical importance of accessible and affordable renewable energy in green production location decisions. Particularly, as two out of these four highly relevant factors—raw material supply (9.6%) and costs (7.2%)—further support the renewable pull effect, particularly in the context of green ammonia. As discussed in Section 2.2, the Haber–Bosch process for green ammonia production primarily requires GH<sub>2</sub> and nitrogen, with nitrogen air extraction being largely location-independent. GH<sub>2</sub> access becomes the crucial determinant from a raw material perspective. This phenomenon extends to other basic chemicals that also rely on carbon-based raw materials. In contrast, DRI facilities, like conventional blast furnaces, depend on iron ore as a primary input. Although historically steel production facilities were situated near iron ore deposits (Küster-Simic et al. 2020), the globalization of iron ore trade has shifted this paradigm. Nonetheless, an expert highlights that “access and costs of iron ore remain relevant, but energy factors have become even more critical in determining green production locations.” Thus, the study highlights a discrepancy between the steel and chemical industry. Whereas energy factors primarily indicate the renewable pull effect in steel production, both raw material and energy factors play this role in the chemical sector. This difference is reflected in the AHP results, showing a 4% GW delta for both factors between the industries. For both DRI and green ammonia, renewable pull effect representing factors outweigh all other location factors.

Nevertheless, the study indicates that other location factors counterbalance the renewable pull effect. An expert describes this dynamic as “a tug-of-war between cheap access to green energy and the current tight integration with downstream production processes close to the customer.” This tension is evidenced by the GWs of 8.1% for proximity to the next production step and 5.5% for agglomeration and integration benefits, making them the second-most influential factors. The ability of DRI and green ammonia production facilities to seamlessly integrate into existing production processes and downstream value chains is a considerable advantage (Baas 2011). One expert highlights that “being part of agglomerated steelworks or chemical parks not only provides synergies but also ensures efficient logistics and infrastructure use.” The AHP findings further reveal that existing infrastructure with a GW of 3.3%, such as pipelines, grid networks, and harbors, is more critical than existing production assets (1.3% GW), which often lose value in a green transformation. The agglomeration benefits also extend to downstream production processes. For instance, locating DRI facilities close to electric arc furnaces can enhance efficiencies. Hot DRI can be directly fed into an electric arc furnaces, potentially reducing electricity consumption and boosting productivity by 10%–15% compared to using DRI at

ambient temperatures (Salemi et al. 2022). Therefore, proximity to subsequent production steps remains a valuable consideration (Day 2022). Although proximity to customers of final products only holds a GW of 1.8% in the AHP, experts emphasize that a “demand pull definitely exists, particularly in industrialized countries like Germany where RER are limited but the customer base for EIIs is essential.” The expert further explained that the *local-to-local* strategy adopted by downstream producers, such as specialty chemical firms (BASF 2024), implies an indirect relevance for primary production location decisions. The 3.6% GW for size of local market of final products supports this view, suggesting that even if the direct customer proximity is less critical, market size still influences primary production siting.

Ultimately, the tug-of-war among location factors could lead to one of three scenarios: The entire production value chain relocates to RER-rich regions, all production steps remain near customer bases, or a geographical separation of the value chain emerges. The AHP results strongly favor the renewable pull effect for primary production stages like DRI and green ammonia. Experts also anticipate that highly customized final production steps will remain close to customers due to the robust demand pull. Therefore, only geographical separations of the value chains remain as potential option, which one expert concludes with “a shift in the steel and chemical industries is likely, with primary production moving towards renewable energy sources while finishing processes stay near end-users. This reflects a broader transformation in the geographical distribution of these industries.” However, the exact nature of this shift remains uncertain. The AHP results suggest that a relocation of primary production to RER-rich regions could create a *gravitational pull* potentially encouraging subsequent processing steps to follow. In the steel industry, for instance, the strong agglomeration benefits (4.7% GW) and a more global sales approach (5% GW delta in size of local market of final products) may drive such a shift. An expert posits that “in the future, three green steel production routes could coexist: transporting GH<sub>2</sub>, DRI, and even entire slabs.” In the chemical sector, despite even higher agglomeration benefits (6.1% GW), the potential cost savings from the renewable pull effect remain substantial (Egerer et al. 2024; Verpoort et al. 2024). Although a broader relocation of processing steps is possible in both industries, the precise configuration of green value chains may vary by product. Therefore, the empirical analysis of potential geographical separations within different value chains appears as important area for future research, which is beyond the scope of this study.

## 4.2 | Regulatory Influence on Green Production Costs and Location Decisions

As outlined in Section 2.2, establishing green production facilities for DRI and green ammonia requires new facilities or substantial modifications to existing ones. Despite this, the AHP results reveal that access to new green production facilities holds minimal relevance (GW of 1.2%). Experts attribute this to the capability of leading plant manufacturers to construct high-quality, cost-comparable facilities globally. However, setting up a fully operational green production facility involves excessive CAPEX. Nearly all interviewees agree on the statement that “energy-intensive assets are

**TABLE 6** | Synthesized AHP results for all expert inputs ( $n = 20$ ) and for separated inputs by chemistry ( $n = 10$ ) and steel ( $n = 10$ ).<sup>a</sup>

SCs	LWs	Factors	LWs	GWs	Rank	Chemistry GWs	Steel GWs	GWs delta
Production costs	<b>0.246</b>	CAPEX	0.157	0.039	7	0.061	0.021	<b>0.04</b>
		Labor costs	0.059	0.015	21	0.013	0.014	0.00
		<b>Raw material costs</b>	0.293	<b>0.072</b>	<b>5</b>	0.093	0.050	<b>0.04</b>
		<b>Energy costs (incl. GH<sub>2</sub>)</b>	0.426	<b>0.105</b>	<b>2</b>	0.076	0.129	<b>-0.05</b>
		Outbound transportation costs	0.065	0.016	18	0.013	0.017	0.00
Regulation and financing costs	0.065	Carbon costs	0.201	0.013	25	0.015	0.009	0.01
		Access to subsidies	0.240	0.015	19	0.007	0.031	-0.02
		Access to capital market (incl. WACC)	0.259	0.017	17	0.019	0.012	0.01
		Local taxation	0.132	0.009	30	0.008	0.008	0.00
		Customs	0.167	0.011	29	0.010	0.009	0.00
Access to assets	0.127	Access to green production facility	0.092	0.012	28	0.009	0.015	-0.01
		Access to labor forces	0.120	0.015	20	0.011	0.020	-0.01
		Access to infrastructure and logistics	0.258	0.033	9	0.025	0.041	-0.02
		Existing assets at location	0.100	0.013	26	0.012	0.012	0.00
		<b>Agglomeration and integration benefits</b>	0.431	<b>0.055</b>	<b>6</b>	0.061	0.047	0.01
Access to supply	<b>0.294</b>	Proximity to raw material suppliers	0.063	0.018	14	0.025	0.013	0.01
		<b>Reliable raw material supply</b>	0.325	<b>0.096</b>	<b>3</b>	0.114	0.075	<b>0.04</b>
		Proximity to energy supplier (incl. GH <sub>2</sub> )	0.097	0.028	11	0.023	0.033	-0.01
		<b>Reliable energy supply (incl. GH<sub>2</sub>)</b>	0.409	<b>0.120</b>	<b>1</b>	0.093	0.147	<b>-0.05</b>
		Access to bridging energy	0.106	0.031	10	0.024	0.037	-0.01
Access to demand	<b>0.164</b>	<b>Proximity to next production step</b>	0.491	<b>0.081</b>	<b>4</b>	0.075	0.079	0.00
		Proximity to secondary production steps	0.073	0.012	27	0.019	0.007	0.01
		Proximity to customers of final products	0.110	0.018	15	0.024	0.012	0.01
		Flexible delivery of final products	0.105	0.017	16	0.018	0.015	0.00
		Size of local market of final products	0.220	0.036	8	0.064	0.019	<b>0.05</b>

(Continues)



**TABLE 6** | (Continued)

SCs	LWs	Factors	LWs	GWs	Rank	Chemistry GWs	Steel GWs	GWs delta
Political environment	0.067	Stable legal and political system	0.328	0.022	13	0.022	0.019	0.00
		Industrial-friendly political attitude	0.394	0.026	12	0.016	0.039	−0.02
		Low climate action regulations	0.074	0.005	33	0.003	0.007	0.00
		Reliable production certification	0.204	0.014	27	0.007	0.025	−0.02
Environmental and social risks	0.038	Pollution and environmental constraints	0.346	0.013	25	0.016	0.010	0.01
		Affected communities' constraints	0.141	0.005	32	0.007	0.004	0.00
		Quality of life for employees	0.148	0.006	31	0.005	0.006	0.00
		Occupational health and safety standards	0.364	0.014	24	0.011	0.016	−0.01

Note: Factor with a GW > 4% (0.04) is highlighted in gray. SC with a LW > 16% (0.16) and factor with a delta of GWs > 3% (0.03) are written in bold.

<sup>a</sup>The SCs' LWs and the factors' GWs sum up to 1 and distribute the individual relevance of the overall location decision. Similarly, the factors' LW of each SC sum up to 1 and distribute the individual factor's relevance within an SC. For instance, the SC "production costs" with a LW of 0.246 influences the overall location decisions by 24.6%. In turn, the factor CAPEX with a LW of 0.157 influences the SC "production costs" by 15.7% and with a GW of 0.039 influences the overall location decision by 3.9%. Due to complexity reduction of this study, the relevance is directly stated in percentages henceforth.

highly CAPEX-intense." For instance, constructing a DRI facility in Germany with an annual capacity of 2.5 million tons necessitates an upfront investment exceeding €2 billion (Güßgen 2022; thyssenkrupp steel 2023b). The AHP results reflect the high CAPEX burden, with a GW of 3.9%. Despite the relatively short tenures of top managers in large corporations (Schmid and Mitterreiter 2020), the substantial CAPEX and the economic imperative for a production facility to operate for several decades demand long-term investment strategies. This long-term decision-making horizon is also evident in the AHP results, where 89.4% of the SC access to supply is allocated to long-term factors, contrasting with the lower LW of 10.6% for the factor access to bridging energy. Whereas CAPEX is extensive, OPEX for running energy-intensive facilities over the long term is even more substantial. Although CAPEX holds a GW of 3.9%, only 15.7% (LW) of production costs are attributed to CAPEX, with the remaining 84.3% driven by OPEX, primarily due to energy and raw material costs, as discussed in Section 4.1. Other OPEX elements, such as outbound transportation costs (LW of 6.5%), are less relevant due to the relatively low transportation costs for ammonia and DRI. Labor costs, with a LW of 5.9% and a GW of 1.5%, and access to labor (GW of 1.5%) also show limited influence on location decisions. These findings contrast with expert opinions highlighting labor factors' importance. As one expert notes, "Australia, despite its excellent RER and abundant iron ore sources, is not ideal for a new DRI production facility due to high labor costs and reduced working hours." However, other experts suggest that labor concerns are often politically charged and may not substantially impact purely financial location decisions.

Regulatory influence, particularly in terms of protecting employment, could still play a role. An interviewee states "regulators act as both a driving force and a support mechanism. On one hand, they mandate EIIs to transition to greener operations; on the other hand, they aim to sustain national industrial competitiveness, economic wealth, and job security." However, traditional regulatory levers, such as local taxation and customs, exhibit low relevance in the AHP results, with GWs of 0.9% and 1.1%, respectively. Furthermore, factors like carbon costs and low climate action regulations also rank low, with GWs of 1.3% and 0.5%. This aligns with the notion that companies aiming for green production are not driven by carbon leakage but by a strategic commitment to sustainability. The long-term perspective of companies, as highlighted by the AHP results, supports a view that stringent climate regulations are becoming a global norm rather than a differentiator. For instance, Europe, the United States, and China all target climate neutrality between 2050 and 2060 (Oğuz 2024). As one expert points out, "operating in a climate-regulated environment has become inevitable, and thus, regulatory frameworks are no big decisive factors in location decisions—at least not for green production projects."

Although classical regulatory tools are less influential, regulators essentially shape location decisions by subsidizing the critical production costs of EIIs. Recently, CAPEX subsidies have gained prominence, with countries such as Germany, Saudi Arabia, China, and the United States offering substantial financial support for new facilities within their borders. In the green steel sector, CAPEX subsidies have proven particularly

impactful. For instance, the German government provided nearly €2 billion in support for the new DRI production facility mentioned above (thyssenkrupp steel 2023a). Similar subsidies have been allocated to other steel producers in Germany (Kress 2024). In contrast, fewer subsidies have been granted in the chemical industry, leading to a 4% delta in CAPEX relevance in the AHP results between the two industries. However, despite the short-term effectiveness of CAPEX subsidies, experts emphasize that OPEX remains the dominant cost factor. The current subsidy strategies do not address the long-term OPEX challenges of green production. Many companies benefiting from CAPEX subsidies remain in regions with limited RER, resulting in persistent economic challenges and heightened dependency on regulatory support. As one expert argues, “without a shift towards subsidizing operational costs, many EIIs may find themselves uncompetitive in the global market.” Therefore, to effectively influence green production location decisions and support long-term business success, OPEX reductions are more impactful. The AHP results and expert insights align on this observation, highlighting that the most impactful regulatory measures include “providing direct energy subsidies, enhancing green energy generation, and investing in infrastructure to lower energy costs.” Ultimately, a regulatory approach that prioritizes affordable and reliable access to renewable energy could prevent the relocation of EIIs even stronger than current CAPEX subsidies.

### 4.3 | Prevailing Prerequisites for Green Relocation Decisions

In the AHP results, the political environmental factor of a stable legal and political system is assigned a relatively low relevance, with a GW of 2.2%. The interviewees attribute this outcome to the fact that, when conducting pairwise judgments within the AHP framework, they only consider a “decision space comprising certainly feasible location options.”<sup>9</sup> For instance, it is not viable for EIIs to relocate to regions where war or substantial corruption prevail. Consequently, countries afflicted with such prerequisites are excluded from the conceivable option space. Once these locations are omitted, and only those countries where fundamental prerequisites—such as political stability—are met remain under consideration, the factor stable legal and political system becomes comparatively less essential than more business-centric determinants.

Similarly, the SC environmental and social risks receive a low LW of 3.8%. As outlined in Section 3.1, the expert sample consists solely of professionals employed by global corporations, which enforce uniform governance standards regarding environmental and social risks across all operational locations. If a potential location does not align with these standards, it is directly eliminated from consideration. Thus, when selecting a location within the remaining option space, both SCs exhibit minimal significance in the AHP results. Nonetheless, from the perspective of RER-rich countries seeking to attract green relocations, ensuring the fulfillment of such prerequisites remains crucial.

Additionally, climate policy clarity has emerged as a critical prerequisite, as highlighted in numerous expert interviews. Experts define this as “long-term certainty regarding which climate

regulations and instruments will remain in place in a stable, continuous, and globally coordinated manner.” Many policies and regulatory instruments currently shaping the green transition of EIIs have only recently been introduced or are still in development. Consequently, the global climate action policy landscape remains highly dynamic, rapidly evolving, and challenging to forecast. Furthermore, regulatory visions are heterogeneously distributed across different regions (Evro et al. 2024). Although all major industrialized nations have pledged to achieve carbon neutrality, their approaches vary essentially. For instance, European policies emphasize indirect market-based carbon pricing mechanisms and border adjustments, such as the Carbon Border Adjustment Mechanism (European Commission 2019). In contrast, the United States relies on direct financial incentives, as exemplified by the Inflation Reduction Act, which aims to stimulate private-sector investments in green technologies (The White House 2023). Meanwhile, China employs a hybrid model that integrates market-based approaches with regulatory directives, facilitated by its centralized political and economic structure (Shi et al. 2022). An interviewee states that globally diverse climate policies are “developed mostly independently, lack transnational coordination, and even conflict with each other. Regulators prioritize the protection of their own industries, and in the worst-case scenario, this approach could lead to trade embargoes between major industrialized nations with severe economic repercussions.” Particularly for potentially highly traded commodities such as DRI or green ammonia, these regulatory discrepancies could substantially impact location decisions for respective green production facilities. Experts emphasize that persistent regulatory uncertainty places a considerable burden on EIIs’ decision-making processes. Consequently, top managers tend to delay substantial investment decisions in large-scale green production facilities, opting instead to await greater climate policy clarity. This delay predominantly affects long-term, high-volume green production projects requiring billion-euro investments, rather than smaller-scale pilot initiatives.

In summary, decision prerequisites serve to narrow the option space for potential locations, potentially weakening the renewable pull effect in certain countries. Furthermore, the prevailing lack of climate policy clarity is temporarily halting large-scale green relocation decisions.

## 5 | Discussion: Theoretical Considerations, Practical Implications and Future Research

The study’s results, derived from the combined AHP and thematic analysis, demonstrate that the renewable pull effect substantially influences location decisions for green production facilities within EIIs. These findings support Samadi et al.’s (2023) call for further research into the rapidly emerging renewable pull effect to ensure that academic literature remains ahead of industrial developments.

However, the findings also contribute new and empirically grounded insights—some of which challenge prevailing theoretical perspectives—within the ongoing discourse on the renewable pull effect’s applicability to EIIs. Whereas other scholars, including Egerer et al. (2024), Samadi et al. (2023), and Verpoort et al. (2024) mention the relevance of additional factors



**FIGURE 3** | Theoretical model illustrating how the renewable pull effect leads to green relocation of energy-intensive production.

in strategic green relocation decisions, our study advances this understanding by empirically identifying and assessing these factors in direct comparison to those representing the renewable pull effect—an approach not previously addressed in academic literature, to the best of our knowledge.

Our analysis reveals that for the renewable pull effect to translate into investment-intensive and thus long-term green relocation decisions, three critical conditions must be met: weaker agglomeration and demand pull, minimal counteractive subsidies from regulators, and the fulfillment of sociopolitical and environmental prerequisites, as summarized in Figure 3.

Firstly, this study identifies **agglomeration and demand pull** as particularly strong counterforces to the renewable pull effect. Customers of EIIs increasingly prefer close proximity to suppliers, which strengthens agglomeration benefits and minimizes transportation costs, tariff risks, and geopolitical uncertainties (Verpoort et al. 2024). This outcome challenges foundational assumptions in prior renewable pull effect research, which often compares RER-poor regions with strong industry and customer demand to RER-rich regions without considering additional criteria beyond RER availability (Egerer et al. 2024; Verpoort et al. 2024). Our analysis suggests that regions with abundant renewable resources might not be viable if they lack adequate agglomeration advantages and demand. Moreover, our findings reveal that the ongoing tug-of-war between affordable access to renewable energy and integration with downstream production processes near customers (local-to-local production) varies substantially depending on the specific energy-intensive product. As highlighted in Section 4, even within the context of DRI and green ammonia production, notable differences emerge, although the renewable pull effect may prevail for these specific product steps. However, these products represent only a portion of the broader value chain involved in producing green steel or green chemicals, as shown by Egerer et al. (2024) and Verpoort et al. (2024). We argue that the precise configuration of a green value chain from a strategic perspective for energy-intensive products remains uncertain, leaving ambiguity about which value creation steps or entire chains of green production in EIIs are likely to relocate. Therefore, future research modeling potential geographical separations within value chains for individual energy-intensive products, driven by the renewable pull effect, could lead to novel insights.

Secondly, the study highlights the strong **influence of regulatory subsidies** on location decisions, with the potential to hinder green relocations. Currently, CAPEX subsidies play a decisive role, such as in keeping DRI production within Germany. To promote green relocations, subsidies should align with rather than counteract the renewable pull effect, potentially being offered by regulators in RER-rich countries. The current global subsidy race to attract green EII production facilities further

emphasizes this need. This study demonstrates the high risk for regulators in RER-poor regions, particularly in countries with large industrial sectors like Europe and Northeast Asia, underscoring the critical importance of strategic subsidy policies. Additionally, our research identifies practical pathways for regulators to influence EII location decisions. OPEX incentives may hold the greatest way, with policies like “Carbon Contracts for Difference” (applied in the United Kingdom, Netherlands, and potentially in Germany) showing promise. Such policies equalize cost disparities between carbon costs and green production expenses, including OPEX (BWK 2024). Future research should explore effective policy incentives from both RER-rich and RER-poor regulators, helping policymakers design frameworks and strategies to retain or attract green EII facilities and assess the broader macroeconomic implications of these measures.

Thirdly, our analysis indicates that **decision prerequisites** must be met for green relocations to occur. On the one hand, RER-rich locations must satisfy minimum political, legal, environmental, and social standards. Many potential host countries could be excluded if they fail to meet these prerequisites. This is particularly concerning as regions with high RER potential often belong to the economically weaker countries in the Global South (Berger 2023). The renewable pull effect not only offers a pathway to cost-effective green production for EIIs but also presents socioeconomic growth opportunities for developing countries, particularly in Africa and South America (Day 2022). However, researchers have already raised concerns over major investments in green energy projects in developing countries, where the primary goal is to export generated energy to developed nations (Achuo et al. 2023; Agyekum 2024). This approach risks repeating the resource-curse pattern seen with oil, coal, and natural gas, where limited wealth generation remains in the local economy. UNIDO et al. (2024) advocate for developing countries to prioritize domestic green energy applications, thereby fostering local business development. Future research should explore policy models that enable developing countries to leverage green relocations for socioeconomic growth while avoiding the pitfalls of a resource curse, including examining how these nations can meet the decision prerequisites. On the other hand, our study underscores the need for transparency regarding how conflicting climate regulations and instruments from major industrialized nations will affect global trade dynamics. The current lack of climate policy clarity creates uncertainty that can delay green production facility location decisions, particularly for EIIs with large production volumes. The real-world impact of this perceived lack of climate policy clarity could be explored through quantitative studies, examining whether it contributes to the postponement of investments in green production facilities within EIIs. Thus, the study’s findings emphasize the importance of fulfilling decision prerequisites for countries to capitalize on their RER abundance. They also echo the call from EII top management to major regulators to establish long-term

**TABLE 7** | Summary of derived future research potential.

Potential future research avenues	Description
Green value chain configurations	Investigate how agglomeration benefits and demand forces influence the applicability of the renewable pull effect by model potential geographical separations within value chains for different energy-intensive products
Regulatory subsidy strategies	Explore effective policy incentives from RER-rich and RER-poor regulators to attract or retain green EII facilities
Policy models for developing countries	Develop frameworks to attract green relocations to leverage socioeconomic growth by avoiding the resource-curse pattern
Impact of lacking climate policy clarity	Quantify how the potential absence of a climate policy clarity affects investment decisions for green production facilities
Country attractiveness analysis	Analyze the attractiveness of different countries or regions for green relocation strategies depending on relocated value chain steps
Empirical evidence of green relocations	Examine real-world evidence, such as company announcements and reports, to determine if green relocations are already occurring and understand the underlying reasons
Decarbonization strategy evaluation	Assess how green relocation strategies contribute to achieving decarbonization targets within EIIs

climate policy clarity, addressing the regulatory ambiguity that currently hampers strategic decision-making.

The findings of this study are subject to certain limitations. The research focuses on highly complex, strategic, sensitive, and novel top-management decisions within leading corporations. This inherently constrains data availability but simultaneously justifies the chosen exploratory methodology, involving in-depth interviews with top managers and experts. Data collection through semi-structured interviews is susceptible to sample bias and potential inaccuracies in interviewee responses. These limitations were mitigated through two key measures. Firstly, the study employed a well-established sampling technique by Robinson (2014), widely used in peer-reviewed research. Secondly, the application of the AHP method provides precise numerical judgments, complementing qualitative insights and enhancing the robustness of the study. Despite these measures, a degree of subjectivity within the interview responses remains (Birkin et al. 2009).

Nevertheless, addressing the limitations of the exploratory research design opens further avenues for research. The proposed location decision model and the AHP results could serve as a foundation for developing hypotheses for quantitative research validation. Additionally, new opportunities for further exploratory qualitative research emerge, including, but not limited to, firstly, an attractiveness analysis of different countries or region types for potential green relocation strategies, possibly considering the specific value chain steps likely to be relocated, and secondly, an empirical investigation into whether green relocations are already occurring in practice, as suggested by Samadi et al. (2023). Although comprehensive quantitative data might still be scarce, real-world evidence—such as company announcements, reports, and news articles—could help illustrate ongoing green relocations and potentially shed light on the published rationales behind such decisions. Lastly, an evaluation of how internationalization strategies, particularly green

relocations, could accelerate the achievement of decarbonization targets in EIIs.

Table 7 summarizes all identified future research directions. In general, this study aims to stimulate interest in green relocations and encourage further investigation into their potential impacts.

## 6 | Conclusion

The study sheds light on the complex dynamics of green relocation decisions within EIIs amidst the global push for sustainability. The renewable pull effect, driven by low green energy costs in regions with high RER, emerges as a substantial factor influencing location decisions for green production facilities, particularly for DRI and green ammonia (Egerer et al. 2024; Samadi et al. 2023; Verpoort et al. 2024). However, this effect is not absolute and is moderated by three critical conditions. Firstly, the interplay between the renewable pull effect and counteracting agglomeration and demand forces varies depending on the specific energy-intensive product and its position in the value chain. Secondly, regulatory subsidies, particularly CAPEX subsidies, play a pivotal role in shaping location decisions, with a growing emphasis on OPEX incentives as a potential decisive influence in the global subsidy race. Thirdly, fulfilling political, legal, environmental, and social prerequisites is essential for RER-rich regions to attract green relocations, with the current lack of climate policy clarity posing a barrier to timely decision-making.

The study contributes to an ongoing debate by moving beyond theoretical models and techno-economic analyses to provide comprehensive insights into the factors that drive or hinder green relocations in EIIs. By identifying and empirically evaluating location factors beyond cheap renewable energy access, employing both thematic analysis (Braun and Clarke 2006) and



the AHP method (Saaty 1987), the study provides a structured assessment of these factors' relative importance in the academic literature for the first time. The empirical approach, leveraging insights from top management of leading steel and chemical corporations, offers a tangible perspective. The findings not only enhance the theoretical discourse but also provide practical guidance for corporate leaders evaluating green production sites and for policymakers aiming to retain or attract green EII facilities.

Future research should continue exploring how agglomeration benefits and demand forces affect green relocations, analyze effective regulatory subsidy strategies, and develop policy models that enable developing countries to attract green relocations while promoting socioeconomic growth. Additionally, quantitative studies could assess how climate policy clarity impacts investment decisions and evaluate how green relocations contribute to achieving decarbonization targets in EIIs. Empirical research is also needed to identify whether green relocations are already taking place.

Overall, this study advances both theoretical understanding and practical application if the renewable pull effect leads to green relocation, contributing to the broader objective of sustainable industrial transition.

## Nomenclature

AHP	analytical hierarchy process
CAPEX	capital expenditures
CR	consistency ratio
DRI	direct-reduced iron
EIIs	energy-intensive industries
GH <sub>2</sub>	green hydrogen
GHG	greenhouse gas
GW	global weight
LW	local weight
OPEX	operational expenditures
RER	renewable energy resources
SCs	strategic considerations

## Author Contributions

Sven Colen: writing – original draft, validation, methodology, data curation, conceptualization. Alwine Mohnen: writing – review and editing, validation, supervision, conceptualization.

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## Conflicts of Interest

The authors declare no conflicts of interest.

## Data Availability Statement

Data will be made available on request.

## Endnotes

- <sup>1</sup> Including indirect emissions from power and heat generation.
- <sup>2</sup> In this study, green production is defined as a production which minimizes the release of GHG emissions.
- <sup>3</sup> Due to clarity and readability reasons, the references of individual factors are only gathered in Table 1 and are not repeated in the text.
- <sup>4</sup> Secondary production refers to the further processing of any by-products.
- <sup>5</sup> Beside the classical AHP, a fuzzy logic version has been applied frequently in literature. Van Laarhoven and Pedrycz (1983) and Buckley (1985) originally developed the modified version of AHP, which uses fuzzy triangular functions in the pairwise comparison process to reduce imprecisions. However, Chan et al. (2019) demonstrate that the application of fuzzy AHP could be redundant and even counterproductive if the examined problem becomes complex. In this case, classical AHPs, involving many factors, are thereby already fuzzy. Thus, since this study investigates a highly complex decision with 33 factors, the classical AHP is applied.
- <sup>6</sup> The study remains in optimal sample size to apply an AHP effectively, as suggested by Muralidharan et al. (2001) and Talib and Rahman (2015).
- <sup>7</sup> Green ammonia production facility for chemistry experts and DRI production facility for steel experts.
- <sup>8</sup> The Random Index is derived by approximating values for matrices of order 1 to 10, based on a sample size of 500. According to Saaty, the Random Index values for matrix sizes 2 through 10 are 0.00, 0.58, 0.90, 1.12, 1.24, 1.32, 1.41, 1.45, and 1.49, respectively (Fageha and Aibinu 2016).
- <sup>9</sup> This approach by the experts is also methodologically intended and essential. Otherwise, such conditioning factors would have overruled all other factors and would have made the AHP analyses worthless. Further, a high AHP group consensus rating of 82% for the pairwise SC relevance judgments proofs that all the experts defined the solution space similarly.

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## Appendix

### Interview Guideline Draft for Semi-Structured Interview With an Expert

#### 0. Introduction

##### 0.0 Small talk

- Establish rapport with the interviewee and briefly discuss current events or mutual professional interests.

##### 0.1 Interviewer introduction

- Self-introduction, including research background.
- Context: Analyzing green production in the steel and chemistry industry, with a focus on location selection. This interview specifically explores DRI or green ammonia production.

##### 0.2 Declaration of consent

- Assurance of anonymity: *All collected data will be anonymized, and your name will not be disclosed.*
- Recording consent: *To ensure accuracy, I would like to record this interview. Is this acceptable to you?*
- Time efficiency: *Due to time constraints, brief and precise answers would be appreciated.*

##### 0.3 Agenda overview

1. Introductory questions
2. Analytical hierarchy process (AHP) exercise on location decision factors (if possible, otherwise skipped)
3. Deep dive questions on green relocation conditions

##### 0.4 Interviewee introduction

- What is your current position in the company?

## 1. Explorative questions (general questions)

### 1.0 Green production (warm-up)

- How advanced is your company in transitioning to green production?
- In your opinion, what are the biggest hurdles in switching to green production?

### 1.1 Decision factors for site selection

- What are the most important factors when selecting a location for a green production facility?
- (Optional) Do you differentiate between location selection for green versus non-green production facilities?

## 2. Analytical hierarchy process matrix (unbiased exercise)

### 2.1 Framing and exercise

- In the next 30 min, we will conduct a structured exercise.
  - Imagine this scenario: You are advising on the location decision for a new green DRI or green ammonia production facility.
  - In the first step, you will assess the most relevant factors influencing location selection.
  - Your team has categorized relevant factors, and we will compare them in pairs to determine priority.
  - I will share my screen, and we will go through the factors systematically.
- Guidance: Decision-making can be challenging, and intuitive responses are welcome. There are no absolute right or wrong answers.
- This exercise abstracts real-world complexities and aims to identify fundamental decision drivers.

### 2.2 Follow-up questions (biased questions)

- If strong ratings (7+) were given: *Why is factor X so relevant for you?*

## 3. Deep dive questions on green relocation conditions (biased questions)

- Some researchers suggest a "renewable pull effect," shifting production sites to regions with renewable energy surpluses. Do you see this trend impacting your company?
  - What could enable the renewable pull effect?
  - What are the biggest challenges?
  - What could hinder relocations based on the renewable pull effect?
  - What do you think about Europe's position in this shift?
- Could your company expand its green production to new international locations?
  - Could developing countries become attractive locations?
- How do you see internationalization affecting the green transformation of your industry? Will it strengthen or weaken the transition?

## 4. Interview closing

- Is there anything else you would like to add regarding green production?
- Thank you for your insights—this was extremely valuable. I will share the results in autumn 2024.

## Appendix

### Synthesized AHP Results for Each SC and Location Factor, Including All Experts' Judgments ( $n = 20$ )

Strategic considerations	Local weights	SC rank	Location factors	Local weights	Global weights	Factor rank
Production costs	0.246	2	CAPEX	0.157	0.039	7
			Labor costs	0.059	0.015	21
			<b>Raw material costs</b>	<b>0.293</b>	<b>0.072</b>	<b>5</b>
			<b>Energy costs (incl. GH<sub>2</sub>)</b>	<b>0.426</b>	<b>0.105</b>	<b>2</b>
Regulation and financing costs	0.065	6	Outbound transportation costs	0.065	0.016	18
			Carbon costs	0.201	0.013	25
			Access to subsidies	0.240	0.015	19
			Access to capital market (incl. WACC)	0.259	0.017	17
			Local taxation	0.132	0.009	30
			Customs	0.167	0.011	29
Access to assets	0.127	4	Access to green production facility	0.092	0.012	28
			Access to labor forces	0.120	0.015	20
			Access to infrastructure and logistics	0.258	0.033	9
			Existing assets at location	0.100	0.013	26
			<b>Agglomeration and integration benefits</b>	<b>0.431</b>	<b>0.055</b>	<b>6</b>
Access to supply	0.294	1	Proximity to raw material suppliers	0.063	0.018	14
			<b>Reliable raw material supply</b>	<b>0.325</b>	<b>0.096</b>	<b>3</b>
			Proximity to energy supplier (incl. GH <sub>2</sub> )	0.097	0.028	11
			<b>Reliable energy supply (incl. GH<sub>2</sub>)</b>	<b>0.409</b>	<b>0.120</b>	<b>1</b>
Access to demand	0.164	3	Access to bridging energy	0.106	0.031	10
			<b>Proximity to next production step</b>	<b>0.491</b>	<b>0.081</b>	<b>4</b>
			Proximity to secondary production steps	0.073	0.012	27
			Proximity to customers of final products	0.110	0.018	15
			Flexible delivery of final products	0.105	0.017	16
			Size of local market of final products	0.220	0.036	8
Political environment	0.067	5	Stable legal and political system	0.328	0.022	13
			Industrial friendly political attitude	0.394	0.026	12
			Low climate action regulations	0.074	0.005	33
			Reliable production certification	0.204	0.014	23



Strategic considerations	Local weights	SC rank	Location factors	Local weights	Global weights	Factor rank
Environmental and social risks	0.038	7	Pollution and environmental constraints	0.346	0.013	24
			Affected communities' constraints	0.141	0.005	32
			Quality of life for employees	0.148	0.006	31
			Occupational health and safety standards	0.364	0.014	22

Note: A factor with a global weight larger than 4% (0.04) is highlighted in gray.

## Appendix

### Synthesized AHP Results for SCs, Judgments Categorized by Chemistry ( $n=10$ ) and Steel ( $n=10$ )

#	Strategic considerations	Chemistry local weights	Steel local weights	Delta local weights
01	Production costs	0.257	0.232	0.02
02	Regulation and financing costs	0.059	0.069	−0.01
03	Access to assets	0.118	0.135	−0.02
<b>04</b>	<b>Access to supply</b>	<b>0.279</b>	<b>0.305</b>	<b>−0.03</b>
<b>05</b>	<b>Access to demand</b>	<b>0.201</b>	<b>0.132</b>	<b>0.07</b>
<b>06</b>	<b>Political environment</b>	<b>0.048</b>	<b>0.091</b>	<b>−0.04</b>
07	Environmental and social risks	0.039	0.037	0.00

Note: A delta larger than 3% (0.03) is highlighted in gray.

## Appendix

### Synthesized AHP Results for Factors, Judgment Categorized by Chemistry ( $n=10$ ) and Steel ( $n=10$ )

SC	Factors	Chemistry global weights	Steel global weights	Delta global weights
01	<b>CAPEX</b>	<b>0.061</b>	<b>0.021</b>	<b>0.04</b>
	Labor costs	0.013	0.014	0.00
	<b>Raw material costs</b>	<b>0.093</b>	<b>0.050</b>	<b>0.04</b>
	<b>Energy costs (incl. GH<sub>2</sub>)</b>	<b>0.076</b>	<b>0.129</b>	<b>−0.05</b>
	Outbound transportation costs	0.013	0.017	0.00
02	Carbon costs	0.015	0.009	0.01
	Access to subsidies	0.007	0.031	−0.02
	Access to capital market (incl. WACC)	0.019	0.012	0.01
	Local taxation	0.008	0.008	0.00
	Customs	0.010	0.009	0.00
03	Access to green production facility	0.009	0.015	−0.01
	Access to labor forces	0.011	0.020	−0.01
	Access to infrastructure and logistics	0.025	0.041	−0.02
	Existing assets at location	0.012	0.012	0.00
	Agglomeration and integration benefits	0.061	0.047	0.01

SC	Factors	Chemistry global weights	Steel global weights	Delta global weights
04	Proximity to raw material suppliers	0.025	0.013	0.01
	<b>Reliable raw material supply</b>	<b>0.114</b>	<b>0.075</b>	<b>0.04</b>
	Proximity to energy supplier (incl. GH <sub>2</sub> )	0.023	0.033	−0.01
	<b>Reliable energy supply (incl. GH<sub>2</sub>)</b>	<b>0.093</b>	<b>0.147</b>	<b>−0.05</b>
	Access to bridging energy	0.024	0.037	−0.01
05	Proximity to next production step	0.075	0.079	0.00
	Proximity to secondary production steps	0.019	0.007	0.01
	Proximity to customers of final products	0.024	0.012	0.01
	Flexible delivery of final products	0.018	0.015	0.00
	<b>Size of local market of final products</b>	<b>0.064</b>	<b>0.019</b>	<b>0.05</b>
06	Stable legal and political system	0.022	0.019	0.00
	Industrial friendly political attitude	0.016	0.039	−0.02
	Low climate action regulations	0.003	0.007	0.00
	Reliable production certification	0.007	0.025	−0.02
07	Pollution and environmental constraints	0.016	0.010	0.01
	Affected communities' constraints	0.007	0.004	0.00
	Quality of life for employees	0.005	0.006	0.00
	Occupational health and safety standards	0.011	0.016	0.01

Note: A delta larger than 3% (0.03) is highlighted in gray.