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Europe's Future Industrial Landscape: A Green Industrial Location Attractiveness Index

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Abstract

Increased gas prices, constraints in nuclear power generation, and diminished hydroelectric production have introduced challenges for Europe, coinciding with an emerging green industrialization. Utilizing data from the European Commission and Eurostat, we introduce the Green Industrial Location Attractiveness Index, a tool designed to help assessing locations of future green industrial developments. Our findings highlight Sweden, Finland, and France as probable destinations for green industrial projects. A revealing geographical divide where northern European countries rank higher compared to their southern counterparts. This analysis enhances our understanding of Europe's changing industrial landscape amidst volatile electricity prices, offering insights for policymakers and investors. An overarching conclusion of the paper is that well-crafted energy policies help mitigate the economic impacts of energy price fluctuations on energy-intensive industries, ensuring that Europe's industrial landscape remain competitive.

Keywords: Electricity, Industry, Europe, Renewable, Transformation.
JEL classification: Q41, L94, Q42, Q54.

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1. Introduction

Despite the surge in electricity prices in 2022, the European Union (EU) witnessed an increase in industrial employment and output compared to 2021 while output in electricity-intensive industries such as basic metals, chemicals, non-metallic minerals, and paper saw a decline (Sgaravatti et al., 2023). Electricity prices significantly affect the European industry, particularly the energy-intensive sectors (Makridou et al., 2016). Demand for electricity varies across sectors, with industrial sectors typically having the highest demand (Zhao et al., 2014; Makridou et al., 2016). Energy prices are expected to remain at historically high levels in the foreseeable future (Ari et al., 2022). The considerable fluctuations in the European electricity market highlight the challenges faced by several countries aiming to maintain or expand their industrial bases.

The phenomenon of European deindustrialization was viewed as an inherent development in contemporary economies (Rodrik, 2016; Škuflić and Družić, 2016; Sarra et al., 2019). However, present Europe appears to be reversing deindustrialization, undergoing a reindustrialization process characterized by the return of production and the rise of a new green industry (Capello and Cerisola, 2023). The green industrial sector, heavily reliant on electricity, urgently requires non-CO2 energy sources (Larsen and Dupuy, 2023). Consequently, countries meeting non-CO2 energy demand are in position to become leaders in the reindustrialization. This leads to this papers research question: Which countries have the capacity to excel in the green re-industrialization of Europe?

The purpose of this paper is to analyze Europe's future industrial landscape and to present an analytical tool for forecasting green industrial developments in Europe. A notable contribution of this work is the development of the Green Industrial Location Attractiveness Index (GILAI), crafted to aid in forecasting future green industrial location. GILAI evaluates factors such as electricity prices, energy intensity, wind installations, price fluctuations, and the share of renewable energy, attributing specific values to each considered region or location. The ranking system assigns scores to countries on a scale from 1 to 27, where the location with the highest score is awarded 27 points and the one with the lowest score, 1 point. These scores are aggregated to establish an overall ranking for each location.

The decision regarding industrial location is complex and influenced by multiple interconnected factors, including the scale of operations, the combination of production factors, and market conditions (von Thünen, 1826; Weber, 1909; Smith, 1966). The location that maximizes profits may vary depending on the factory size, the specific mix of production factors used, and how demand shifts based on the chosen location (Lopez-Bayo et al., 2004; Hanawalt and Rouse, 2017). While the complexity of analyzing these interrelated factors can make location decisions challenging, simplifying assumptions can help streamline the problem. The proposed GILAI is designed as an analytical tool, aimed at facilitating ongoing assessment and providing insights into the reindustrialization process. GILAI is not intended to offer definitive conclusions, as the landscape is subject to temporal change influenced by country-specific decisions, market dynamics, energy policies, technological progress, and global economic conditions.

The discussion of energy related policy implications highlights the importance of targeted interventions to enhance a country's stability and competitiveness in the GILAI. Twenty different policy measures are suggested as a start. The analysis suggests that effective policies on both the supply and demand sides can mitigate challenges and optimize energy usage. On the supply side, strategies such as tax reductions, direct subsidies, and support for renewable energy development, including public-private partnerships, are critical. On the demand side, implementing energy efficiency regulations, incentivizing renewable energy adoption, and creating industrial rate plans for stable electricity pricing are essential. Additionally, promoting market-based mechanisms and investing in smart grid technology can further reduce energy intensity and improve the overall efficiency of the energy market, positioning countries more favorably in the green industrial landscape.

Europe's reindustrialization is likely intricately tied to the provision of competitive electricity prices, the enhancement of energy efficiency, and the encouragement of renewable energy within the industrial sector. From a policy standpoint, exploring the effects of variable electricity prices on Europe's industrial domain is crucial for facilitating informed policymaking, fostering economic competitiveness, advancing sustainable energy transitions, and bolstering energy security.

The structure of the remainder of this paper is as follows: Section 2 provides background information on recent developments in electricity and energy that affect industrial competition and pricing trends. Section 3 outlines the data utilized and describes the methodology for constructing the GILAI index. Section 4 presents the findings from the GILAI rankings. Section 5 discusses these results. Finally, Section 6 concludes the paper and explores its policy implications.

2. Industrial location and Recent development of the European Energy market

2.1 Industrial location choices

Over the years, numerous factors and frameworks have been explored to determine the optimal location for an industry (Kazem, 2021; Tirkolaee et al., 2023). Classical theories, grounded in microeconomic principles such as production costs, were first introduced by scholars like von Thünen (1826) and Weber (1909). These theories analyze the impact of locational inputs and outputs on productivity. Emphasis was put on factors like capital, location, power, transportation costs, labor availability, and raw materials as significant determinants (Renner, 1947). Despite their age, these theories continue to hold relevance today (McCann and Sheppard, 2003). Expanding upon these foundations, New economic geography theories include access to knowledge and skills (see Krugman, 1992).

New economic geography theories revive two primary forces that influence the geographical location of industries: centripetal forces, which encourage firms to cluster together, and centrifugal forces, which drive them apart (Colby, 1933). The co-location of firms results in agglomeration rents, yielding benefits like knowledge spillovers, shared inputs, and access to a specialized labor pool (Lopez-Bayo et al., 2004: Acs et al., 2009). However, an increased concentration of firms can raise land costs and potentially lead to the relocation of production.

The concept of agglomeration economies has been extensively researched, showing that the clustering of firms along a value chain enhances productivity, innovation, and profitability (Lopez-Bayo et al., 2004; Schiele, 2008; Crabbé and De Bruyne, 2013; Devereux et al., 2014). The generation of agglomeration benefits are influenced by local policies and regulations (Ekhart and Breese, 2023). Research by Devereux et al. (2014) into firm preferences for clustering versus geographical dispersion reveals variability across industries but generally lower entry rates in more agglomerated sectors. Location decisions are also affected by regional differences in taxes, duties, and legal restrictions (Tate et al., 2014; Pavlínek, 2020; Ekhart and Breese, 2023), with governments able to tax agglomeration rents without deterring new firms in denser districts (Crabbé and De Bruyne, 2013). Energy prices also plays a role since energy is a major input in many production processes (Bae, 2009; Moreno et al., 2012; Elliott et al, 2019). Additionally, the challenges of accessing green electricity are becoming increasingly significant (Larsen and Dupuy, 2023).

Building on this literature, the foundational factors of capital, location, energy, transportation costs, labor availability, and raw materials continue to guide industrial location decisions. Different industries require wide-ranging compositions of these factors; for example, in the car manufacturing industry, labor rates, material costs, and logistics account for 54 percent of the weighted attributes determining a country's attractiveness (Hanawalt and Rouse, 2017).

As firms strive to be recognized as green, the importance of location factors evolves. Firms must consider the sustainability of their power sources to market their products as green and avoid future climate tariffs, such as the EU's Carbon Border Adjustment Mechanism (CBAM), which will tax carbon-intensive production outside the EU. Thus, while a firm requires energy, the energy is preferably green and hence the relevance of its industrial location.

2.2 Electricity and energy affecting firm competition and employment.

Industries in regions with lower electricity cost holds a long-term advantage, potentially influencing trade balances and investments in energy-intensive sectors (Jansen and Seebregts, 2010). The capability of firms to adjust and effectively manage their energy—especially electricity consumption—based on price signals can mitigate the impact of high electricity prices, thereby reducing costs and boosting competitiveness. Demand response programs and flexible production processes enable firms to optimize their energy usage during periods of high prices (Strbac, 2008). Electricity prices significantly affect the industrial landscape in Europe, with fluctuations influencing the competitiveness and profitability of energy-intensive industries (Faiella and Mistretta, 2020). Higher electricity prices can lead to increased production costs, reduced profitability, and potentially influence investment decisions, whereas lower electricity prices could enhance industrial competitiveness and attractiveness for investment.

Energy intensity, defined as the amount of energy required to produce one unit of economic output, is typically measured by energy consumption per unit of GDP. Energy intensity is a critical indicator of a country's or region's energy efficiency, providing insights into its economic development, energy consumption patterns, and environmental sustainability. Energy-intensive industries are sensitive to changes in electricity prices, with higher energy costs significantly affecting their production costs, profitability, and global competitiveness (Rokicki et al., 2022).

The EU has established targets for member states to reduce energy consumption and enhance energy efficiency (Chlechowitz et al., 2022), including the Energy Efficiency Directive, which set a goal of improving energy efficiency by 20 percent by 2020 (European Commission, 2018). In Europe, as depicted in Figure 1, industrial energy intensity has been consistently declining over recent decades (Lamb et al., 2021). This decrease is attributable to factors such as advancements in energy efficiency, technological progress, economic restructuring, and policy measures aimed at sustainable development.

Europe has actively promoted the interconnection of national power grids to help cross-border electricity trade, optimizing electricity generation mixes, accessing renewable resources from neighboring countries, and enhancing grid stability (Hawker et al., 2017). Interconnection support the integration of intermittent renewable energy sources into the grid, influencing electricity prices across Europe (González and Alonso, 2021). Cross-border trading and grid interconnections are meant to improve resource allocation and price convergence, potentially stabilizing electricity prices for industries and impacting their competitiveness, especially in energy-reliant sectors (Ovaere et al., 2023). The relationship between electricity prices and industrial employment is complex, affected by sector-specific factors and international market dynamics (Hille and Möbius, 2019).

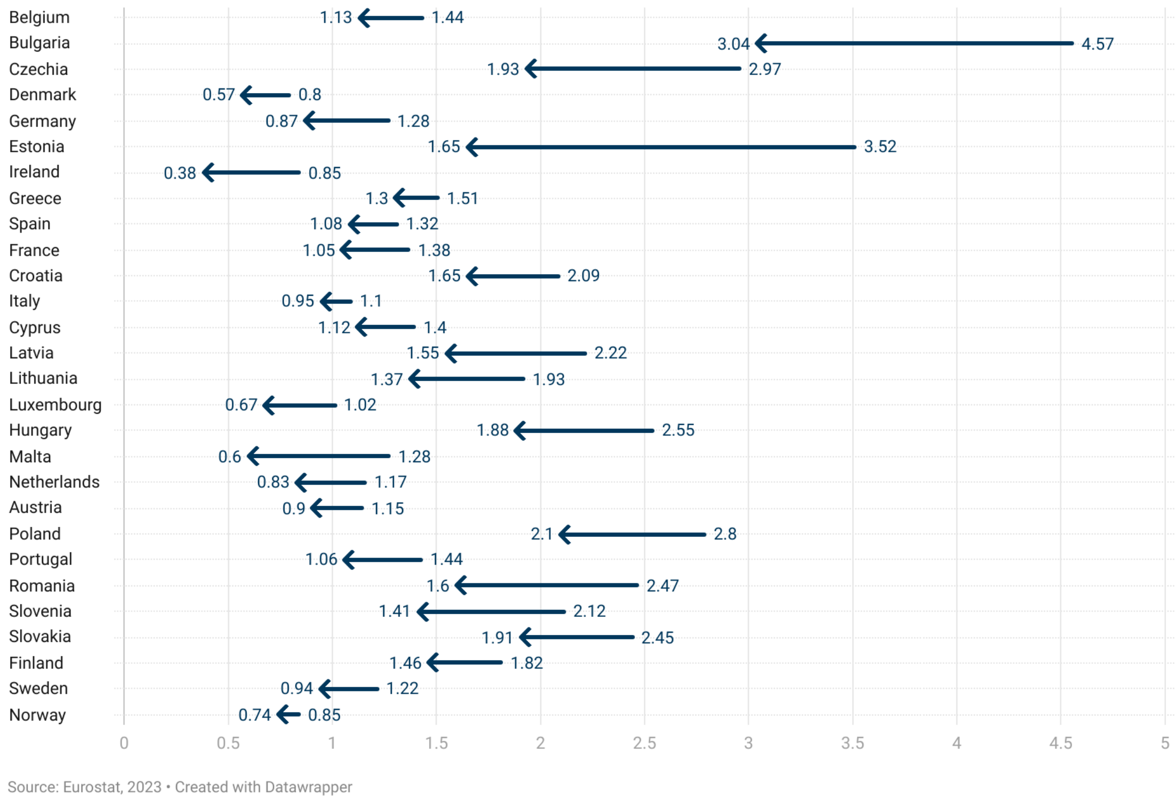

Figure 1 Energy intensity change 2013-2021 GWh/GDP (million). Source: Eurostat 2023.

Research indicates varied impacts of electricity prices on employment. Deschênes (2011) identifies a weak negative correlation between state-level electricity prices and employment rates, while Cox et al. (2014) find limited substitutability between electricity and labor, suggesting that higher electricity prices may reduce employment due to output reductions. Marin (2017) observed that a 10 percent increase in energy prices modestly impacted French manufacturing employment negatively, especially in energy-intensive and trade-exposed sectors. Bijnes et al. (2022) reported negative employment elasticity in Europe's most energy-intensive industries. Li et al. (2022) demonstrated that rising electricity prices decreased labor demand in Chinese manufacturing, with more pronounced effects in high-GDP cities, labor-intensive industries, and enterprises with foreign private ownership.

Hille and Möbius (2019) highlight positive net employment effects of increasing energy prices, indicating a shift towards energy-saving sectors. Marin and Vona (2019, 2021) examined labor market impacts, noting job reallocation mitigates some negative effects. Saussay and Sato (2018) focus on international investment shifts due to relative price increases, while Barteková and Ziesemer (2019) suggest rising electricity prices may deter foreign direct investment. Li and Leung (2021) linked economic growth to renewable energy expansion in Europe. Countries with economies more focused on services usually exhibit lower energy intensity, whereas those with manufacturing or heavy reliance on fossil fuels tend to have higher levels.

2.3 Recent price development and the energy transition

Throughout 2022, the European wholesale electricity market experienced several instances of record-high prices, peaking in August (European Commission, 2023). A surge in gas prices, limited availability of nuclear power, the conflict in Ukraine, and reduced hydroelectric output due to drought collectively exacerbated the strain on an already tight electricity market (IEA, 2022). Drought conditions resulted in a 19 percent decline in hydroelectric output across Europe from January to September 2022. In France, maintenance work caused most of the country's 56 reactors to be offline in September (Horowitz, 2022). Over the year, the European Power Benchmark averaged 230 €/MWh, marking a substantial increase of 121 percent compared to 2021. Italy recorded the highest average baseload electricity prices among European countries at 304 €/MWh, followed by Malta (294 €/MWh), Greece (279 €/MWh), and France (275 €/MWh) ranking high as well (Ari et al., 2022).

Network prices in Europe was on a steady upward trajectory until 2012, peaking at €0.0943 per kWh. Prices then declined leading up to 2020, reaching €0.0781 per kWh in the second half of 2019 and €0.0820 per kWh in the second half of 2020. Although there was an increase from 2020, the prices remained lower than the peak observed in the first half of 2008. In the second half of 2022, a significant surge occurred, as depicted in Figure 2, with prices soaring to €0.1986 per kWh, the highest point since data collection began (Eurostat, 2023a).

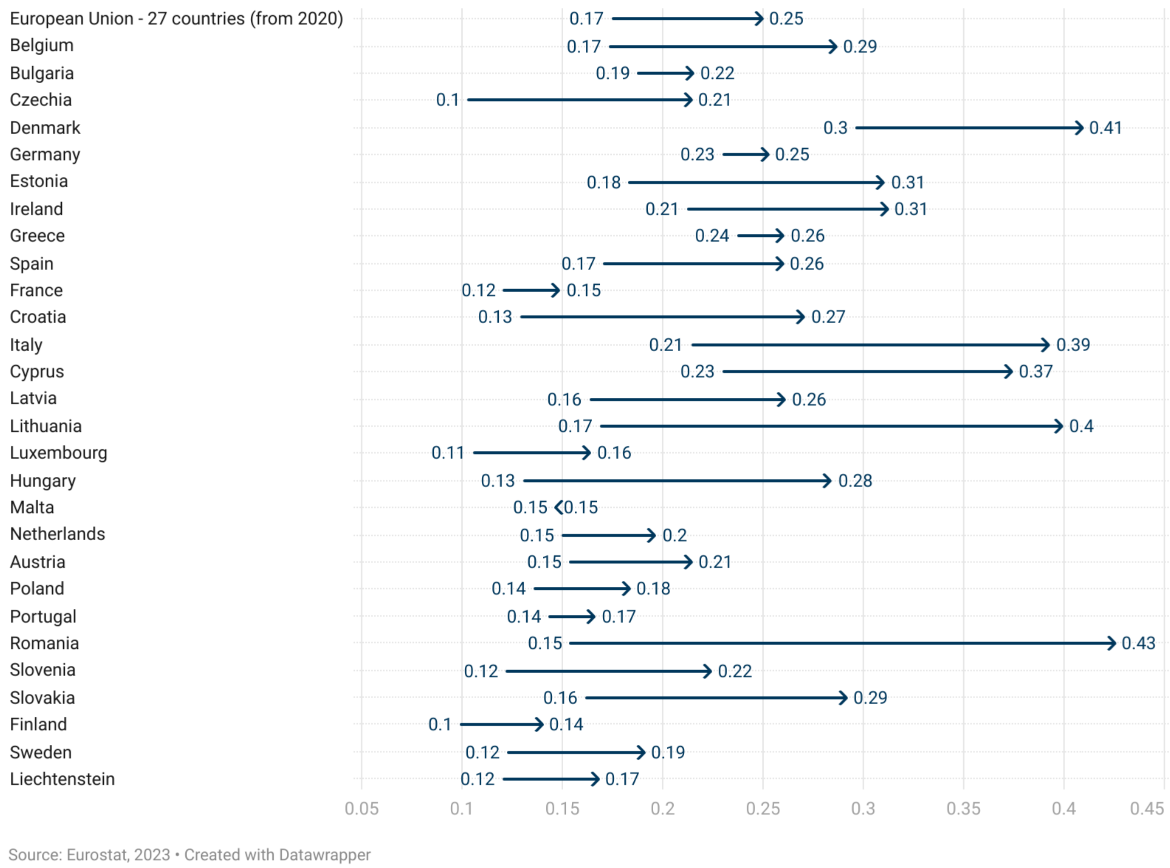

Figure 2 Change in Electricity prices 2021-2022. Source: Eurostat, 2023.

When adjusted for inflation, the total price for non-household consumers, including taxes, was €0.1244 per kWh in the second half of 2022, lower than the actual price with taxes for the same period. Conversely, the total price for non-household consumers, excluding taxes, reached €0.1986 per kWh in the second half of 2022, surpassing the actual price without taxes from the first half of 2008 (Eurostat, 2023a).

Following the European energy crisis in August and September, the final quarter of 2022 saw a return to normalcy (Eurostat, 2023a). Despite a decrease from their peak levels, gas prices remained high through November and December, with a temporary dip in October. Prices peaked at about 150 €/MWh in early December before gradually falling to around 70 €/MWh by the end of the month. To offset the reduced supply from Russian pipeline gas due to the Nord Stream supply cut in the third quarter, the European market significantly increased its reliance on LNG imports, which rose by 13 billion cubic meters (bcm), a 70 percent increase from the previous year. Additional pipeline imports mainly came from Norway and the UK. Monthly imports of Russian pipeline gas stabilized at about 3-4 bcm, markedly lower than the 11-12 bcm per month seen in Q4 2021. As a result, the share of Russian pipeline gas imports fell by about 15 percent in Q4 2022, a drop of over 25 percentage points compared to the same quarter in 2021 (Eurostat, 2023a).

The price premium over Asian markets gradually decreased, reaching around 10 €/MWh by late December, down from its peak above 100 €/MWh during the August crisis (Eurostat, 2023). This decrease in price premium was facilitated by an abundance of LNG in southwestern Europe and reduced grid congestion in northwestern Europe, aiding in the normalization of LNG import prices relative to the Title Transfer Facility (TTF) and other continental benchmarks (Eurostat, 2023a).

In the fourth quarter of 2022, the United States became the largest supplier of LNG to the European Union, delivering 13.2 (bcm), which constituted 36.9 percent of total EU LNG imports. Qatar was the second-largest supplier with 6 bcm (16 percent of EU imports), followed by Russia with 5.6 bcm (15 percent). During this period, the EU surpassed both Japan and China to become the world's top LNG importer. EU gas consumption in Q4 2022 saw a year-on-year decrease of 21 percent, totaling 95.4 bcm, which is 25 bcm less than the previous year. Nevertheless, gas usage in power generation remained strong, experiencing a 1.7 percent increase to reach 133 terawatt-hours (Eurostat, 2023a).

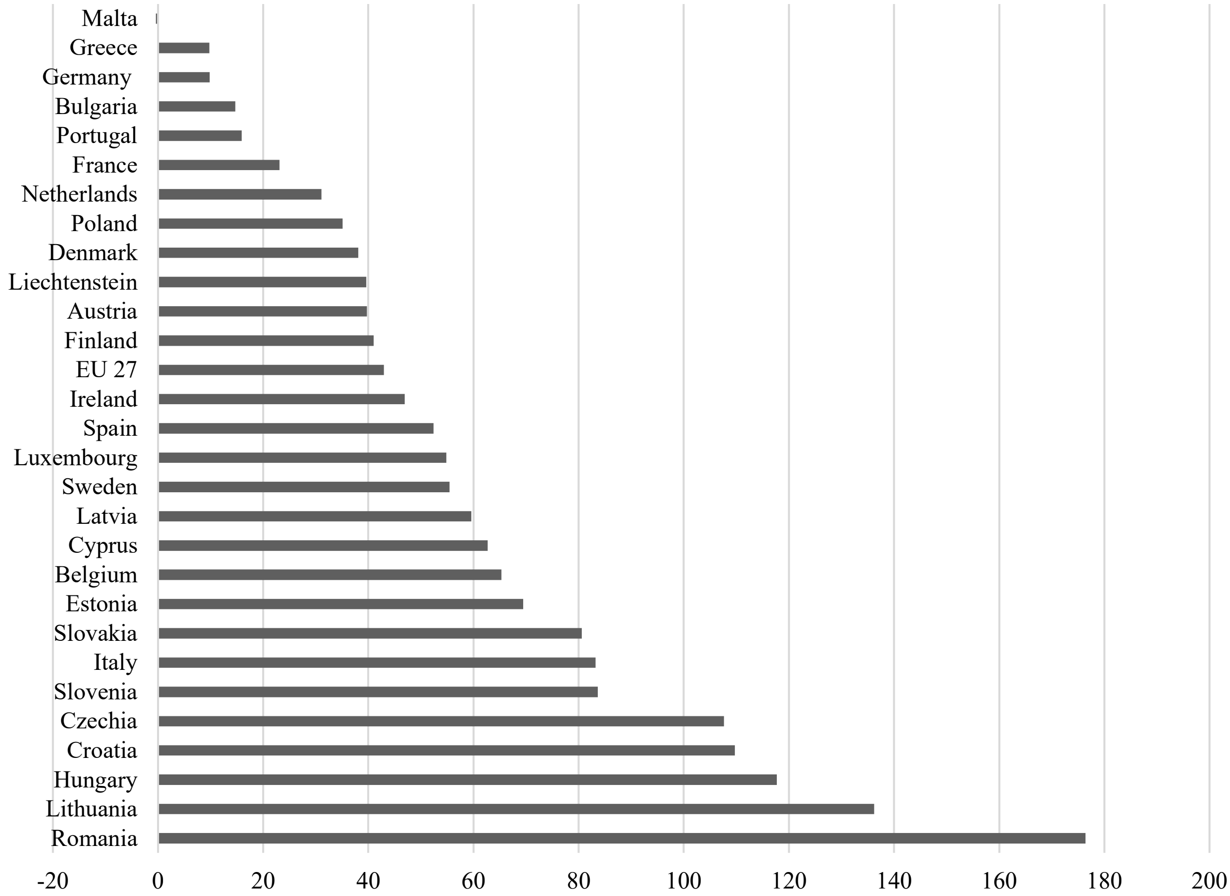

Figure 3 Change in electricity prices for non-household consumers compared with previous year's same semester, second half 2022. Source: Eurostat (2023).

Taxes play a crucial role in shaping the final energy prices for consumers throughout the EU, significantly influencing consumption and investment decisions (European Commission, 2023b). Notably, European average taxes on electricity experienced a significant rise, increasing by 37.3 percentage points from 16.1 percent in the first half of 2008 to a peak of 53.4 percent in the first half of 2020 (Eurostat, 2023). In the second half of 2022, the share of taxes dropped to the lowest level since the commencement of data recording, at only 5.6 percent. When considering the total price for non-household consumers, including non-recoverable taxes, there was an increase of 138.1 percent from the first half of 2008, rising from €0.0834 per kWh to €0.1986 per kWh in the second half of 2022.

The EU aims to reduce greenhouse gas emissions by 80-95 percent relative to 1990 levels by 2050 (European Commission, 2023b). To meet this goal, a significant boost in the proportion of RES within the overall electricity mix is necessary. RES are characterized by variable generation patterns, influenced by weather conditions and the time of day, introducing intermittency. Intermittency necessitates the integration of energy storage technologies and grid flexibility measures, potentially introducing additional costs to the electricity system (Kiss et al., 2024).

Investing in RES offers benefits but may lead to higher for businesses and consumers (Bijnens et al., 2022), though some studies report a negligible electricity price effect (Sisodia et al., 2015). Wang et al. (2016) found that the adoption of Renewable Portfolio Standards (RPS) in the United States initially increased electricity prices. Similarly, Río et al. (2018) identified that the costs associated with promoting renewable energy in the EU had a positive and statistically significant impact on retail electricity prices, although the effect was minor. Dillig et al. (2016) argued that the rise in electricity prices in Germany was not primarily due to renewables but to the liberalization of the European energy market, which introduced investment risks and hindered necessary investments before the advent of renewable energy sources.

The shift towards renewable energy, including wind and solar power, affects electricity prices (Wang et al., 2016; Dillig et al., 2016; Río et al., 2018). While renewable energy contributes to decarbonization, the upfront investments and infrastructure costs can sometimes increase electricity prices in the short term. Dogan et al. (2022) noted that energy taxes and environmental taxes negatively impact the deployment of renewable energy.

While the energy mix varies among European countries, broad trends and shifts have been observed. In 2021, the majority of electricity in the EU was generated from non-combustible primary sources, making up 58.1 percent of the total (Eurostat, 2023c). In contrast, combustible fuels such as natural gas, coal, and oil accounted for 41.9 percent of net electricity generation. Nuclear power stations provided a quarter of the electricity, totaling 25 percent. Among renewable energy sources, wind turbines had the highest share of net electricity generation in 2021 at 13.7 percent, followed by hydropower plants at 13.3 percent, and solar power contributed 5.8 percent to the EU's net electricity generation, with wind generation increasing by 33 TWh (8.6 percent).

Historically, Europe's electricity generation was dominated by fossil fuels, including coal, natural gas, and oil. However, their usage has been declining as many European countries phase out coal-fired power plants or implement stricter emission regulations. In 2022, fossil fuels produced 1.11 million gigawatt-hours (GWh) of electricity, a 3.3 percent increase from 2021, while renewables generated 1.08 million GWh, reflecting a marginal 0.1 percent rise. The most significant growth in electricity generation was in the solar photovoltaic sector, with a 29.3 percent increase, and wind energy, which grew by 8.9 percent. Conversely, electricity production from hydro sources declined by 17.7 percent, and solid biofuels saw a decrease of 7.4 percent during the same period (Eurostat, 2023d).

Nuclear energy plays a crucial role in Europe's electricity generation mix, with countries like France, Sweden, and Finland significantly relying on it. The future of nuclear energy in Europe, however, is a subject of ongoing debate due to concerns over safety and long-term waste management, leading some countries to consider phase-outs or reducing their reliance on nuclear power. Meanwhile, several nuclear projects are either planned or underway. France plans to add an EPR reactor at the Flamanville 3 Nuclear

Power Plant with a capacity of 1650 MWe in 2024. Slovakia aims to bring online the Mochovce 4 reactor, a VVER-440 type with a capacity of 471 MWe, also in 2024. The United Kingdom is undertaking a significant project with the construction of Hinkley Point C1 and C2, both EPR models with a capacity of 1720 MWe each.

According to the World Nuclear Association (2023), European nuclear power has seen upgrades. All operating reactors in Switzerland have been upgraded, increasing capacity by 13.4 percent. Spain has embarked on a program to boost its nuclear capacity by 810 MWe (11 percent) through upgrades to its nine reactors, with most of the increase already completed. For instance, the Almarez nuclear plant's capacity was increased by 7.4 percent at a cost of $50 million. Finland's original Olkiluoto nuclear plant has seen a capacity increase of 29 percent to 1700 MWe. Additionally, the Loviisa plant, which operates with two VVER-440 reactors, has been uprated by 90 MWe (18 percent). In Sweden, utilities have conducted upgrades on three plants, with significant capacity increases noted at the Ringhals, Oskarshamn 3, and Forsmark 2 plants.

The share of RES in electricity generation has been steadily increasing in Europe, driven by declining costs of renewable energy technologies, supportive policies, and commitments to decarbonization (Tutak and Brodny, 2022; Dogan et al., 2023). In 2022, Europe experienced a significant increase in new wind installations (see Figure 4), totaling 19.1 GW, despite economic challenges and supply chain issues. Of this, 16.7 GW were installed onshore and 2.5 GW offshore (Wind Europe, 2023). Wind power output increased by 33 TWh (+8.6 percent) during the year. Wind energy contributed 15 percent (equivalent to 420 TWh) to the total electricity generation in the EU. Germany was the leading wind power producer with 126 TWh, accounting for 22 percent of its overall electricity mix. Spain was a close second with 62 TWh, also representing 22 percent of its electricity (see Figure 5). Denmark had the highest relative contribution, with wind energy comprising 55 percent of its mix, equal to 19 TWh. Other notable countries in terms of wind power shares include Ireland (34 percent) and Portugal (26 percent).

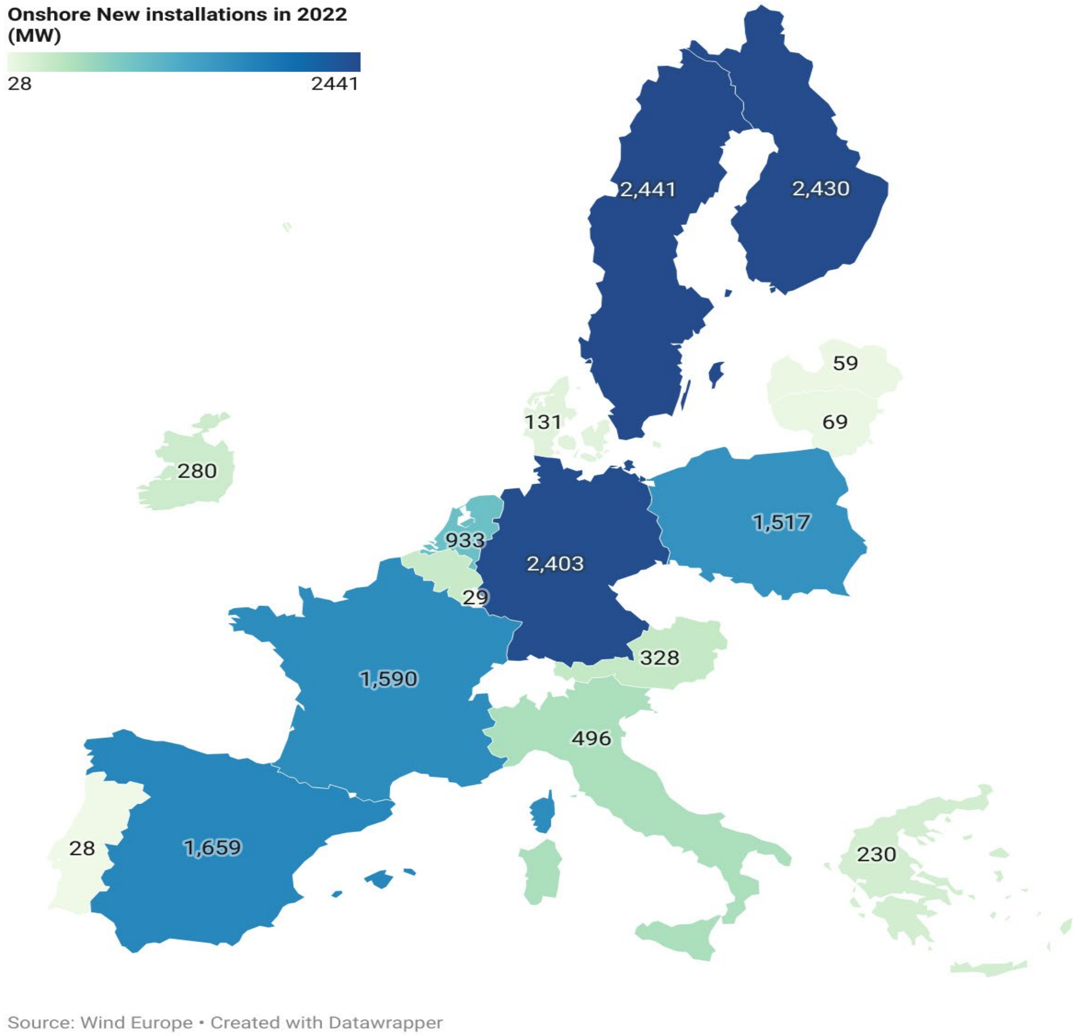

Figure 4 Onshore New Installation in 2022 (MW). Source Wind Europe.

To meet the EU's goal of achieving 45 percent renewable energy by 2030, wind energy installations need to average 31 GW annually from 2023 to 2030 (Wind Europe, 2023). This requirement aligns with the target of reaching an installed wind power capacity of 440 GW. In 2022, Germany was at the forefront of wind farm installations in Europe, with nearly 90 percent of its capacity installed onshore. Additionally, Germany integrated the Kaskasi offshore wind farm, with a capacity of 342 MW, into the grid, contributing to a total installation of 2.7 GW. Sweden and Finland each added 2.4 GW of capacity, while France installed 2.1 GW, notably including its first large-scale offshore wind farm, Saint Nazaire, with a 480 MW capacity.

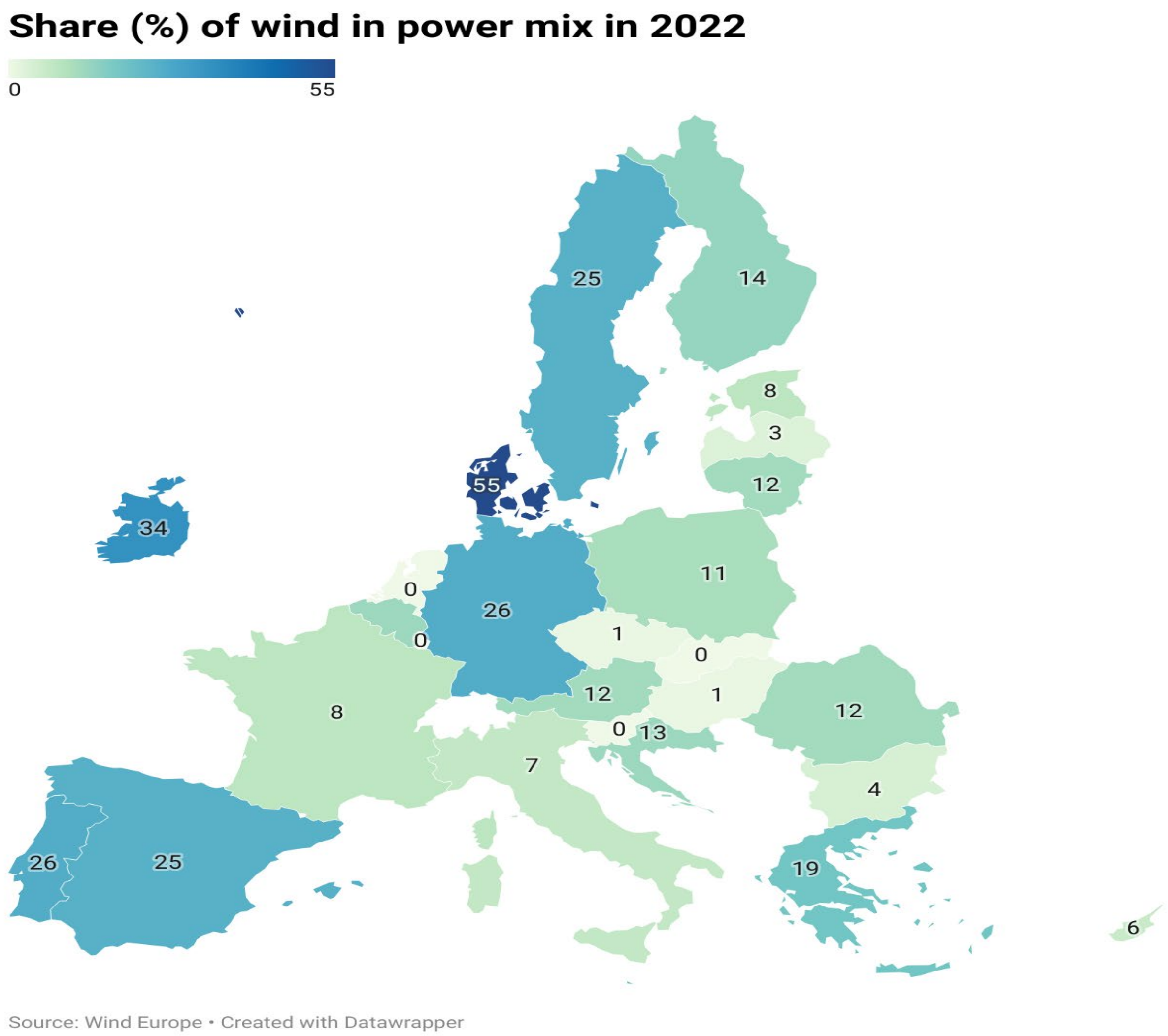

Figure 5 Share (percent) of Wind in power mix 2022. Source: Wind Europe.

Solar energy has experienced significant growth due to decreasing costs and technological advancements (Grafström and Poudineh, 2023). Countries with favorable conditions for solar energy, such as Spain, Italy, and Germany, have witnessed substantial installations of solar photovoltaic systems. Electricity generation from solar power increased by 39 terawatt-hours (TWh) or 24 percent in 2022, raising the share of solar power in the electricity mix to 7.3 percent, up 1.6 percentage points from the previous year's 5.7 percent. This expansion in solar generation was led by Germany, with a 9.6 TWh increase (20 percent). Spain saw a 5.7 TWh increase (21 percent), the Netherlands 5.8 TWh (51 percent), France 4.3 TWh (27 percent), and Poland 4.1 TWh (104 percent).

Biomass, derived from organic materials such as agricultural waste, wood pellets, and energy crops, has been a staple for electricity generation in Europe. It offers a renewable and carbon-neutral energy source, though sustainability and emissions concerns related to biomass utilization persist. Biomass constitutes around 60 percent of the EU's renewable energy, primarily used in the heating sector (European Commission, 2021).

Countries like Norway, Sweden, and Switzerland have a longstanding tradition of harnessing hydroelectric power, a significant contributor to electricity generation in areas rich in water resources. However, the potential for expansion is limited due to the protection of existing unused rivers (Spänhoff, 2014).

The energy mix and development pace differ across European countries, influenced by resource availability, policy priorities, and market dynamics. Despite these variances, Europe's overall trend has been moving towards cleaner electricity generation sources, with an increasing share of renewable energy contributing to the continent's power supply.

3. Data and approach

The factors influencing the location of green industrial investments are complex. Recent investments in green sectors, such as battery factory establishments, have been driven by dual objectives: ensuring energy security and committing to green energy. After four decades of no new steel mills, planning, construction, and opening of new steel mills with a goal of no emissions are underway. The process of green re-industrialization in Europe is in its early stages, yet the precise locations for this transformation across the continent remain to be determined.

To aid in the analytical assessment of potential locations for new industrial establishments, an index is developed. The index considers factors, including electricity prices, energy intensity, wind installations, price changes, and renewable energy share, assigning specific values to each region or location under consideration. Countries are ranked on a scale from 1 to 27, with the highest-scoring location receiving 27 points and the lowest-scoring location receiving 1 point.

These individual scores are combined to form an overall ranking, culminating in the creation of a GILAI. A higher GILAI score signifies a more attractive destination for establishing green industries. In calculating the GILAI, weights (w1, w2, w3, w4, w5) are assigned to each factor based on their importance, which can be determined through empirical analysis or expert opinion. Initially in Equation (1), all factors are given equal weight due to the subjective nature of ranking and the varying preferences of firms based on their specific needs. The formula offers flexibility, allowing for the adjustment of weights and input values to tailor the analysis to specific contexts and objectives:

*Green Industrial Location Attractiveness Index (GILAI) = (w1 * Electricity Prices) + (w2 * Energy Intensity) + (w3 * Wind Installations) + (w4 * Price Change) + (w5 * Renewable Energy Share).* (1)

Countries with higher GILAI scores are deemed more attractive for such investments, while those with lower scores are considered less so. The data for this index were sourced from Eurostat, the European Commission, and Wind Europe. The focus year is 2022 and the result for that year is presented with different weightings, but for robustness in Table 5 the years 2018, 2019, 2020 and 2021 is also presented.

Some indicators were unavailable for Liechtenstein (the country's exclusion is of a lesser concern since its capacity to host major industrial establishments might be limited). The factors chosen for inclusion in the GILAI are believed to be relevant and contribute to understanding the impact on the decision-making process regarding the location of industrial establishments.

1. **Electricity Prices for Non-Household Consumers**: High electricity prices can increase operational costs, which may make a country less attractive for industrial development. Conversely, lower electricity prices can be an incentive for businesses to establish themselves in a particular area. Prices is a function of the existing generation infrastructure and will in the short run be fixed.
2. **Energy Intensity of the Economy**: Energy intensity measures the amount of energy required to produce one unit of GDP. Countries with a high energy intensity may be less attractive to energy-intensive industries since they would incur higher costs. The already existing industries could have a grandfathered position on the market or access to the power grid in such a manner that it is hard to be given capacity for new establishments.
3. **New Wind Installations in 2022 (MW)**: The availability of renewable energy sources, such as wind power, can be a crucial factor for industries that aim to reduce their carbon footprint and energy costs. The installation of wind serves as a proxy for the ability to expand the generation capacity in an industrial manner. Solar is a factor, but due to data availability for all countries wind was chosen.
4. **2021-2022 Price Change**: The variable reflects the stability of the energy market; price stability is essential for businesses to plan their operations effectively. The variable captures the variance introduced due to the Russian invasion of Ukraine. Other exogeneous shocks will likely occur and the 2021-2022 should serve as a proxy for further reactions.
5. **Renewable Energy Share in 2021**: Industries committed to sustainability and environmental responsibility may prefer countries with a higher share of renewable energy in their energy mix. Carbon intensive energy will be faced out in the EU and will see its price go up due to changes in the EUETS system, hence carbon-based energy is not a reliable energy source in the long run. The variable also is important for firms that wants to have a green production.

The selection of a location for industrial establishments is influenced by a complex interplay of factors, and firms may weigh additional considerations such as institutional stability, ease of doing business, and labor costs or availability. The index is intended to be a developmental tool, serving as an indicative guide rather than a definitive statement. It is useful for illustrating relative attractiveness; for instance, when scores are close—such as Sweden's 107 points versus France's 106 points—it indicates not a clear advantage but rather a proximity in attractiveness. The adaptable nature of the GILAI underlines its potential for future research seeking to explore and incorporate additional determinants of industrial attractiveness. For instance, the index could be enriched by introducing variables such as ease of doing business indexes, economic freedom indexes, labor costs, and other relevant factors. An expantion approach would make the index a more comprehensive tool for assessing industrial locations as seen in Equation (2):

GILAI = *f(Original variables + Energy Variables, Ease of Doing Business, Economic Freedom Indexes, Labor Costs).* (2)

4. Results

In Section 4, we explore the GILAI as detailed in Table 1. The index reflects the position of the countries in 2022 except for renewable energy share which data was from 2021. Table 2 presents alternative weightings for the index, shedding light on how different emphases on these factors can influence the attractiveness rankings. Table 3 provides the underlying values and data that underpin these rankings, ensuring transparency for the GILAI. Table 4 presents the names of the countries instead of rank values. Table 5 presents yearly score overtime 2018-2021 to show the stability of the chosen variables. Table 6 (in Appendix A2) provides the standardized values for each country.

The calculations displayed in Table 1 show the comparative attractiveness of each country for industrial establishments. Countries with higher GILAI scores are deemed more attractive, whereas those with lower scores are seen as less attractive. A maximum score would be 135 and a minimum score would be five if all could be ranked but in the case of New wind installations several countries had zero installations and hence they all was given a score of one and then the point ranking got up from there and hence did not reach the maximum of 27.

Table 1 Green Industrial Location Attractiveness Index (GILAI).

	Electricity prices non household	Energy intensity of the economy	New Wind installations in (MW)	Percent change electricity price	Renewable energy share	Total
Finland	27	12	25	17	26	107
Sweden	21	20	26	13	27	107
France	25	21	24	22	14	106
Germany	15	23	27	25	13	103
Austria	18	22	19	18	23	100
Portugal	23	16	11	23	21	94
Greece	13	15	16	26	16	86
Spain	14	19	23	15	15	86
Denmark	2	26	15	19	22	84
Netherlands	20	18	21	21	4	84
Luxembourg	24	25	12	14	1	76
Poland	22	5	22	20	7	76
Latvia	12	9	13	12	25	71
Ireland	6	27	17	16	3	69

Italy	4	24	20	7	12	67
Malta	26	2	1	27	2	58
Belgium	9	14	18	10	5	56
Slovenia	16	13	1	6	18	54
Bulgaria	17	1	1	24	8	51
Croatia	11	11	1	4	20	47
Cyprus	5	17	1	11	11	45
Lithuania	3	7	14	2	19	45
Estonia	7	3	1	9	24	44
Czechia	19	4	1	5	10	39
Slovakia	8	8	1	8	9	34
Romania	1	10	1	1	17	30
Hungary	10	6	1	3	6	26

1. Finland (107): Finland ties Sweden. Finland's index score for non-household electricity prices is 27. In terms of energy intensity of the economy, it has an index score of 12. Finland achieved an index score of 25 for new wind installations in 2022. The country also holds an index score of 26 for renewable energy share in 2021.

2. Sweden (107): Sweden benefits from a lower index score of 21 for non-household electricity prices, providing a competitive advantage for its industries. Its energy intensity index score is 20. Sweden's expanding renewable energy capacity is demonstrated by an index score of 26 for new wind installations in 2022. Additionally, the country got an index score of 27 for renewable energy share in 2021.

3. France (106): France maintains a balance between electricity prices and energy intensity, with index scores of 25 and 21, respectively. France demonstrated a commitment to renewable energy with an index score of 24 for new wind installations in 2022. While the index score for renewable energy share in 2021 was relatively lower at 14 (the nuclear production could be seen as green), the significant progress in wind energy installation indicates France's transition to greener energy sources.

The initial index gives equal weighting for each factor. Robustness checks were conducted to observe the impact of assigning lesser weights to different variables. For instance, the variable for new wind installations received a lower weight, considering many countries did not construct any wind power facilities that year. Despite these adjustments, the top-ranking countries, particularly Sweden and Finland, remained unchanged, although their positions were closely contested by Germany.

The weighted rankings in Table 2 show relatively stable patterns despite variations in weighting, with the extent of change depending on the specific weighting scheme applied. For example, when the renewable energy share is assigned the highest weight (40 percent), Sweden consistently holds the top position. Conversely, Finland's ranking in the four different weighting scenarios never drops below third place, even when energy prices are heavily weighted (40 percent).

The weighting of factors introduces some variability in rankings, yet the overarching trends remain consistent. Sweden consistently ranks as a top-performing country across various dimensions of green industrial location attractiveness, while the rankings of other countries may shift based on the specific emphasis placed on different factors. Although the results show changes, roughly the same countries remain in the top ten. The rankings of the bottom countries also remained stable. In Appendix A1, calculations with both wind and energy intensity set to zero are provided, offering some alternative scenarios with varied weighting of the variables.

Table 2 Alternative weightings for the index.

2: Emphasis on Renewable Energy (40 percent for Renewable Energy Share 2021, 15 percent for each of the other factors)	3: Focus on Energy Prices (40 percent for Electricity Prices Non-Household, 15 percent for each of the other factors)	4: Balancing Energy Efficiency and Renewable Energy (30 percent for Energy Intensity, 30 percent for Renewable Energy Share, 10 percent for each of the other factors)	5: Emphasis on Change in Electricity Price (40 percent for 2021-2022 Price Change, 15 percent for each of the other factors)
1. Sweden	1. Germany	1. Germany	1. Germany
2. Finland	2. Sweden	2. Sweden	2. Sweden
3. France	3. Finland	3. Finland	3. Finland
4. Portugal	4. Latvia	4. Austria	4. Austria
5. Denmark	5. Austria	5. Netherlands	5. Portugal
6. Austria	6. Portugal	6. Portugal	6. Netherlands
7. Germany	7. Netherlands	7. France	7. France
8. Spain	8. Spain	8. Spain	8. Spain
9. Netherlands	9. Denmark	9. Denmark	9. Denmark
10. Greece	10. Greece	10. Greece	10. Greece

Table 3 is designed to provide transparency in the data used to create the GILAI. By presenting the data, the index can be extended for analysis with countries outside the European Union. Researchers and policymakers can use this data to benchmark EU countries against global counterparts, enhancing the index's applicability in broader contexts. The table's format is structured for easy data extraction and subsequent analysis. Additional data is presented adjacent to new wind installations (in parentheses), showing not only the extent of wind power capacity expansion in each country but also the share of wind power within the country's overall energy mix (the data is based on Wind Europe, 2023 and some own calculations). The proportion of wind power is telling as it highlights the relative importance and integration of wind energy in the national power grids. The added metric is indicative due to several factors, the variability of wind power generation dependent on geographical and meteorological conditions, the country's investment in and commitment to renewable energy infrastructure, and the evolving efficiency of wind technology. The share of wind power is influenced by the overall growth in national energy demand and the concurrent development of other energy sources. As such, the contrast of wind power capacity expansion with its share of the national energy portfolio nuances the view of a country's progress and possibility towards renewable energy adoption and its potential for future wind energy integration. For example, Denmark did not add much wind power but is a strong wind power nation and the suitable places for wind power might be saturated.

Table 3 Values that the ranking is based on.

	Electricity prices non household	Energy intensity of the economy	New Wind installations in (MW), percent share of countries electricity in parentheses	Percent change electricity price	Renewable energy share
Finland	0,14	162,6	2430 (14)	41,0	43,1
Sweden	0,19	108,4	2441 (25)	55,4	62,6
France	0,15	108,2	2070 (8)	23,1	19,3
Germany	0,25	100,3	2745 (26)	9,8	19,2
Austria	0,21	102,1	328 (12)	39,7	36,4
Portugal	0,17	125,5	28 (26)	15,9	34,0
Greece	0,26	129,9	230 (19)	9,7	21,9
Spain	0,26	111,7	1659 (25)	52,4	20,7
Denmark	0,41	58,6	131 (55)	38,1	34,7
Netherlands	0,20	119,7	1302 (19)	31,1	13,0
Luxembourg	0,16	76,4	29 (25)	54,8	11,7
Poland	0,18	212,0	1517 (11)	35,1	15,6
Latvia	0,26	197,8	59 (3)	59,6	42,1
Ireland	0,31	44,2	280 (34)	46,9	12,6
Italy	0,39	97,3	526 (7)	83,2	19,0
Malta	0,15	280,0	0 (0)	-0,4	12,2
Belgium	0,29	147,8	303 (13)	65,3	13,0
Slovenia	0,22	155,3	0 (0)	83,7	25,0
Bulgaria	0,22	405,2	0 (4)	14,7	17,0
Croatia	0,27	175,4	0 (6)	109,7	31,3
Cyprus	0,37	120,8	0 (6)	62,7	18,4
Lithuania	0,40	199,3	69 (12)	136,2	28,2
Estonia	0,31	239,3	0 (8)	69,5	38,0
Czechia	0,21	216,8	0 (1)	107,7	17,7
Slovakia	0,29	198,5	0 (0)	80,6	17,4
Romania	0,43	189,7	0 (12)	176,4	23,6
Hungary	0,28	211,6	0 (2)	117,7	14,1

Including a rank-based version of Table 4, where actual values are replaced with country names, enables a simplified overview and enhancing the accessibility of the data. It serves as a benchmarking tool, allowing for an evaluation of progress and comparison with peers in a straightforward manner.

Table 4 Ranking but with country name instead of value.

Electricity prices non household	Energy intensity of the economy	New Wind installations in (MW)	Percent change electricity price	Renewable energy share	Overall Ranking
Finland	Ireland	Germany	Malta	Sweden	Finland
Malta	Denmark	Sweden	Greece	Finland	Sweden
France	Luxembourg	Finland	Germany	Latvia	France
Luxembourg	Italy	France	Bulgaria	Estonia	Germany
Portugal	Germany	Spain	Portugal	Austria	Austria
Poland	Austria	Poland	France	Denmark	Portugal
Sweden	France	Netherlands	Netherlands	Portugal	Greece
Netherlands	Sweden	Italy	Poland	Croatia	Spain
Czechia	Spain	Austria	Denmark	Lithuania	Denmark
Austria	Netherlands	Belgium	Austria	Slovenia	Netherlands
Bulgaria	Cyprus	Ireland	Finland	Romania	Luxembourg
Slovenia	Portugal	Greece	Ireland	Greece	Poland
Germany	Greece	Denmark	Spain	Spain	Latvia
Spain	Belgium	Lithuania	Luxembourg	France	Ireland
Greece	Slovenia	Latvia	Sweden	Germany	Italy
Latvia	Finland	Luxembourg	Latvia	Italy	Malta
Croatia	Croatia	Portugal	Cyprus	Cyprus	Belgium
Hungary	Romania	Malta	Belgium	Czechia	Slovenia
Belgium	Latvia	Slovenia	Estonia	Slovakia	Bulgaria
Slovakia	Slovakia	Bulgaria	Slovakia	Bulgaria	Croatia
Estonia	Lithuania	Croatia	Italy	Poland	Cyprus
Ireland	Hungary	Cyprus	Slovenia	Hungary	Lithuania
Cyprus	Poland	Estonia	Czechia	Belgium	Estonia
Italy	Czechia	Czechia	Croatia	Netherlands	Czechia
Lithuania	Estonia	Slovakia	Hungary	Ireland	Slovakia
Denmark	Malta	Romania	Lithuania	Malta	Romania
Romania	Bulgaria	Hungary	Romania	Luxembourg	Hungary

Table 5 ranks countries from 2018 to 2021 based on their annual total scores in GILAI. There is a component of a dynamic nature of green industrial attractiveness across European nations, reflecting evolving policies and market conditions. Over this four-year period, the table reveals shifts in rankings. Countries like Finland and Sweden consistently improve or maintain high rankings. Finland shows a notable increase in attractiveness, moving from a score of 91 in 2018 to 103 in 2021. Sweden remains a consistently high performer, with minor fluctuations but consistently at the top. France also ranks highly overall, and Germany gains steadily. The distribution has shifted from a more average state to one where countries are either scoring high or low. Conversely, some countries experience a decline in their overall ranking, such as Greece, which falls from a score of 87 in 2018 to 52 in 2021. Countries like Bulgaria (69 in 2018 and 62 in 2022) and Ireland (63 in 2018 and 52 in 2022) show significant negative fluctuations in their rankings over the observed period. This variability suggest vulnerability in some factors. Other lower-ranked countries may possess untapped potential for growth in green industrial sectors, and only improving some factors might attract some investments. For instance, a drive to expand renewable output or decreasing variability in prices with grid expansion to other countries might be helpful.

Table 5 Score overtime 2018-2021

	Overall score 2018	Overall score 2019	Overall score 2020	Overall score 2021
Austria	95	87	71	90
Belgium	69	71	64	62
Bulgaria	61	60	73	34
Croatia	59	65	82	85
Cyprus	37	33	64	57
Czechia	74	61	52	66
Denmark	96	96	89	85
Estonia	56	68	80	49
Finland	91	99	95	103
France	99	92	86	102
Germany	83	82	69	79
Greece	87	95	91	52
Hungary	56	38	45	57
Ireland	63	75	77	52
Italy	86	70	69	68
Latvia	83	78	74	66
Lithuania	68	66	64	59
Luxembourg	77	69	72	83
Malta	70	66	68	79
Netherlands	76	67	70	65
Poland	60	71	43	57
Portugal	78	81	85	95
Romania	61	50	56	59
Slovakia	39	35	42	61
Slovenia	60	56	64	84
Spain	74	83	78	75
Sweden	98	113	122	101

5. Discussion

5.1 Discussion of the results

The top three countries distinguish themselves with competitive electricity prices, energy efficiency, a commitment to renewable energy, and stable pricing environments. However, the green industry allocation will ultimately hinge on the specific requirements and priorities of industrial establishments, in addition to industry-specific factors. Regarding the countries at the bottom of the rankings, while they possess some positive aspects, they consistently rank low across most factors in the index.

Table 1 indicates a North/South divide in Europe concerning electricity prices, energy intensity, and renewable energy. Northern European countries typically rank higher, reflecting strong performance in these areas and indicating a greater emphasis on sustainability and lower energy intensity. In contrast, Southern European countries generally rank lower, highlighting challenges related to electricity prices, energy intensity, and the adoption of renewable energy. These disparities likely come from differences in energy policies, resources, and the historical development of energy infrastructure across the countries.

Table 2 indicates that the GILAI's stability is relatively robust, showing a consistent ranking across various weighting scenarios. This consistency is particularly noticeable in the case of Sweden, which maintains a top position regardless of the specific factors emphasized or the weights assigned to them. The rankings of other countries may fluctuate somewhat when different factors receive higher or lower weights. For instance, Finland's ranking can significantly change depending on the emphasis placed on factors. Despite some variability in rankings due to the weighting of factors, the overall trends, and the continued prominence of countries like Sweden suggest that the model is generally reliable and stable for assessing the attractiveness of locations for green industrial development.

Following historical and contemporary research presented in Section 2.1 the determinants of optimal industrial location, highlighting the relevance of both classical microeconomic theories and New Economic Geography. Classical theories, introduced by figures such as von Thünen (1826) and Weber (1909), emphasize the significance of production costs, capital, location, power, transportation, labor availability, and raw materials in influencing industrial productivity and location decisions (Renner, 1947; McCann and Sheppard, 2003). These theories underscore the influence of local policies, taxes, and regulations on the attractiveness of a location (Devereux et al., 2014; Ekhart and Breese, 2023). In the context of the green transition, the importance of these factors evolves to include green power sources to meet the demands of the green market and comply with regulatory measures like the EU's Carbon Border Adjustment Mechanism (CBAM) but also one’s forthcoming. There are reasons to believe that there is a growing significance of green electricity access in industrial location decisions and other related issues, hence the Index serve as a guide.

The evolving rankings in Tabel 5 highlight areas for further research, particularly in understanding the factors that drive changes in green industrial location attractiveness. Policymakers can use these insights to develop strategies that bolster their country's attractiveness, such as through enhanced support for innovation in green technologies, infrastructure upgrades, and international collaborations. What we see is stability in the top but maybe also a divergence upward by the top countries which might indicate that these countries have a more developed green agenda and might benefit in the future when it comes to green industrial investments.

The EU has undertaken several initiatives to promote RES and reduce greenhouse gas emissions (Grafström, 2018a; Grafström, 2018b). This shift towards clean energy may influence electricity prices and potentially transform the industrial landscape by encouraging or requiring the adoption of sustainable practices. In 2022, wind and solar power reached a historic milestone by generating one-fifth (22 percent) of the EU's electricity, marking the first time RES outpaced fossil gas (20 percent) and exceeded coal power (16 percent) in their contribution to the electricity mix (Eurostat, 2023c). In response to Russia's incursion into Ukraine in 2022, Europe accelerated its transition towards a more sustainable electricity system, focusing on rapidly reducing gas consumption and phasing out coal.

Without an adequate and reliable electricity supply, sectors may face limitations in production capacity, leading to decreased productivity and potential job losses. An insufficient electricity supply can deter businesses from expanding or initiating new ventures, thereby limiting job creation, and narrowing opportunities in the labor market. Higher electricity prices may lead to reduced employment due to decreased output, yet they could also increase the demand for technicians while reducing the demand for manual labor. The impact of rising energy prices on employment within the manufacturing sector hinges on multiple factors, such as energy intensity, trade exposure, and the capacity for intra-firm job reallocation.

The shift towards renewable energy sources, although advantageous for decarbonization and sustainability, can initially elevate electricity prices due to the costs of infrastructure investments and associated expenses. The integration of energy storage technologies and measures to enhance grid flexibility, necessary to manage the intermittency of renewable sources, further adds to the costs of the electricity system. The service sector, encompassing areas like information technology, telecommunications, and hospitality, relies heavily on a steady electricity supply for smooth operations. Disruptions or inadequacies in electricity supply can hinder their activities. Industries such as mining, heavy manufacturing, and data centers, characterized by high energy demands, may find it challenging to fulfill their operational needs without sufficient electricity. The influence of electricity prices on the industrial landscape is just one of many factors affecting economic activity and industrial development, with labor costs, the regulatory environment, market demand, technological progress, and government policies also playing crucial roles.

5.2 Discussion of implications for effective policy

Considering the discussion above and the presented index, policy that emerge from the analysis to improve a country’s position is natural to bring to discussion. Effective policy interventions are essential for improving countries position in terms of both stability and competitiveness. This section will explore how targeted policies can mitigate challenges, optimize energy usage, and support sustainable industrial growth, thereby positioning countries favorably in the GILAI. It is not overall comprehensive in terms of every possible policy, but rather a few policies that could be implemented on the demand side and supply side are provided.

	Electricity prices non household	**Energy intensity of the economy**	**New Wind installations in (MW)**	**Percent change electricity price**	**Renewable energy share**

Supply side policy	Tax Rebates, direct subsidies, Feed-in-Tariffs	Market based mechanisms	Stable regulatory environment, Regulatory efficiency, Tax rebates, direct subsidies	Support base production, grid connection to other countries,	R&D Funding, Reduce monopoly power.
Demand side policy	Reduced taxes, Bulk purchasing agreements	Energy efficiency regulations	Renewable energy portfolio standards	Industrial rate plans, Power Purchase Agreements (PPAs)	Pilot programs, Competition on the market

The factors used in the index are focused on energy issues, which can be influenced to varying extents by energy policy. Starting with electricity prices for non-household consumers, governments can take several steps to reduce prices, particularly in the long run (Li and Yao, 2020). On the supply side, governments can introduce tax reductions within the EU framework to lower prices. They can also provide direct subsidies to industries, especially those that are energy-intensive, to reduce their electricity costs, although this may pose challenges with EU competition rules (Burke and Kurniawati, 2018). However, states can offer loans, tax rebates or credits to industries that achieve certain energy efficiency targets or construct their own renewable energy capacity, which aligns with the EU's Fit for 55 frameworks.

Industrial policy has become a central issue in the international economic debate (Juhász et al., 2023; Evenett et al., 2024). Increased geopolitical tensions, the pandemic, and climate change have brought questions of economic and national security to the forefront. Many governments are under pressure to adopt active industrial policies (Aiginger and Rodrik, 2020). However, countries should exercise caution when engaging in industrial policies that allocate resources to firms. The conventional argument against industrial policy is that it is difficult to implement successfully due to the risks of regulatory failures and negative market effects (Munger, 2022; Juhász and Lane, 2024). Industrial policies have often been costly and can lead to corruption and resource misallocation. To expand energy supply, a feed-in-tariff system could be more effective, as it has been successful in increasing supply in the past, though not without problem.

There were problems with feed-in-tariffs in Spain in 2008 and France in 2010, the combination of feed-in-tariffs with an underestimation of cost reductions triggered a rapid expansion in the photovoltaic market (del Río and Mir-Artigues, 2012; de La Tour et al., 2013). This rapid growth led to a sudden policy shift, including the introduction of a payment cap for installations and a reduction in FITs, which ultimately caused the market to collapse. Such generous deployment policies can drive up integration costs and result in technology lock-in (Kim and Tang, 2020).

To rapidly increase supply, it may be necessary to facilitate public-private partnerships to attract investment in the energy sector, particularly in renewable energy projects, combined with state-led grid improvement initiatives and energy efficiency programs to manage demand (Martins and Cruz, 2011). In the long term, the initiation of nuclear power plants may be justified, with full awareness of the uncertainties surrounding nuclear costs and political risks. However, countries with nuclear energy have performed well in the index. Currently, adding nuclear power could provide a significant boost for a country, though the effect may diminish over time.

Reducing taxes can, depending on the supply sources and grid connection to other countries, be counterproductive. If demand surges, more marginal producers, such as gas power plants, might be brought online, increasing prices. Uncoordinated actions by individual firms might not be optimal for everyone. If all firms increase production, the prices they pay could rise. In the GILAI Index, we have assumed that lower electricity prices are a competitive advantage that will be a key factor in industry establishments. This could be counterbalanced by allowing the negotiation of bulk energy purchase agreements on behalf of industries, securing lower rates through collective bargaining.

A solution is to simultaneously work on policies directed toward the supply side. This can be done at all government levels. Tax deductions for homeowners installing solar panels might have a small impact individually, but if several hundred thousand people take advantage, the collective effect could be significant (Matisoff and Johnson, 2017). In the medium term, it is necessary to enable the construction of wind power farms. The time to obtain permits needs to be shortened in several countries where it can currently take decades. Simplifying and speeding up the permitting process for energy projects would reduce development time and costs. Over time, renewables can provide cheaper electricity once the initial capital costs are amortized.

When it comes to improving the energy intensity of the economy, steps can be taken that benefit all energy consumers. This can be achieved by implementing and enforcing stricter energy efficiency standards for industrial machinery and processes, and by encouraging the adoption of best available technologies (BAT) that consume less energy. The state can implement future requirements for the minimum technology standards that will be allowed to operate. Additionally, the state can promote the adoption of energy management systems, such as ISO 50001, which help organizations systematically reduce energy consumption. There is a wealth of knowledge that does not always spill over. The state can engage in training programs for businesses on best practices in energy management, helping them to optimize their energy use.

If a government pursues green, future-oriented industries, it could be acceptable to impose stricter conditions on incumbent industries that consume large amounts of energy with little value added. Introducing market-based mechanisms, such as cap-and-trade systems for carbon emissions, can incentivize firms to reduce energy use and improve energy intensity.

Stability is crucial for electricity-intensive industries, as variability introduces uncertainty in production planning. The government can assist by developing specific industrial rate plans that offer lower electricity prices in exchange for commitments to higher or stable consumption levels (Guang et al., 2022). In the short term, price stability can be achieved by adopting policies that promote a balanced energy mix through investments in various types of power plants (renewables, nuclear, natural gas) to reduce reliance on any single, potentially expensive source. A politically challenging but potentially necessary step is to collaborate with neighboring regions or countries to import/export electricity during peak periods or shortages. The political challenge here is that citizens in countries with lower average prices may not want to be connected to markets with higher average prices, as this could raise their prices. However, for production to expand, it is necessary for producers to receive better compensation for their product.

For renewable energy to play a larger role, energy markets need to function more effectively. The energy market has long faced challenges with dominant market players and natural monopolies (Tulloch et al., 2018; Halkos, 2019). This market structure, characterized by high entry barriers, can delay the development of renewable energy (Przychodzen and Przychodzen, 2020; Painuly, 2001). EU regulations are gradually moving the electricity market toward openness and increased competition (Halkos, 2019; Duso et al., 2019; Tulloch et al., 2018). Energy companies are now offering similar prices and services, resulting in more options for customers. This has led to more frequent switching of suppliers by customers, who benefit from a greater variety of market offers (Halkos, 2019). Tulloch et al. (2018) observed a decline in electricity companies’ returns over 17 years, indicating increased competition in the European electricity market. However, slow implementation of these changes has allowed some market failures to persist.

For all points in the index, it would be beneficial to invest in smart grid technology to reduce energy losses and manage supply and demand more efficiently. The grid is the basic infrastructure, much like railroads are for heavy transports, and if it operates more effectively, transaction costs in the sector will decrease, integrating renewable energy sources more efficiently. Upgrading transmission and distribution infrastructure can reduce inefficiencies and energy losses, ultimately lowering costs.

6. Conclusion

In the end it comes down to energy policy. Energy policy is crucial for all aspects discussed in this paper because it underpins the successful implementation of a green reindustrialization in Europe. If a country has effective energy policy it facilitates stable and competitive electricity prices, ensures the availability of renewable energy sources, and promotes energy efficiency—all of which can bring new green industries. To accurately predict where green industries will be allocated in Europe, it is essential to consider a broader range of factors and conduct detailed market and feasibility studies. While the index can serve as a valuable starting point and provide a general overview.

AI statement

During the preparation of this work the author(s) used ChatGPT4 in order to grammar check. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the publication.

References

Acs, Z. J., Braunerhjelm, P., Audretsch, D. B., & Carlsson, B. (2009). The knowledge spillover theory of entrepreneurship. *Small business economics*, 32, 15-30.

Aiginger, K., & Rodrik, D. (2020). Rebirth of industrial policy and an agenda for the twenty-first century. *Journal of industry, competition and trade*, 20, 189-207.

Ari, M. A., Arregui, M. N., Black, M. S., Celasun, O., Iakova, M. D. M., Mineshima, M. A., ... & Zhunussova, K. (2022). Surging energy prices in Europe in the aftermath of the war: How to support the vulnerable and speed up the transition away from fossil fuels. International Monetary Fund.

Astrov, V., Hanzl-Weiss, D., Leitner, S. M., Pindyuk, O., Pöschl, J., & Stehrer, R. (2015). Energy efficiency and EU industrial competitiveness: Energy costs and their impact on manufacturing activity (No. 405). wiiw Research Report.

Bae, S. (2009). The responses of manufacturing businesses to geographical differences in electricity prices. *The Annals of Regional Science*, 43, 453-472.

Barteková, E., & Ziesemer, T. H. W. (2019). The impact of electricity prices on foreign direct investment: evidence from the European Union. *Applied Economics*, 51(11), 1183-1198.

Bijnens, G., Konings, J., & Vanormelingen, S. (2022). The impact of electricity prices on European manufacturing jobs. *Applied Economics*, 54(1), 38-56.

Burke, P. J., & Kurniawati, S. (2018). Electricity subsidy reform in Indonesia: Demand-side effects on electricity use. *Energy Policy*, 116, 410-421.

Capello, R., & Cerisola, S. (2023). Regional reindustrialization patterns and productivity growth in Europe. *Regional Studies*, 57(1), 1-12.

Chlechowitz, M., Reuter, M., & Eichhammer, W. (2022). How first comes energy efficiency? Assessing the energy efficiency first principle in the EU using a comprehensive indicator-based approach. *Energy Efficiency*, 15(8), 59.

Colby, C. C. (1933). Centrifugal and centripetal forces in urban geography. *Annals of the Association of American Geographers*, 23(1), 1-20.

Cox, M., Peichl, A., Pestel, N., & Siegloch, S. (2014). Labor demand effects of rising electricity prices: Evidence for Germany. *Energy Policy*, 75, 266-277.

Crabbé, K., & De Bruyne, K. (2013). Taxes, agglomeration rents and location decisions of firms. *De Economist*, 161(4), 421-446.

de La Tour, A., Glachant, M., & Ménière, Y. (2013). Predicting the costs of photovoltaic solar modules in 2020 using experience curve models. *Energy*, 62, 341-348.

del Río, P., & Mir-Artigues, P. (2012). Support for solar PV deployment in Spain: Some policy lessons. Renewable and Sustainable Energy Reviews, 16(8), 5557-5566.

Deschenes, O. (2011). *Climate policy and labor markets. In The design and implementation of US climate polic*y (pp. 37-49). University of Chicago Press.

Devereux, M. P., Griffith, R., & Simpson, H. (2004). The geographic distribution of production activity in the UK. *Regional science and urban economics*, 34(5), 533-564.

Dillig, M., Jung, M., & Karl, J. (2016). The impact of renewables on electricity prices in Germany–An estimation based on historic spot prices in the years 2011–2013. *Renewable and Sustainable Energy Reviews*, 57, 7-15.

Dogan, E., Hodžić, S., & Šikić, T. F. (2023). Do energy and environmental taxes stimulate or inhibit renewable energy deployment in the European Union?. *Renewable Energy*, 202, 1138-1145.

Duso, T., Seldeslachts, J., & Szücs, F. (2019). The impact of competition policy enforcement on the functioning of EU energy markets. *The Energy Journal*, 40(5), 97-120.

Ekhart, G., & Breese, R. (2023). The influence of government upon multinational company manufacturing location decisions. *European Management Review*, 20(3), 512-529.

Elliott, R., Sun, P., & Zhu, T. (2019). Electricity prices and industry switching: evidence from Chinese manufacturing firms. *Energy Economics*, 78, 567-588.

European Commission, (2023). 2050 long-term strategy. https://climate.ec.europa.eu/eu-action/climate-strategies-targets/2050-long-term-strategy_en

European Commission, 2018. Energy efficiency directive. https://energy.ec.europa.eu/topics/energy-efficiency/energy-efficiency-targets-directive-and-rules/energy-efficiency-directive_en

European Commission, 2023. The Commission produces quarterly reports on EU gas and electricity markets. https://energy.ec.europa.eu/data-and-analysis/market-analysis_en#electricity-market---recent-developments

European Commission, 2023b. Energy taxation. https://energy.ec.europa.eu/topics/markets-and-consumers/energy-taxation_en

European Commission, Joint Research Centre, Camia, A., Giuntoli, J., Jonsson, R. et al., The use of woody biomass for energy production in the EU, Publications Office, 2021, https://data.europa.eu/doi/10.2760/831621

Eurostat, 2023a. Electricity price statistics. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Electricity_price_statistics#Electricity_prices_for_non-household_consumers

Eurostat, 2023c. Electricity production, consumption and market overview https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Electricity_production,_consumption_and_market_overview#Market_shares

Eurostat, 2023d. Preliminary 2022 data for energy show mixed trends. https://ec.europa.eu/eurostat/web/products-eurostat-news/w/ddn-20230705-2. Accessed 2023-10-06.

Evenett, S., Jakubik, A., Martín, F., & Ruta, M. (2024). The return of industrial policy in data. The World Economy. IMF.

Faiella, I., & Mistretta, A. (2020). Energy costs and competitiveness in Europe. Bank of Italy Temi di Discussione (Working Paper) No, 1259.

González, J. S., & Alonso, C. Á. (2021). Industrial electricity prices in Spain: A discussion in the context of the European internal energy market. *Energy Policy*, 148, 111930.

Grafström, J. (2018a). International knowledge spillovers in the wind power industry: evidence from the European Union. *Economics of Innovation and New Technology*, 27(3), 205-224.

Grafström, J. (2018b). Divergence of renewable energy invention efforts in Europe: an econometric analysis based on patent counts. *Environmental Economics and Policy Studies*, 20, 829-859.

Grafström, J., & Poudineh, R. (2023). No evidence of counteracting policy effects on European solar power invention and diffusion. *Energy Policy*, 172, 113319.

Guang, F., Wen, L., & Sharp, B. (2022). Energy efficiency improvements and industry transition: An analysis of China's electricity consumption. *Energy*, 244, 122625.

Halkos, G. (2019). Examining the level of competition in the energy sector. Energy Policy, 134, 110951.

Hanawalt, E., & Rouse, W. (2017). Assessing location attractiveness for manufacturing automobiles. *Journal of Industrial Engineering and Management (JIEM)*, 10(5), 817-852.

Hawker, G., Bell, K., & Gill, S. (2017). Electricity security in the European Union—The conflict between national Capacity Mechanisms and the Single Market. *Energy Research & Social Science*, 24, 51-58.

Hille, E., & Möbius, P. (2019). Do energy prices affect employment? Decomposed international evidence. *Journal of Environmental Economics and Management*, 96, 1-21.

Horowitz, J. (2022). Europe's Scorching Summer Puts Unexpected Strain on Energy Supply. New York Times. https://www.nytimes.com/2022/08/18/world/europe/drought-heat-energy.html

IEA (2022), Hydroelectricity, IEA, Paris https://www.iea.org/reports/hydroelectricity, License: CC BY 4.0

Jansen, J. C., & Seebregts, A. J. (2010). Long-term energy services security: What is it and how can it be measured and valued?. *Energy Policy*, 38(4), 1654-1664.

Juhász R., och Lane N. (2024). The Political Economy of Industrial Policy. CESifo Working Paper No. 11143.

Juhász, R., Lane, N., & Rodrik, D. (2023). The new economics of industrial policy. *Annual Review of Economics*, 16.

Kazem, H. K. (2021). Determine the optimal location for the industrial facility. *Journal Port Science Research*, 4(4), 243-251.

Kim, J. E., & Tang, T. (2020). Preventing early lock-in with technology-specific policy designs: The Renewable Portfolio Standards and diversity in renewable energy technologies. *Renewable and Sustainable Energy Reviews*, 123, 109738.

Kiss, V. M., Hetesi, Z., & Kiss, T. (2024). The effect of time resolution on energy system simulation in case of intermittent energies. *Renewable and Sustainable Energy Reviews*, 191, 114099.

Krugman, P. R. (1992). A dynamic spatial model. *NBER Working Paper* 4219.

Lamb, W. F., Wiedmann, T., Pongratz, J., Andrew, R., Crippa, M., Olivier, J. G., ... & Minx, J. (2021). A review of trends and drivers of greenhouse gas emissions by sector from 1990 to 2018. *Environmental research letters*, 16(7), 073005.

Larsen, M. L., & Dupuy, K. (2023). Greening industry: Opportunities and challenges in electricity access for Norwegian industry firms. *Journal of Cleaner Production*, 136534.

Li, J., Jiang, Q., Dong, K., & Dong, X. (2022). Does the local electricity price affect labor demand? Evidence from China's industrial enterprises. *Environment, Development and Sustainability*, 1-25.

Li, R., & Leung, G. C. (2021). The relationship between energy prices, economic growth and renewable energy consumption: Evidence from Europe. *Energy Reports*, 7, 1712-1719.

Li, X., & Yao, X. (2020). Can energy supply-side and demand-side policies for energy saving and emission reduction be synergistic?---A simulated study on China's coal capacity cut and carbon tax. *Energy Policy*, 138, 111232.

López-Bazo, E., Vayá, E., & Artis, M. (2004). Regional externalities and growth: evidence from European regions. *Journal of regional science*, 44(1), 43-73.

Makridou, G., Andriosopoulos, K., Doumpos, M., & Zopounidis, C. (2016). Measuring the efficiency of energy-intensive industries across European countries. *Energy Policy*, 88, 573-583.

Marin, G., & Vona, F. (2017). The impact of energy prices on employment and environmental performance: Evidence from French manufacturing establishments. Working paper 053.2017. Fondazione Eni Enrico Mattei (FEEM).

Marin, G., & Vona, F. (2019). Climate policies and skill-biased employment dynamics: Evidence from EU countries. *Journal of Environmental Economics and Management*, 98, 102253.

Marin, G., & Vona, F. (2021). The impact of energy prices on socioeconomic and environmental performance: Evidence from French manufacturing establishments, 1997–2015. *European Economic Review*, 135, 103739.

Martins, A. C., Marques, R. C., & Cruz, C. O. (2011). Public–private partnerships for wind power generation: The Portuguese case. *Energy policy*, 39(1), 94-104.

Matisoff, D. C., & Johnson, E. P. (2017). The comparative effectiveness of residential solar incentives. Energy Policy, 108, 44-54.

McCann, P., & Sheppard, S. (2003). The rise, fall and rise again of industrial location theory. *Regional studies*, 37(6-7), 649-663.

Moreno, B., López, A. J., & García-Álvarez, M. T. (2012). The electricity prices in the European Union. The role of renewable energies and regulatory electric market reforms. *Energy*, 48(1), 307-313.

Munger, M. (2022). A" Good" Industrial Policy Is Impossible: With an Application to AB5 and Contractors. JL Econ. & Pol'y, 17, 517.

Ovaere, M., Kenis, M., Van den Bergh, K., Bruninx, K., & Delarue, E. (2023). The effect of flow-based market coupling on cross-border exchange volumes and price convergence in Central Western European electricity markets. *Energy Economics*, 118, 106519.

Painuly, J. P. (2001). Barriers to renewable energy penetration; a framework for analysis. *Renewable energy*, 24(1), 73-89.

Pavlínek, P. (2020). Restructuring and internationalization of the European automotive industry. *Journal of Economic Geography*, 20(2), 509-541.

Przychodzen, W., & Przychodzen, J. (2020). Determinants of renewable energy production in transition economies: A panel data approach. Energy, 191, 116583.

Renner, G. T. (1947). Geography of industrial localization. *Economic Geography*, 23(3), 167-189.

Rodrik, D. (2016). Premature deindustrialization. *Journal of economic growth*, 21, 1-33.

Rokicki, T., Jadczak, R., Kucharski, A., Bórawski, P., Bełdycka-Bórawska, A., Szeberényi, A., & Perkowska, A. (2022). Changes in Energy Consumption and Energy Intensity in EU Countries as a Result of the COVID-19 Pandemic by Sector and Area Economy. *Energies*, 15(17), 6243.

Sarra, A., Di Berardino, C., & Quaglione, D. (2019). Deindustrialization and the technological intensity of manufacturing subsystems in the European Union. *Economia Politica*, 36(1), 205-243.

Schiele, H. (2008). Location, location: the geography of industry clusters. *Journal of business strategy*, 29(3), 29-36.

Sgaravatti, G., S. Tagliapietra and Zachmann G. (2023). Adjusting to the energy shock: the right policies for European industry. Brugele. https://www.bruegel.org/policy-brief/adjusting-energy-shock-right-policies-european-industry

Sisodia, G. S., Soares, I., Ferreira, P., Banerji, S., Van den Poel, D., & Kumar, M. (2015). Does the use of solar and wind energy increase retail prices in Europe? Evidence from EU-27. *Energy Procedia*, 79, 506-512.

Škuflić, L., & Družić, M. (2016). Deindustrialisation and productivity in the EU. Economic research-*Ekonomska istraživanja*, 29(1), 991-1002.

Smith, D. M. (1966). A theoretical framework for geographical studies of industrial location. *Economic Geography*, 42(2), 95-113.

Solar Europe, 2023. https://api.solarpowereurope.org/uploads/5222_SPE_EMO_2022_full_report_ver_03_1_319d70ca42.pdf

Spänhoff, B. (2014). Current status and future prospects of hydropower in Saxony (Germany) compared to trends in Germany, the European Union and the World. Renewable and Sustainable Energy Reviews, 30, 518-525.

Strbac, G. (2008). Demand side management: Benefits and challenges. *Energy policy*, 36(12), 4419-4426.

Tate, W. L., Ellram, L. M., Schoenherr, T., & Petersen, K. J. (2014). Global competitive conditions driving the manufacturing location decision. *Business Horizons*, 57(3), 381-390.

Tirkolaee, E. B., Goli, A., & Mardani, A. (2023). A novel two-echelon hierarchical location-allocation-routing optimization for green energy-efficient logistics systems. *Annals of operations research*, 324(1), 795-823.

Trujillo-Baute, E., del Río, P., & Mir-Artigues, P. (2018). Analysing the impact of renewable energy regulation on retail electricity prices. *Energy Policy*, 114, 153-164.

Tulloch, D. J., Diaz-Rainey, I., & Premachandra, I. M. (2018). The impact of regulatory change on EU energy utility returns: the three liberalization packages. Applied Economics, 50(9), 957-972.

Tutak, M., & Brodny, J. (2022). Renewable energy consumption in economic sectors in the EU-27. The impact on economics, environment and conventional energy sources. A 20-year perspective. *Journal of Cleaner Production*, 345, 131076.

Von Thünen, J. H. (1826). *Der isolierte staat in beziehung auf landwirtschaft und nationalökonomie*. Germany: Jena.

Wang, H. (2016). Do mandatory US state renewable portfolio standards increase electricity prices?. *Growth and Change*, 47(2), 157-174.

Weber, A. (1909). *Über den Standort der Industrien (Theory of the location of industries)*. Chicago: University of Chicago Press.

Wind Europe, 2023. Wind energy in Europe. https://windeurope.org/intelligence-platform/product/wind-energy-in-europe-2022-statistics-and-the-outlook-for-2023-2027/

World Nuclear organization. (2023). Plans For New Reactors Worldwide. https://world-nuclear.org/information-library/current-and-future-generation/plans-for-new-reactors-worldwide.aspx

Zhao, Y., Ke, J., Ni, C. C., McNeil, M., Khanna, N. Z., Zhou, N., ... & Li, Q. (2014). A comparative study of energy consumption and efficiency of Japanese and Chinese manufacturing industry. *Energy Policy*, 70, 45-56.

Appendix:

Appendix A1: Explained calculation

Here we calculate the Total (GILAI) scores for all countries in the table when "Energy Intensity of the Economy" and "New Wind Installations in 2022 (MW)" are weighted as zero, it serves as an example for how the index is calculated:

GILAI = (w1 * Electricity Prices) + (0 * Energy Intensity) + (0 * Wind Installations) + (w4 * Price Change) + (w5 * Renewable Energy Share). GILAI for each country based on the remaining factors:

- Sweden: GILAI = (1 * 21) + (0 * 20) + (0 * 26) + (1 * 15) + (1 * 27) = 21 + 0 + 0 + 15 + 27 = 63
- Finland: GILAI = (1 * 27) + (0 * 12) + (0 * 25) + (1 * 11) + (1 * 26) = 27 + 0 + 0 + 11 + 26 = 64
- Austria: GILAI = (1 * 18) + (0 * 22) + (0 * 19) + (1 * 10) + (1 * 23) = 18 + 0 + 0 + 10 + 23 = 51

- France: GILAI = (1 * 25) + (0 * 21) + (0 * 24) + (1 * 6) + (1 * 14) = 25 + 0 + 0 + 6 + 14 = 45
- Spain: GILAI = (1 * 14) + (0 * 19) + (0 * 23) + (1 * 13) + (1 * 15) = 14 + 0 + 0 + 13 + 15 = 42
- Germany: GILAI = (1 * 15) + (0 * 23) + (0 * 27) + (1 * 3) + (1 * 13) = 15 + 0 + 0 + 3 + 13 = 31
- Italy: GILAI = (1 * 4) + (0 * 24) + (0 * 20) + (1 * 21) + (1 * 12) = 4 + 0 + 0 + 21 + 12 = 37
- Luxembourg: GILAI = (1 * 24) + (0 * 25) + (0 * 12) + (1 * 14) + (1 * 1) = 24 + 0 + 0 + 14 + 1 = 39
- Portugal: GILAI = (1 * 23) + (0 * 16) + (0 * 11) + (1 * 5) + (1 * 21) = 23 + 0 + 0 + 5 + 21 = 49
- Latvia: GILAI = (1 * 12) + (0 * 9) + (0 * 13) + (1 * 16) + (1 * 25) = 12 + 0 + 0 + 16 + 25 = 53
- Denmark: GILAI = (1 * 2) + (0 * 26) + (0 * 15) + (1 * 9) + (1 * 22) = 2 + 0 + 0 + 9 + 22 = 33
- Netherlands: GILAI = (1 * 20) + (0 * 18) + (0 * 21) + (1 * 7) + (1 * 4) = 20 + 0 + 0 + 7 + 4 = 31
- Slovenia: GILAI = (1 * 16) + (0 * 13) + (0 * 1) + (1 * 22) + (1 * 18) = 16 + 0 + 0 + 22 + 18 = 56
- Lithuania: GILAI = (1 * 3) + (0 * 7) + (0 * 14) + (1 * 26) + (1 * 19) = 3 + 0 + 0 + 26 + 19 = 48
- Croatia: GILAI = (1 * 11) + (0 * 11) + (0 * 1) + (1 * 24) + (1 * 20) = 11 + 0 + 0 + 24 + 20 = 55
- Ireland: GILAI = (1 * 6) + (0 * 27) + (0 * 17) + (1 * 12) + (1 * 3) = 6 + 0 + 0 + 12 + 3 = 21
- Belgium: GILAI = (1 * 9) + (0 * 14) + (0 * 18) + (1 * 18) + (1 * 5) = 9 + 0 + 0 + 18 + 5 = 32
- Poland: GILAI = (1 * 22) + (0 * 5) + (0 * 22) + (1 * 8) + (1 * 7) = 22 + 0 + 0 + 8 + 7 = 37
- Greece: GILAI = (1 * 13) + (0 * 15) + (0 * 16) + (1 * 2) + (1 * 16) = 13 + 0 + 0 + 2 + 16 = 31
- Czechia: GILAI = (1 * 19) + (0 * 4) + (0 * 1) + (1 * 23) + (1 * 10) = 19 + 0 + 0 + 23 + 10 = 52
- Romania: GILAI = (1 * 1) + (0 * 10) + (0 * 1) + (1 * 27) + (1 * 17) = 1 + 0 + 0 + 27 + 17 = 45
- Estonia: GILAI = (1 * 7) + (0 * 3) + (0 * 1) + (1 * 19) + (1 * 24) = 7 + 0 + 0 + 19 + 24 = 50
- Cyprus: GILAI = (1 * 5) + (0 * 17) + (0 * 1) + (1 * 17) + (1 * 11) = 5 + 0 + 0 + 17 + 11 = 33
- Hungary: GILAI = (1 * 10) + (0 * 6) + (0 * 1) + (1 * 25) + (1 * 6) = 10 + 0 + 0 + 25 + 6 = 41
- Slovakia: GILAI = (1 * 8) + (0 * 8) + (0 * 1) + (1 * 20) + (1 * 9) = 8 + 0 + 0 + 20 + 9 = 37
- Malta: GILAI = (1 * 26) + (0 * 2) + (0 * 1) + (1 * 1) + (1 * 2) = 26 + 0 + 0 + 1 + 2 = 29
- Bulgaria: GILAI = (1 * 17) + (0 * 1) + (0 * 1) + (1 * 4) + (1 * 8) = 17 + 0 + 0 + 4 + 8 = 29

These are the Total (GILAI) scores for all countries in the table when "Energy Intensity of the Economy" and "New Wind Installations in 2022 (MW)" are weighted as zero. The scores are based on the remaining factors: Electricity Prices, Price Change, and Renewable Energy Share.

Table 6 provides the standardized values for each country across the given metrics, which is done by subtracting the mean and then dividing by the standard deviation for each column. This normalization process helps in comparing the data across different scales and distributions by bringing them to a common scale without distorting differences in the range of values. The index encompasses variables with different units and scales, such as electricity prices (measured in euros per kWh), energy intensity (measured in kWh per unit of GDP), and new wind installations (measured in MW). Standard normalization allows these diverse measures to be compared and combined, providing a transparency of factors influencing the green industrial location attractiveness of countries. By standardizing the data, it is easier to identify outliers and discern patterns across countries and over time. This helps in understanding which countries significantly deviate from the mean in positive or negative directions for each indicator, thereby offering insights into exceptional performances or areas requiring improvement.

Appendix A2: Table 6 Standardized values for each country

Country	Electricity prices non household	Energy intensity of the economy	New Wind installations in 2022 (MW)	Percent change	Renewable energy share 2021
Finland	-1.40	-0.06	2.02	-0.45	1.52
Sweden	-0.81	-0.67	2.03	-0.11	3.11

France	-1.28	-0.67	1.62	-0.88	-0.43
Germany	-0.10	-0.77	2.37	-1.19	-0.43
Austria	-0.57	-0.75	-0.30	-0.48	0.97
Portugal	-1.04	-0.44	-0.63	-1.05	0.78
Greece	0.02	-0.38	-0.59	-1.19	-0.21
Spain	0.02	-0.59	1.14	-0.18	-0.31
Denmark	1.79	-1.41	-0.61	-0.52	0.83
Netherlands	-0.69	-0.49	0.83	-0.69	-0.94
Luxembourg	-1.16	-1.20	-0.63	-0.12	-1.05
Poland	-0.93	0.22	1.04	-0.59	-0.73
Latvia	0.02	0.10	-0.63	0.00	1.44
Ireland	0.61	-1.50	-0.59	-0.31	-0.97
Italy	1.55	-0.80	-0.47	0.55	-0.45
Malta	-1.28	1.04	-0.66	-1.43	-1.01
Belgium	0.37	-0.24	-0.57	0.13	-0.94
Slovenia	-0.45	-0.19	-0.66	0.56	0.04
Bulgaria	-0.45	1.30	-0.66	-1.08	-0.61
Croatia	0.14	-0.00	-0.66	1.18	0.55
Cyprus	1.31	-0.47	-0.66	0.06	-0.50
Lithuania	1.67	0.11	-0.63	1.81	0.30
Estonia	0.61	0.25	-0.66	0.23	1.10
Czechia	-0.57	0.32	-0.66	1.13	-0.56
Slovakia	0.37	0.12	-0.66	0.49	-0.58
Romania	2.02	0.06	-0.66	2.76	-0.07
Hungary	0.25	0.25	-0.66	1.37	-0.85