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A comparison between China and the EU's green industrial policies: strengthening clean energy leadership under the Paris Agreement framework

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Table of contents

Abstract *1*

Summary *2*

Introduction *7*

Chapter 1 – Industrial Policy and Green Industrial Policy *10*

1.1 Industrial policy: definitions, evolution, and theoretical foundations 10

1.2 Climate Policy: concept, evolution and instruments 16

1.3 Green Industrial Policy: concept, instruments and limits 21

Chapter 2 – Green Industrial Policy in China *27*

2.1 Political and economic context: from 1978 to present 27

2.2 Key strategies and initiatives in green industrial policy 32

2.3 The role of the state and key institutional dynamics in shaping the Chinese Green Industrial Policy 42

Chapter 3 – European Union Green Industrial Policy *46*

3.1 Evolution and political-economic context of green industrial policy in the EU 46

3.2 Regulatory and policy frameworks 50

3.3 Challenges and strategic dimensions of the EU's Green Industrial Policy implementation 64

Chapter 4 – Comparative Analysis of China and EU's Green Industrial Policies *69*

4.1 Policy approaches: instruments, targets, and governance 69

4.2 Role in the global green energy transition leadership 73

4.3 Concluding remarks on China and EU's approaches 84

Chapter 5 – Green Industrial Policy and the Paris Agreement *86*

5.1 Focus on the Paris agreement: framework and goals 86

5.2 China's green industrial policies and the Paris Agreement 89

5.3 Alignment of EU policies with the Paris Agreement goals 92

5.4 Lessons learned and policy implications for global climate governance 96

Conclusion *99*

Bibliography *102*

Abstract

This thesis examines the intersection of industrial and climate policies, focusing on Green Industrial Policy as a key driver for the global energy transition. The study is guided by the following research question: “To what extent do China and the European Union’s green industrial policies strengthen their leadership in clean energy, and how is this leadership reflected and aligned with the goals of the Paris Agreement?”.

The study employs a multidisciplinary approach, integrating the analysis of primary legislative sources, such as Chinese Five-Year Plans and EU Green Deal regulations, with technical reports and academic literature.

The main results highlight a fundamental divergence: while China dominates global supply chains through state coordination and massive production, the EU exerts leadership by establishing global sustainability standards and market mechanisms. The study concludes that these divergent strategies strengthen the respective roles of both actors in the clean energy transition. Although industrial sovereignty creates geopolitical tensions, this "green competition" acts as a vital catalyst, transforming the diplomatic pledges of the Paris Agreement into concrete industrial actions and significantly accelerating the global reduction of renewable technology costs.

Summary

Questa tesi esplora l'intersezione tra clima e industria attraverso la lente della Green Industrial Policy. A tal fine, Cina e Unione Europea sono state selezionate come casi di studio principali, in quanto rappresentano due poli dominanti con approcci profondamente diversi. Da ciò deriva la research question che guida l'intera analisi: "In che misura le politiche industriali verdi della Cina e dell'Unione Europea rafforzano la loro leadership nel settore dell'energia pulita, e in che modo tale leadership si riflette ed è allineata con gli obiettivi dell'Accordo di Parigi?". L'obiettivo è quindi valutare non solo l'efficacia interna di queste politiche, ma anche la loro proiezione internazionale, analizzando come la competizione per la leadership tecnologica influenzi l'architettura climatica globale.

La tesi si apre descrivendo come l'intervento pubblico abbia storicamente plasmato lo sviluppo economico e come, nel tempo, le considerazioni climatiche siano diventate inseparabili dalla strategia industriale. L'industrial policy viene presentata come l'insieme delle azioni pubbliche rivolte a orientare la struttura economica verso obiettivi sociali di lungo periodo, soprattutto nei contesti in cui il solo mercato non riesce ad allocare le risorse in modo efficiente. La sua evoluzione mostra una ricorrenza storica: nei momenti di cambiamento strutturale, il ruolo dello Stato torna inevitabilmente centrale. La politica climatica segue una traiettoria parallela: nata come tematica meramente scientifica, è diventata progressivamente un tema cruciale di governance economica man mano che i Paesi hanno riconosciuto i rischi sistemici associati al degrado ambientale e alle emissioni di gas serra. Eventi fondamentali a livello internazionale, come la creazione dell'UNFCCC e del Protocollo di Kyoto, hanno gettato le basi per un'azione globale, successivamente rafforzata da quadri più ambiziosi che hanno incentivato strategie di mitigazione, meccanismi di carbon pricing e la diffusione delle energie rinnovabili. La convergenza tra questi due filoni ha dato origine alla green industrial policy, un ambito in cui gli Stati perseguono simultaneamente la decarbonizzazione e la leadership tecnologica. Questo nuovo paradigma si basa su strumenti come sussidi, supporto alla ricerca e sviluppo, cooperazione pubblico-privato, standard tecnici e interventi regolatori, ma deve confrontarsi anche con limiti legati alla capacità istituzionale, al reperimento delle informazioni, ai vincoli politici e alle disparità territoriali.

All’interno di questo quadro concettuale, la Cina risulta essere un esempio rilevante di come trasformazione industriale e priorità ambientali possano convergere in una strategia nazionale coerente. A partire dalla fine degli anni Settanta, il Paese ha vissuto una rapida industrializzazione, accompagnata da una forte pressione sulle risorse naturali e sugli ecosistemi. Con il progredire delle riforme economiche e l’intensificarsi delle preoccupazioni ambientali globali, le autorità cinesi hanno progressivamente integrato la sostenibilità nella pianificazione di lungo periodo. La governance climatica è passata dall’essere un tema tecnico e marginale a un pilastro dello sviluppo nazionale, soprattutto con la crescita del ruolo della Cina nei negoziati internazionali legati al clima.

La transizione verde cinese prende forma attraverso un modello fortemente diretto dallo Stato. Piani pluriennali e programmi mirati definiscono obiettivi precisi di riduzione delle emissioni, miglioramento dell’efficienza energetica, ristrutturazione dell’industria pesante e accelerazione nella diffusione delle tecnologie rinnovabili. Queste ambizioni sono implementate tramite direttive regolatorie, incentivi finanziari, crediti preferenziali, appalti pubblici e grandi investimenti infrastrutturali. Le imprese statali (SOE) svolgono un ruolo centrale non solo per il loro peso economico, ma anche perché ci si aspetta che allineino le proprie strategie alle priorità nazionali, assumendo responsabilità sociali e ambientali. Nel complesso, l’approccio cinese riflette un modello di industrializzazione verde fondato sulla forte coordinazione centrale, sulla pianificazione strategica e sulla mobilitazione della capacità industriale per accelerare la transizione verso tecnologie a basse emissioni.

L’Unione Europea, inserita in un contesto istituzionale e politico molto diverso, ha sviluppato un proprio percorso per collegare politica industriale e ambizione climatica. Storicamente, l’industrial policy europea ha attraversato una sequenza di fasi: dal protezionismo nazionale all’interventismo coordinato del dopoguerra, poi verso la liberalizzazione e il rafforzamento delle regole di concorrenza, fino a un rinnovato attivismo in risposta alla globalizzazione, alla competizione tecnologica e alla crisi climatica. La protezione dell’ambiente è diventata progressivamente una caratteristica centrale del processo di integrazione europea, sostenuta da un corpus normativo sempre più vasto su emissioni, energia, biodiversità e inquinamento. Con il tempo, gli obiettivi climatici si sono radicati profondamente nei processi decisionali dell’UE, culminando nell’adozione di una strategia che pone la neutralità climatica al centro della

trasformazione economica. Attraverso pacchetti normativi complessi, piani di investimento e iniziative legislative, l'UE mira a ridurre le emissioni, espandere l'energia rinnovabile, migliorare l'efficienza energetica e rafforzare la competitività dell'industria verde. Strumenti come l'ETS, le direttive sulle energie rinnovabili e le *Industrial Alliances* evidenziano un orientamento industriale sempre più strategico. Tuttavia, invece di ricorrere a un controllo diretto dello Stato, l'UE basa il suo approccio su regolazione, incentivi di mercato, obiettivi condivisi e governance multilivello che coinvolge istituzioni, Stati membri, regioni e attori privati. Ciò genera complessità, ma favorisce anche coordinamento, innovazione e un quadro coerente in cui obiettivi climatici e industriali si rafforzano reciprocamente. Le pressioni esterne spingono ulteriormente l'UE a combinare ambizione climatica, resilienza economica e autonomia tecnologica, consolidando la sua capacità di definire norme e standard globali per la transizione verde.
Il confronto tra i due modelli mostra come Cina ed Unione Europea perseguono la decarbonizzazione e la leadership nelle tecnologie pulite attraverso paradigmi modellati dai rispettivi contesti politici, economici e istituzionali. Infatti, la *strategia top-down* della Cina e il ruolo centrale dello Stato contrastano con l'approccio europeo, basato su regolazione, meccanismi di mercato e governance multilivello; questo ha portato anche a forme diverse di leadership globale.
Nello specifico, l'Unione Europea ha utilizzato le politiche industriali verdi per rafforzare la propria leadership energetica tramite strumenti regolatori, economici e diplomatici. Strumenti come il Green Deal rappresentano una forma di *leadership by example,* mentre altre forme di leadership come la *leadership by coalition* e *by power* promuovono l'adesione globale agli standard climatici e pratiche in linea con gli obiettivi di sostenibilità.
La Cina, invece, ha costruito la propria leadership tramite un modello fortemente guidato dallo Stato, caratterizzato da investimenti massicci, sussidi coordinati e pianificazione strategica, che le hanno permesso di affermarsi rapidamente nei settori dell'energia solare, eolica, delle batterie agli ioni di litio e della mobilità elettrica. La Belt and Road Initiative amplifica tale influenza sostenendo la diffusione di tecnologie pulite e rafforzando la posizione della Cina nella transizione globale. Tuttavia, questa leadership è condizionata da pressioni economiche interne, da vulnerabilità delle catene di

approvvigionamento e dalla volontà di mantenere una certa flessibilità negli impegni climatici.

Nel complesso, le politiche cinesi hanno prodotto risultati rapidi e tangibili in termini di capacità industriale e dominio tecnologico, mentre l'approccio europeo consolida una leadership normativa e istituzionale di lungo periodo. Questi due modelli mostrano come la leadership nella transizione energetica possa manifestarsi sia attraverso il potere produttivo e la scala industriale, sia attraverso la capacità di definire regole, standard e meccanismi di governance. È proprio alla luce di questa duplice traiettoria che emerge un interrogativo centrale: in che modo tali forme di leadership si allineano agli obblighi internazionali e agli obiettivi dell'Accordo di Parigi?

In questo contesto, il ruolo di alto profilo della Cina durante Conferenza di Parigi (COP21) evidenzia la necessità strategica di integrare l'azione climatica nelle più ampie iniziative verdi nazionali, promuovendo una crescita socioeconomica sostenibile e affermandosi come potenza globale responsabile. La Cina ha sostenuto un modello di governance multilaterale basato sulla cooperazione *win-win* e sul principio delle responsabilità comuni ma differenziate. L'allineamento cinese all'Accordo dimostra una forte sinergia tra impegni climatici internazionali e strategia industriale nazionale. Difatti, l'uso operativo degli NDC, la pianificazione centralizzata e programmi come "Made in China 2025" mostrano che per la Cina le politiche industriali verdi non sono semplici strumenti ambientali, ma il motore di una nuova fase di crescita e competitività globale.

Anche l'Unione Europea ha svolto un ruolo rilevante nei negoziati di Parigi, adottando un approccio improntato alla costruzione di coalizioni e alla mediazione diplomatica. L'allinemento delle politiche europee passa soprattutto attraverso il pacchetto Fit for 55, essenziale per raggiungere gli obiettivi degli NDC presentati dall'UE nel 2020. L'UE ha costantemente cercato di trasformare i mandati climatici internazionali in un vantaggio competitivo, utilizzando il proprio potere regolatorio per orientare i mercati globali, in linea con il "Brussels Effect".

In conclusione, l'analisi mostra che Cina e Unione Europea hanno intrapreso percorsi profondamente diversi ma complementari verso la leadership nella transizione energetica, evidenziando come la leadership possa assumere forme differenti: da un lato, potere industriale e scala produttiva; dall'altro, capacità di modellare regole, incentivi e meccanismi di mercato.

L’interrogativo sull’allineamento di tali leadership agli obiettivi dell’Accordo di Parigi trova risposta nelle strategie adottate da entrambi gli attori. Il ruolo assunto dalla Cina alla COP21 e le diverse iniziative confermano la volontà di integrare l’azione climatica nelle più ampie strategie di sviluppo e dimostrano una forte convergenza tra obiettivi industriali e impegni climatici, facendo delle politiche verdi il motore di una nuova fase di crescita e competitività globale. Parallelamente, l’Unione Europea ha contribuito in maniera decisiva alla definizione dell’Accordo, promuovendo meccanismi di revisione periodica e obiettivi climatici basati sulla scienza. L’allineamento conferma la volontà europea di trasformare i mandati internazionali in un vantaggio competitivo, consolidando il proprio ruolo di potenza normativa.

Dalla comparazione emerge che la competizione tra Cina e UE, più che ostacolare la cooperazione multilaterale, agisce come catalizzatore della transizione globale. La ricerca della leadership tecnologica accelera innovazione e riduzione dei costi, facilitando l’adozione di NDC più ambiziosi e avvicinando la comunità internazionale agli obiettivi cruciali dell’Accordo di Parigi. Entrambi i modelli risultano indispensabili: la Cina offre velocità e capacità produttiva, l’UE fornisce stabilità regolatoria e architetture di governance.

La sfida principale resta chiudere il divario tra ambizione diplomatica e attuazione concreta, garantendo un equilibrio tra rapida espansione industriale e alti standard ambientali e sociali, a conferma di come la transizione energetica sia un processo complesso in cui politica industriale e diplomazia climatica procedono in modo strettamente interdipendente.

Introduction

Climate change is the defining issue of our time and represents one of the most significant challenges facing humanity. It is not merely an environmental emergency or an ethical dilemma, but a powerful catalyst for transforming the global economy, geopolitics, and production systems. While mitigation policies were previously viewed as a constraint on industrial growth, this paradigm has shifted. As sustained by the United Nations, we are at a defining moment: decarbonization has become the central force of a new global industrial competition. In this context, the energy transition serves as a primary driver, where technological leadership in renewable energy defines the economic power and strategic autonomy of nations.

This thesis aims to analyze the intersection between climate and industry through the lens of Green Industrial Policy. To this end, China and the European Union have been selected as the primary case studies, representing two different models of green development with divergent structural approaches. Therefore, the core of this research lies in a fundamental question that guides the entire analysis: “To what extent do China and the European Union’s green industrial policies strengthen their leadership in clean energy, and how is this leadership reflected and aligned with the goals of the Paris Agreement?”. The objective is therefore to evaluate not only the domestic effectiveness of these policies but also their international projection, analyzing how the competition for technological leadership influences global climate architecture.

In this context, China has adopted an extremely effective 'top-down' model, characterized by strong central direction, a pervasive role of state-owned enterprises (SOEs), and long-term planning, as highlighted by the Five-Year Plans and the *Made in China 2025* strategy, which has allowed the country to dominate global supply chains. Conversely, the European Union pursues a leadership based on regulatory and normative power. Through the *European Green Deal*, the *Fit for 55* package, and the recent *Net-Zero Industry Act*, the EU aims to create an ecosystem where sustainability becomes the competitive standard, seeking to balance climate ambition with the protection of its industrial base and energy independence.

This comparison takes place within the international framework defined by the 2015 Paris Agreement. The Agreement marked a turning point, transforming mitigation

commitments into clear market signals for investors. However, the nature of Nationally Determined Contributions (NDCs) has triggered a new dynamic: leadership is measured on the ability to provide the technological solutions necessary for global decarbonization. Therefore, the thesis investigates how the strengthening of domestic industrial capacities in China and the EU is reflected in their positioning within the Paris Agreement.

Regarding the research methodology, this study employs a multidisciplinary approach that integrates the analysis of both primary and secondary sources. The analytical framework includes official legislative texts, such as the Chinese Five-Year Plans and European Green Deal regulations, as well as technical reports published by different international organizations, such as the International Energy Agency (IEA). These data have been complemented by an extensive review of existing academic literature in environmental economics and international relations, in order to provide a critical and comparative assessment of the industrial strategies of both actors.

The thesis is structured in five chapters. The first chapter outlines the theoretical foundations of industrial policy and climate policy, highlighting how the concept of green industrial policy is strategic for positioning nations in the future of the global clean energy. Chapters two and three delve respectively into the Chinese and European case studies. The chapter on China analyzes the historical evolution of its policies from 1978 to the present and focuses on four of the major industrial policies: 12th China Five Year Plan, Made in China, Industrial Green Development and 14th China Five Year Plan. This paragraph concludes with a focus on the role of the state and the key institutional dynamics that shape Chinese green industrial policy, highlighting how central coordination and state-owned enterprises drive the country's strategic objectives.
Instead, the chapter on the European Union focuses the historical evolution from the early environmental directives to the Green Deal for the European Union. It analyzes the development of key regulatory and policy instruments, in particular, it focuses on the European Green Deal, the Green Deal Industrial Plan for the Net-Zero Age, the Fit for 55 package and the Industrial Alliances.

This section concludes with an analysis of the challenges and strategic dimensions of the EU's implementation process, focusing on how its regulatory-driven model aims to balance decarbonization with industrial competitiveness and strategic autonomy.

The fourth chapter is dedicated to a comparative analysis of the case studies. Through the examination of instruments, targets, and governance models, this section explores how these two different approaches shape their respective roles in the global green energy transition. Specifically, it examines how China's manufacturing dominance and the EU's regulatory leadership interact within the global market. Finally, the fifth chapter synthesizes how these dynamics align with the goals of the Paris Agreement, assessing the growing tensions between industrial sovereignty and multilateral cooperation. This final section examines whether the competition for clean energy leadership helps accelerate global climate action or instead creates obstacles to the cooperation required by the Paris Agreement.

Chapter 1 – Industrial Policy and Green Industrial Policy

1.1 Industrial policy: definitions, evolution, and theoretical foundations

To understand Green Industrial Policy is essential to first understand what Industrial Policy and Climate Policy are, since these two concepts blend into the focus area of this thesis: the Green Industrial Policy.

The literature about Industrial Policy shows that there is not a common and agreed definition of this industrial policy, and all descriptions differ slightly. It usually refers to "government actions to alter the structure of an economy, encouraging resources to move into particular sectors that are perceived as desirable for future development" (Altenburg and Assmann, 2017: 2). Other authors define it as "government policies that explicitly target the transformation of the structure of economic activity in pursuit of some public goal" (Juhász et al., 2024: 216). The lack of a common and shared definition of industrial policy is also the causes of the main limit of industrial policy: the lack of a distinct framework of objectives, tools, and institutions, including a legal structure that defines the boundaries of industrial policy and specific public bodies responsible for implementing it (Heinrich et al., 2024: 89)

Nevertheless, a common aspect shared in the different definitions of industrial policy is that it targets a set of economic activities to achieve long-term benefits for society, moving beyond short-term competitiveness and economic growth and focalizing on a multidimensional objective usually defined as long-term social welfare (Tagliapietra and Veugelers, 2020: 14).

Industrial Policy addresses problems and different constraints that can lead to a failure in the market growth and can prevent the development and birth of new markets (Tagliapietra and Veugelers, 2020: 15). In other words, the core of industrial policy can be defined as the attempt to challenge market failures. This characteristic is also central when analyzing Green Industrial Policy.

The origins of industrial policy date back to the late 18th century. In 1791, Alexander Hamilton laid the foundations for U.S. industrial policy with his *Report on the Subject of Manufactures*, in which he proposed high tariffs to protect emerging industries, subsidies for small domestic firms, import restrictions, tax exemptions for strategic sectors, a ban

on technology exports, and major infrastructure investments to achieve industrial self-sufficiency.

During the 19th century, governments increasingly focused on infrastructure. The United Kingdom invested heavily in railways and steamships while beginning to liberalize trade, whereas the United States expanded railways, canals, and telegraph networks. By the late 19th and early 20th centuries, industrial policies evolved to balance state intervention with market forces. For example, the United Kingdom supported SMEs through tariffs and subsidies, while Latin American countries like Argentina, Brazil, and Mexico adopted import substitution industrialization (ISI), using quotas and tariffs to foster domestic industries.

After the Second World War, industrial policies became central to reconstruction efforts. A broad consensus emerged around the idea that public investment, innovation support, and multilateral trade and financial arrangements were essential for economic recovery and growth. This approach influenced both advanced and developing economies, with remarkable successes in East Asia. The focus was on correcting coordination failures and stimulating sectors that could generate broad economic spillovers.

From the 1970s onwards, enthusiasm for industrial policy decreased as neoliberal economics emphasized the inefficiencies of state intervention.

In the late 1990s and early 2000s, industrial policy experienced a revival, driven by growing awareness of market failures and environmental challenges. Economic crises, inequality, and climate change further reinforced calls for state intervention. Rising geopolitical tensions have also brought strategic industries back into focus. The recent resurgence of Industrial policy created major initiatives as the *European Green Deal in the EU's* and the *Made in China 2025* plan, launched in 2015 by China. Both initiatives aim to promote innovation, technological independence, and leadership in high-value industries (European Bank for Reconstruction and Development, 2024).

Industrial policy involves a diverse set of actors whose roles and interactions are crucial to the design, implementation, and evaluation of policies. At the central level, governments define strategic objectives, allocate resources, and set regulatory frameworks, ensuring alignment with national economic priorities (Criscuolo et al., 2022: 33; EBRD, 2024). Implementation is often delegated to specialized public agencies, which manage programs, monitor outcomes, and provide guidance to firms. Firms

themselves are key actors, as both beneficiaries and active participants in policy initiatives, particularly when engaged in public–private partnerships or research and development projects (Juhász et al., 2024). Academic institutions, research centers, and industry associations also play a supportive role by supplying technical expertise, conducting evaluations, and fostering innovation networks (Heinrich et al., 2024: 93). The effectiveness of industrial policy depends not only on the instruments and strategies employed but also on the capacity of these actors to coordinate effectively, share information, and adapt to changing economic conditions. Poor coordination or misalignment among actors can lead to inefficiencies, policy failure, or unintended consequences, highlighting the importance of institutional capacity and coherent governance structures (Juhász et al., 2024: 216).

The main economic rationales for industrial policy are externalities, coordination failures, and activity-specific inputs, and each of these requires a different type of remedy. The first two rationales are common market failures. Indeed, market failures act often as a justification for state intervention and correction via industrial policy.

Economic activity produces positive externalities when the actions of firms or individuals create benefits for others that are not reflected in market prices or captured by the person or company performing the activity (Juhász et al., 2024: 216). Externalities can also be defined as negative when the economic activity impacts create a cost on others not directly involved in the activity in question. The second rationale, the coordination failures, is defined as a "situation in which the profitability of an individual producer depends on the level of related economic activities undertaken by others" (Juhász et al., 2024: 217). This situation is also influenced by the idea that many projects require collaboration in various steps of the value chain (Tagliapietra and Veugelers, 2020: 25). In other words, it means that coordination would help the profitability of producer A and producer B, but they fail in coordinating, and this produces a low-level equilibrium in which no producer invests in development or innovation because it is considered as non-productivity without coordination.

The third rationale refers to the peculiarity of public inputs to specific economic activities. Indeed, private production relies on the provision of public goods, seen as beneficial and neutral. However, producers' needs differ across sectors and locations, leaving them "doomed to choose" which activities to prioritize (Juhász et al., 2024: 217).

Industrial policy attempts to address these market failures, while trying to solve other issues, such as inequality, related to the growing intangible nature of economies (Tagliapietra and Veugelers, 2020: 26).

Moving on the importance of industrial policy in the international landscape, especially in the G20 nations. We can see that its importance and presence is increasing in the last decade, driven by global economic challenges such as technological competition, digitalization and post-pandemic recovery. Juhász (2024) demonstrates an increase in the total count of industrial policy interventions through the 2010s, with notable peaks in 2018 and 2021 (*Figure 2*). Furthermore, higher-income countries are the primary users of industrial policy interventions and frequency of policy industrial intervention increase with income per capita (Juhász et al., 2024: 220-221).

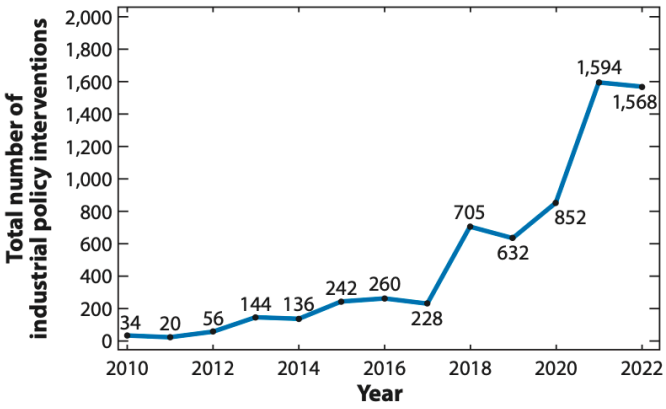

Figure 1: Number of industrial policy interventions globally from 2010 to 2022. Source: Juhász, R., Lane, N. and Rodrik, D. (2024) 'The New Economics of Industrial Policy', Annual Review of Economics, 16, pp. 222.

Industrial policies can be distinguished in three main types. First, *government-driven policies*, in which governments play an active role in directing, coordinating and making decisions. Usually, this approach brings strong financial and regulatory incentives for firms which follow the government's project. Second, *firm-driven* process is characterized by the key role of firms in initiating projects and make both technological and investment decisions. Lastly, in the collaborative industry policy process, firms and governments collaborate to define goals, strategies, projects and investments decision. (Allan and Nahm, 2025: 423).

Industrial policy can also be distinguished as vertical industrial policy or horizontal industrial policy, according to the type of intervention. Vertical approach of industrial

policy prevailed mainly during the 1960s and 1970s and is characterized by the availability of interventions only to a certain type of firms. Its adoption criteria can depend, for example, on the typology of activity, technology or location. Today, industrial policy is mainly horizontal: states apply different approaches across different sector, creating a heterogeneous mix of industrial policies, in some cases even in the same sector (Allan and Nahm, 2025: 420).

To understand how industrial policy works, as cited by Criscuolo et al. (2022), it is interesting to distinguish policy instruments and industrial strategies. A policy instrument is "a tool used by policymakers to affect performance outcomes in the business sector in order to achieve a pre-defined objective" (Criscuolo et al., 2022: 15). On the other hand, industrial strategies are "a consistent and articulated group of policy instruments designed in order to reach specific policy objectives" (Criscuolo et al., 2022: 15). Instruments choice and strategy design have consequences on the formulation of industrial policy, as shown in *Figure 2*. Understanding the interplay between these two dimensions is crucial, since the overall effectiveness of industrial policy depends on the internal coherence between instruments and strategic goals. Furthermore, this distinction allows policymakers to identify whether shortcomings in policy outcomes derive from inappropriate instruments or from inconsistencies at the strategic level.

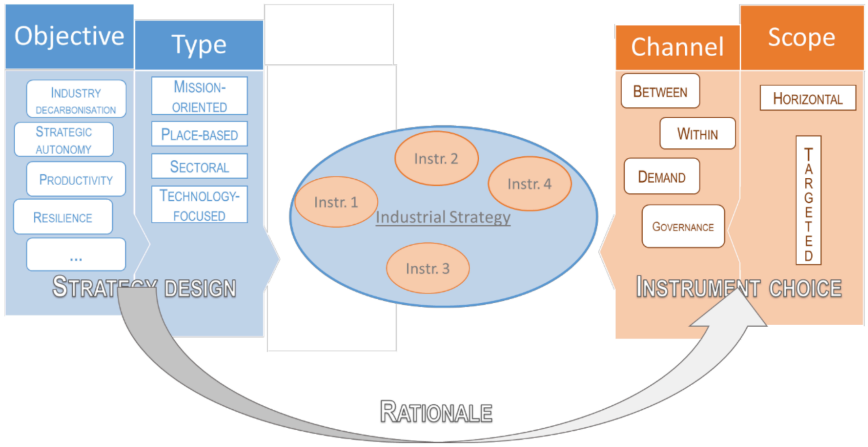

Figure 2: The formulation of industrial policy. Source: Criscuolo, C. et al. *(2022) 'An industrial policy framework for OECD Countries',* OECD Science, Technology and Industry Policy Papers.

The main instruments of industrial policies are diverse, but the most common are subsidies. Subsidies can take various forms and may target specific types of exports, investments, or research and development activities (Juhász et al., 2023: 216). According

to the OECD (2022), subsidies are particularly effective when they are carefully designed to complement broader policy objectives and avoid market distortions. In addition to subsidies, other frequently employed instruments include import protection measures, tax exemptions, and public procurement policies; those can help coordinate private sector activities and address market failures (Criscuolo et al., 2022: 19).

Beyond these, governments often implement preferential loans, and credit guarantees to facilitate access to finance for strategic sectors, as well as investment in human capital and training programs to develop sector-specific skills (Juhász et al., 2024: 91). Regional development incentives and infrastructure support are also widely used to encourage investment in less-developed areas and improve the overall efficiency of industrial ecosystems (OECD, 2022: 32). As highlighted by Heinrich (2025), the effectiveness of these instruments depends on their integration within a coherent industrial strategy, which ensures alignment between individual tools and broader policy objectives.

Critics of industrial policy are mainly inspired by neoclassical theory, which assumes that governments lack the knowledge and information necessary to decide which industries should be promoted or protected. Moreover, governments may fail to provide the appropriate incentives to drive market transformation, reinforcing the belief that free markets and trade are preferable, as markets are presumed capable of self-regulation (Heinrich et al., 2024: 90–91). In addition to these theoretical criticisms, empirical evidence on the effectiveness of industrial policy remains limited. Most studies are constrained in scope, often focusing on specific policies or individual countries, and produce inconsistent findings regarding the outcomes of government interventions. For instance, while some analyses examined by Heinrich et al. (2024) provide valuable insights into national experiences, they do not allow for systematic cross-country comparisons.

According to Juhász et al. (2024) and Heinrich et al. (2024), these limitations highlight the need to consider industrial policy as a complex system in which the choice of instruments, the coherence of strategies, and institutional capacities jointly determine effectiveness. The OECD Policy Paper (2022) further emphasizes that poorly designed instruments may lead to market distortions or suboptimal allocation of resources, which can reinforce the critics' concerns. Therefore, despite promising national experiences, the overall evidence base remains insufficiently rigorous, underlining the need for more

systematic and comparative empirical research to assess the true impact of industrial policy. In summary, both theoretical and empirical limitations suggest that while industrial policy can offer valuable tools for economic development, its design and implementation require careful evaluation to ensure effectiveness and avoid unintended consequences.

1.2 Climate Policy: concept, evolution and instruments

Over the past three decades, new macroeconomic and geopolitical challenges have transformed global political economy and in this contest the perception on climate changes has changed accordingly. Climate change has developed beyond the idea of a purely environmental issue, becoming also a political and economic problem (Allan and Nahm, 2025: 420). Climate change was initially framed solely as an environmental problem that would impose costs on states and was later understood as an economic opportunity (Allan and Nahm, 2024: 422). The collapse of the Kyoto regime and the dramatic cost decline in solar and wind supply chains showed the limits of market-based policy while demonstrating the potential of a technology-focused route.

In this context, climate policy acquired more importance. Nowadays, it refers to the strategies, laws, and actions that governments and institutions develop to address the causes and impacts of climate change. These policies aim to reduce greenhouse gas (GHG) emissions, adapt to climate impacts, and promote sustainable development. The main aim of climate policy is best captured by the idea of achieving decarbonization. Climate policy is not just about environmental protection; it also involves economic, social, and political considerations (Tagliapietra Veugelers, 2020: 38).

The formulation of climate policy is shaped by the interaction of domestic, regional, and international factors, requiring interconnections and synergies to understand the complexities of climate policy. At the domestic level, climate policy is influenced by the interplay of diverse interest groups, national legal frameworks, and socio-economic conditions. Domestic policymakers must balance environmental ambitions with economic competitiveness, social equity, and other national objectives, while responding to the needs of industry, civil society, and local authorities. At the international level, climate governance aims to foster cooperation and accountability among countries in pursuing shared climate goals. Nevertheless, disparities in national priorities, capabilities,

and policy approaches often challenge effective global coordination and collective action (Böttcher at al., 2024: 3).

Approaches to climate policy vary significantly across countries. Some countries adopt more proactive climate measures than other countries.

Four factors can determine the proactivity of governments: international context, the structure of government, the degree of political accountability, and the characteristics of interest groups (Steves and Teytelboym, 2013: 9).

At the international level, governments engage strategically with one another, each one aiming to benefit from the global climate regime while minimizing their own costs. Because there is no overarching authority with real enforcement power, this situation resembles a voluntary contribution game toward a public good, which can be defined as the stabilization of the global climate. At the domestic level, each national government translates these international commitments into concrete policies. In this sense, international pledges act as a background condition rather than a binding constraint for domestic decision-making.

Domestic climate policymaking primarily depends on the structure of government. In each government, there are more parties involved, such as "veto players" or coalitions, which interests may diverge, and these situations can make change and decisions more difficult. The behavior of veto players is shaped by political accountability. In democratic systems, politicians must consider the preferences of their voters. In fact, the responsiveness of a democracy depends not only on electoral rules but also on media freedom and the educational level of citizens.

Lastly, interest groups significantly influence domestic climate policy. Their impact reflects both the underlying economic structure of a society and the degree of organization of specific groups (Steves and Teytelboym, 2013: 9-10).

International attention towards climate change and climate policy intensified in the 1990s. During the 1990 UN General Assembly, the Intergovernmental Negotiating Committee (INC) for a Framework Convention on Climate Change was established, laying the groundwork for the creation of the UN Framework Convention on Climate Change (UNFCCC). The INC involved more than 150 states and discussed binding commitments, targets and timetables for emissions reductions, financial mechanisms, technology transfer, and responsibilities of developed and developing countries. The UN

Framework Convention on Climate Change can instead be defined as the starting point of international climate policy. Indeed, the UNFCCC has worked towards the negotiation of the Kyoto Protocol and the Paris Agreement (Timeline - UNFCCC's website).

The UNFCCC was founded in 1992, but entered into force only in 1994, as a framework for international collaboration aimed at addressing climate change by restricting the rise in global average temperatures and managing the unavoidable environmental consequences that had already become certain (Essential Background - UNFCCC's website). The Convention set only a nonbinding goal of keeping emissions at 1990 levels by 2000. The 1990 baseline was selected because many countries already had greenhouse gas inventories for that year. This nonbinding target ended up benefiting some countries that significantly reduced emissions shortly after 1990, such as Germany after the fall of the Berlin Wall, while disadvantaging others whose emissions had fallen just before 1990 but rose again afterward, like Japan during the post-1988 economic recovery. The Convention's "ultimate objective" of limiting warming to avoid "dangerous human interference" with the climate system (*Article 2 of the UNFCCC*[1]) remained vague and weak, as it is still interpreted more politically than scientifically (Kuyper et al.,2018: 345). As a result of the UNFCCC's ratification, the annual Conferences of the Parties (COPs) were established, providing a regular forum for countries to negotiate, review, and advance global climate action.

Moving on, three years after the entry into force of the UNFCCC, the Kyoto protocol was adopted but entered into force only in 2005 due to the complex ratification process. The Kyoto Protocol puts the UNFCCC into practice by requiring industrialized countries and economies in transition to limit and reduce their greenhouse gas (GHG) emissions according to specific, agreed-upon targets. In contrast, the Convention itself only obliges

[1] *Article 2 of the UN Framework Convention on Climate Change:* The ultimate objective of this Convention and any related legal instruments that the Conference of the Parties may adopt is to achieve, in accordance with the relevant provisions of the Convention, stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner. Available at: https://unfccc.int/resource/docs/convkp/conveng.pdf.

these countries to adopt mitigation[2] policies and measures and to report on their progress periodically.

The Protocol builds on the principles and provisions of the Convention. It is binding only for developed countries and places greater responsibility on them under the principle of "common but differentiated responsibilities and respective capabilities," recognizing that these nations are primarily accountable for the historically high levels of GHG emissions in the atmosphere.

The Kyoto Protocol also establishes legally binding emission reduction targets for 37 industrialized countries, economies in transition, and the European Union. Collectively, these targets aim for an average reduction of 5 percent in emissions relative to 1990 levels over the first commitment period, which ran from 2008 to 2012 (The Kyoto Protocol – UNFCCC's website).

It is interesting to underline that the objectives of the Kyoto Protocol were not completely met for various reasons. A key issue, as mentioned earlier, was the exclusion of developing countries from any binding reduction commitments. In 1997, the United States and the European Union were the largest global emitters of greenhouse gases; by 2006, China had surpassed the United States in annual emissions, and today India's emissions are nearly comparable to those of the EU. Nevertheless, both China and India were classified as developing countries under the Protocol. Another issue is that the Kyoto Protocol did not frame emissions reductions as an economic opportunity to pursue, leading some countries to perceive mitigation measures as a costly obligation rather than a potential benefit (Bassetti, 2023).

Finally, the main policy adopted in the international landscape of climate policy is the Paris Agreement which recognizes the key role of domestic politics in addressing climate change and allows each country to independently determine its own level of commitment to mitigation (Falkner, 2016: 2). This Agreement will be further analyzed in chapter 5 of this thesis.

[2] *Definition of mitigation:* Climate change mitigation refers to any action taken by governments, businesses or people to reduce or prevent greenhouse gases, or to enhance carbon sinks that remove them from the atmosphere. These gases trap heat from the sun in our planet's atmosphere, keeping it warm. Available at: https://climatepromise.undp.org/news-and-stories/what-climate-change-mitigation-and-why-it-urgent.

As with industrial policies, it is essential to examine the instruments employed to fully comprehend the functioning of climate policies and the achievement of their objectives.

Krogstrup and Oman (2019) provide an insightful analysis of the main macroeconomic and financial instruments used in climate policy. The instruments can be distinguished in three categories: Fiscal Policy Tools, Financial Policy Tools and Monetary Policy Tools. Fiscal policy plays a key role in climate mitigation. Instruments such as subsidies for carbon capture, and incentives for R&D help shift consumption and investment toward sustainable models. Fiscal tools include pricing policies (taxes, subsidies), public spending and investment, and government guarantees to attract private capital. Carbon pricing[3] is central to internalizing environmental costs and fostering innovation but must be predictable, gradually implemented, and paired with redistributive spending to ensure social fairness. Public investment in green infrastructure and well-designed public-private partnerships further support the energy transition. Finally, public guarantees and innovative financial instruments can lower risk and mobilize low-carbon investment at scale. (Krogstrup and Oman, 2019: 19-22)

Financial policies play a vital role in mobilizing private investment for climate action. While fiscal tools alone may be insufficient, financial and monetary policies can complement them by correcting market failures and reducing short-termism. Key measures include improving the pricing and transparency of climate risks, reforming governance in financial institutions, and developing markets for green financial instruments like green bonds. Additionally, regulatory incentives may shift investment toward low-carbon assets, though they risk conflicting with prudential standards. Complementary tools, including green asset requirements and standardized certification, can further boost sustainable finance while maintaining financial integrity. (Krogstrup and Oman, 2019: 22-29)

Lastly, monetary policy, traditionally focused on stabilization, can play a supporting role in climate mitigation. Central banks can integrate climate risks into their balance sheets, collateral frameworks, and asset purchases, including ESG criteria to favor low-carbon

[3] *Definition of Carbon Pricing:* "Carbon pricing means incorporating the direct and indirect external costs of CO2 emissions in the prices of fuels, resources, intermediate products, and goods and services. This can be done through a carbon tax or emissions trading (market creation or tradable permits), which do not necessarily generate identical outcomes" (van der Bergh et al., 2021: 748).

assets. Such measures can reduce the cost of capital for sustainable sectors and signal market incentives. Challenges include legal constraints, governance issues, and risks to central bank independence, as these actions complicate monetary and fiscal boundaries. In the long term, rising climate-related financial risks may require adapting monetary policy frameworks to maintain macro-financial stability and support the low-carbon transition. (Krogstrup and Oman, 2019: 29-33)

In conclusion, it is interesting to underline that climate policy establishes the regulatory, fiscal, and financial frameworks necessary to mitigate emissions and manage climate-related risks. But today the approach towards climate action is evolving from traditional climate policy towards a broader green industrial policy that integrates economic development, innovation, and geopolitical competition. This development demonstrates that decarbonization and economic growth can be interconnected, while industrial policy can be an instrument to accelerate green transition. This evolution, in simpler words, is setting the stage for the next phase of research and action in the global energy transition (Allan et al., 2021: 15-16).

1.3 Green Industrial Policy: concept, instruments and limits

Green Industrial Policy consists of investments, incentives, regulations and policy supports designed to encourage and improve the development of environmental technologies, by establishing emphasis on the goal and intent of the policies rather than the instrument used (Allan et al., 2021: 3). In other words, it mobilizes government efforts toward decarbonization while fostering the development of zero-carbon technologies and domestic firms to drive employment, innovation, and growth in green sectors (Rodrik, 2014).

Green Industrial Policy combines the goal of decarbonization and social welfare; this means that, as represented in *Figure 1*, it combines Industrial Policy and Climate Policy. Consequently, this combination raises issues of coordination of the various policies, especially when different institutions or departments are involved.

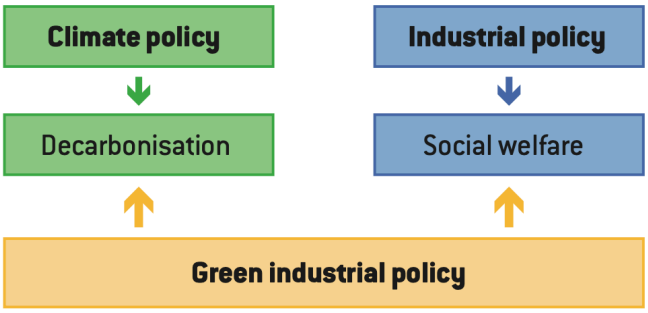

Figure 3: Green Industrial Policy. Source: Tagliapietra, S. and Veugelers, R. (2020) Green Industrial Policy for Europe, Bruegel.

Another important principle at the core of green industrial policy is related to experimentation and the necessity of going beyond the idea of intervention only when clearly needed. Green industrial policy has risks which entails also failures and the awareness that non-action in climate crisis would be dangerous and more costly if delayed (Tagliapietra and Veugelers, 2020: 37-38).

As introduced briefly in the paragraph on Industrial Policy, the economic literature defines green industrial policies as a response to a set of market failures and opportunities related to climate change (Allan et al., 2021: 3). The need of an in-time intervention to correct market failures is also improved by the idea that a clean environment represents a public good.

The main market failure associated with climate change relates to the idea that greenhouse gas emissions are a side-effect of economically valuable activities, but who is responsible of those emissions is not in charge of the costs (Tagliapietra and Veugelers, 2020:16). This brings into account the ethical discourse related to greenhouse gas emissions: emissions impacts subjects external to the market and for this reason, reducing emissions is often seen as an ethical, rather than economic, incentive for businesses and consumers (Tagliapietra and Veugelers, 2020:16). This causes a market failure due to an over-production of greenhouse gas emissions which constitutes an important challenge for green industrial policy (Tagliapietra and Veugelers, 2020: 16). Externalities caused by market failure and by greenhouse gas constitute an important challenge for green industrial policy.

Another concept connected to market failures to consider regards global commons problems and the tragedy of commons. Climate change exemplifies a global commons problem, where the atmosphere serves as a shared sink for greenhouse gases. Indeed,

emissions have global consequences regardless of their origin, meaning that jurisdictions bear the costs of mitigation while the benefits are distributed worldwide. This dynamic leads to the classic tragedy of the commons (Tagliapietra and Veugelers, 2025: 41-42).
In this context, green industrial policy emerges as a strategic response to market failures, particularly those related to environmental externalities and insufficient investment in innovation. Addressing climate change requires multilateral coordination, as unilateral actions are economically disincentivized. While international competition can create zero-sum dynamics, it may also stimulate a race to innovate, helping to correct price distortions and boost R&D (Tagliapietra and Veugelers, 2020: 41-42). Thus, effective green industrial policy should balance cooperation and competition to achieve global climate goals.

Combining classic market failures externalities and green market externalities depicts a relevant challenge for green industrial policy which requires specific instruments, beyond measures usually applied. Green industrial policy encompasses a set of instruments that governments employ to guide technological innovation and economic restructuring toward sustainability and low-carbon growth.
Rodrik (2014) argues that green industrial policy instruments combine traditional industrial policy tools, such as subsidies, trade protection, and credit allocation, with environmental objectives, linking industrial competitiveness to decarbonization (Rodrik, 2014: 485). Key mechanisms include fiscal incentives, targeted public investments, and research and development (R&D) funding, which stimulate private innovation and create markets for green technologies (Harrison, et al., 2017: 255). More recent approaches emphasize a comprehensive "policy mix" that integrates carbon pricing, innovation subsidies, and regulatory standards to enhance synergy among instruments and policy goals (van den Bergh et al., 2021: 746).
This adaptive and experimental character of green industrial policy aligns with the broader "new economics of industrial policy," which stresses iterative learning, institutional experimentation, and close coordination between public and private actors (Juhász et al., 2024: 238). Together, these instruments, namely subsidies, tax credits, R&D investments, public–private partnerships, and sectoral alliance, constitute an integrated governance framework through which states actively drive green transitions in the global economy (Allan et al, 2021: 7).

According to Allan and Nahm (2024), green industrial policies differ along two main dimensions: *policy orientation* and *policy initiative*. Orientation ranges from targeted measures, where governments set clear technological or performance goals, to open-ended approaches that encourage innovation under conditions of uncertainty. Policy initiative refers to whether industrial development is state-driven, firm-driven, or collaborative. State-driven policies involve direct governmental coordination of investment and technology, as exemplified by early Chinese programs or the European Battery Alliance. Firm-driven approaches rely on market-based mechanisms and private-sector leadership. Collaborative models, common in the EU and the United Kingdom, align public and private actors through councils, alliances, or co-investment schemes. Collectively, these strategies combine regulatory frameworks, fiscal incentives, R&D support, and supply-chain coordination to stimulate technological innovation, build domestic industrial ecosystems, and integrate national industries into global green value chains (Allan and Nahm, 2024: 423).

At the international level, green industrial policy is strategic for positioning nations in the future of the global clean energy (Allan and Nahm, 2025: 420). This importance originates not only from its environmental implications but also from its role in redefining patterns of global economic competition. In the current phase of the energy transition, green industrial policy functions as both a developmental and a geopolitical instrument, allowing countries to secure technological leadership, access to critical materials, and control over future green value chains (Meckling and Nahm, 2019: 478). The growing emphasis on clean technology industries, which includes renewable energy, reflects a shift in global industrial paradigms where sustainability and competitiveness increasingly converge.

Moreover, at the international level, green industrial policies contribute to reshaping global governance mechanisms by linking trade, investment, and climate objectives. Countries that integrate industrial and environmental agendas, such as the EU with its Green Deal Industrial Plan, are setting new standards for how sustainability can become a driver of competitiveness.

The combination of industrial policy goals and climate policy goals inherently generates coordination challenges, especially when the policies are implemented across different sectors, government departments, or institutions, each with its own priorities,

timelines, and governance structures. Misalignment between objectives can result in policy overlaps, redundancies, or even contradictory measures that undermine the effectiveness of green industrial strategies.

The primary limitation of green industrial policy is attributable to governments themselves. Firstly, green policies are characterized by high uncertainty and require long-term planning to achieve meaningful results, while governments often operate under short-term electoral cycles and political mandates. This mismatch in time horizons makes it difficult to pursue policies whose benefits may only materialize after several years or decades, thereby constraining the potential scope and effectiveness of such interventions (Tagliapietra and Veugelers, 2020: 42-43). Moreover, the unpredictable nature of technological innovation and market dynamics adds another layer of complexity, increasing the risk of policy failure if governments cannot adapt their strategies over time. In addition, governments frequently lack the detailed information and technical knowledge required to select the most promising firms or sectors for support. Such informational constraints can result in suboptimal allocation of resources, inefficiencies, and unintended distortions in the market. The risk is amplified when political considerations influence decision-making, as governments may favor firms or industries with strong lobbying power or political connections rather than those that offer the greatest potential for green innovation or emissions reduction. This type of political manipulation can undermine both the economic and environmental objectives of green industrial policy (Rodrik, 2014: 472).

Administrative and institutional capacity also plays a critical role in the success of green industrial policies. Designing, implementing, and monitoring targeted support programs requires not only financial resources but also effective coordination mechanisms, regulatory frameworks, and technical expertise. Without sufficient capacity, support measures may disproportionately benefit large firms, which already have the resources and visibility to access government programs, while smaller firms, particularly prevalent in developing countries, remain excluded. This is significant because, although larger firms are the main emitters of greenhouse gases and pollutants, collective actions by networks of smaller firms can contribute substantially to emissions reduction and environmental improvements (Harrison et al., 2017: 257).

Developing countries face additional and often more acute challenges. Limited institutional capacity, inadequate financial resources, and weak enforcement mechanisms reduce the ability to implement and sustain environmental regulations. Effective pollution control, for example, requires knowledge of the location and emissions of polluting factories, the ability to verify compliance with environmental standards, and the means to impose sanctions. In many contexts, corruption, lack of trained personnel, and insufficient political commitment can result in the reduction of the overall effectiveness of green industrial interventions. Moreover, imperfect markets for land, labor, and capital constrain the willingness of firms to invest in environmentally friendly technologies, slowing the transition toward low-carbon industrial development (Henderson et al., 2024: 19).

Another challenge relates to the scalability and inclusiveness of green industrial policies. Programs often focus on large or strategically important firms, leaving smaller enterprises on the periphery, despite their potential contributions through collaborative initiatives, shared infrastructure, or adoption of cleaner production methods. Policies that fail to incorporate mechanisms for small and medium-sized enterprises risk leaving significant sources of emissions unaddressed and can exacerbate existing inequalities in access to government support (Harrison et al., 2017: 258).

Finally, poorly designed green industrial policies may generate economic side effects, including market distortions, fiscal burdens, and trade imbalances. Excessive or prolonged support for selected industries can crowd out competition, inflate production costs, and create inefficiencies, undermining both economic and environmental goals. To mitigate these risks, policies should be designed with transparency, adaptability, and complementarity in mind, ensuring alignment with broader climate strategies and fostering an environment conducive to innovation, competition, and sustainable industrial growth (Henderson et al., 2024: 19).

Chapter 2 – Green Industrial Policy in China

China is the world's largest coal producer and the biggest emitter of greenhouse gas, with an energy sector that has significant implications for the global environment. Indeed, China produced 29,2% of total worldwide emissions in 2024 (Crippa et al., 2025: 10) and placed only 159th out of 180 countries in the Environmental Performance Index (Block et al., 2024: XI). Its rapid development and growing economic influence make China's experience and its attempt to transition towards a green industry a valuable source of insight for the global green transition.

This chapter aims to provide a comprehensive analysis of China's green industrial policies by examining their historical evolution, key strategic initiatives, and the interplay between state intervention, firm behavior, and regional heterogeneity, with the objective of understanding how these policies shape the country's transition toward a low-carbon and sustainable industrial economy.

2.1 Political and economic context: from 1978 to present

A comprehensive understanding of China's green industrial policies requires a thorough examination of the nation's historical economic and political context.

China's industrial development has transformed and developed deeply since 1978 and evolved from rapid growth driven by economic reforms to a new era focused on green and sustainable industrial policy.

Starting in the late 1970s, China initiated a broad program of enterprise reform and Opening-Up process. This transformation can be divided into two main phases. The first phase, during the first fifteen years, concentrated on increasing the role of incentives and market mechanisms in guiding the allocation of resources. Instead, from the mid-1990s onward, the focus of reform shifted toward restructuring existing resource stocks, which led to massive layoffs in state-owned industries and the privatization of many government-run enterprises, known as SOEs (Brandt et al., 2010: 6).

The initial phase included increasing incentives and decision-making power at the firm level, along with the introduction of a dual-track pricing system that divided both inputs and outputs between state-planned quotas at fixed official prices and market transactions

at flexible prices determined by supply and demand. Furthermore, other initiatives established the entry of new firm into sectors usually reserved for state enterprises (Brandt et al., 2010: 6-7).

This phase also opened Chinese economy. Indeed, favorable treatment of foreign direct investment and reductions in tariff barriers helped developing the foreign enterprise sector (Brandt et al., 2010: 7).

In the mid-1990s, the reform process broadened to include a major restructuring of labor and capital inherited from the planned economy. State-owned enterprises, labor surplus, and expensive welfare obligations cut tens of millions of jobs. At the same time, the most rural industries moved into private hands. As the Chinese government intentionally reduced the overall size and role of state ownership, corporatization, privatization, bankruptcies, and both market-driven and administrative mergers rapidly reduced the number of state-owned industrial firms.

Apart from employment, which declined due to layoffs in state enterprises, the manufacturing sector maintained a strong growth after 1995. Output, product quality, exports, and labor productivity continued to rise. However, the nature of industrial activity changed significantly. The late 1990s and early 2000s saw a sharp rise in market-oriented behavior, led by the rapid expansion of foreign-invested firms along with the fast growth of private domestic manufacturing and the increasingly commercial strategies of large state-controlled corporations (Brandt et al., 2010: 8-9).

The rapid expansion of multinational companies operating in China, the growth of international supply networks, and the sharp rise in manufactured exports have integrated Chinese industry into the global economy. This process of globalization has encouraged the adoption of many international business standards and practices.

Today, China's approach to industrial planning exhibits several distinctive characteristics. First, the level of financial assistance extended by the Chinese government to domestic industries in pursuit of national industrial goals is exceptionally large. Second, compliance with the objectives outlined in China's industrial strategies is essentially compulsory. Firms have limited autonomy to disregard these directives, even when market dynamics might suggest alternative commercial decisions.

Third, China's system of industrial planning is broader and more intricate than that of any other nation. Rather than relying on a single overarching plan, it encompasses hundreds

of subsidiary plans spanning virtually every sector of the Chinese economy. The formulation and implementation of these plans involve multiple institutions, including various tiers of government and major state-linked enterprises.

Lastly, while most other countries adopt more open and flexible industrial policies, often allowing the participation of foreign partners and avoiding explicit targets for import substitution or domestic market share, China's model is far more directive and domestically oriented, setting concrete quantitative objectives for national production and self-reliance (Li and Du, 2024: 263-264).

Energy transition and the development of renewable energy began to be systematically incorporated into China's industrial policy instruments over the past two decades. Before 2000, China's administrative and institutional setup indicates that climate change was largely understood as a scientific and environmental issue, rather than an economic one. Coordination of national climate policy started in 1990 with the creation of the National Leading Group for Climate Change Coordination, initially controlled by the National Meteorological Administration (NMA). The NMA was central in carrying out early research, taking part in international scientific initiatives, and fulfilling obligations under the Framework Convention following its 1992 ratification (Jiang, 2021: 114). As climate change rose in the global political agenda, China established an interdepartmental committee to shape the government's stance in upcoming negotiations. Furthermore, in 1996, China issued its first independent environmental protection plan, setting out specific quantitative targets (Jiang, 2021: 113).

Throughout this period, upgrading the electricity grid and fostering a domestic renewable energy sector have consistently been highlighted as key priority areas in major Chinese industrial policy documents. For instance, in 2010, the government's designation of seven Strategic Emerging Industries identified clean energy as a central field to receive state support and to serve as a means of exchanging market access for foreign technologies. Later, the *Made in China 2025* initiative, further analyzed in paragraph 2.2, reinforced this direction, emphasizing China's ambition to lead the global manufacturing of energy-saving and new energy vehicles while securing an 80% domestic share in renewable energy equipment production. These state-driven industrial policies not only aimed to establish China's dominance in global renewable energy manufacturing but also introduced measures that stimulated both the supply and the demand for renewable

energy, reinforcing the country's transition toward a low-carbon economy (Li and Du, 2024: 264).

As analyzed above, China's industrialization has been marked by steady and rapid expansion. Although this process has fueled major economic progress and created a broad-based manufacturing sector, it has also led to severe environmental degradation. Its high dependency on coal and the rapid industrialization and urbanization has caused alarming levels of air, water and soil pollution. The environmental degradation represents a limit to a further economic development. Indeed, as explained by Yang et al. (2022), the increase of acid rains and greenhouse effect is slowing the sustainable development of China's economy (Yang et al., 2022: 1055).

The International Energy Agency shows how coal is still largely used in the Chinese energy mix (IEA's website), making China particularly vulnerable to environmental pressures, public concern over air and water quality, and to international criticism. This has led to an increasing importance of environmental protection and sustainability in the national agenda. At the domestic level, it led to the establishment of stricter environmental laws and the creation of the Ministry of Ecology and Environment in 2018 (Wang, 2018: 113). While, at the international level its position evolved in global climate negotiations since the 2010s, when the first attempts to harmonize its economic ambitions with the pressure to contribute to global emission reductions were made.

China's early involvement in the international climate norm–making helped it to fit into the emerging international system and increased its awareness of global environmental issues. Nonetheless, initially it had limited influence over negotiation agendas and the formation of international norms. Early participation was largely tied to the broader context of reform, openness, and economic development (Jiang, 2021: 114).

From the adoption of the UNFCCC to the Kyoto Protocol's entry into force, global climate governance transitioned from a phase of consultation to one focused on distributing responsibilities.

However, China's ratification of the Kyoto Protocol in 2002 signaled its supportive approach to global climate cooperation and its commitment to sustainable development. Its commitment is visible through the substantial changes of the Chinese domestic institutional framework. In 2003, the State Council approved the creation of the National Coordination Committee on Climate Change, later integrated into the National

Development and Reform Commission (NDRC), a central State Council body responsible for economic and social policymaking, five-year planning, energy price regulation, and other functions. This institutional reform reflects that climate change in China evolved from being primarily a scientific and meteorological matter to a political and economic issue closely linked to the country's overall development strategy (Jiang, 2021: 114).
This evolution in China's domestic governance also paved the way for a more active and assertive role in international climate negotiations.
In fact, the 2015 Paris Agreement marked a turning point. During the Paris Climate Change Conference, China's leader advocated for a future global governance model based on a win-win cooperation, where each country contributes according to its capacity, guided by principles of rule of law, fairness, and justice, as well as inclusiveness, mutual learning, and shared development. China's contributions to the success of the conference are seen as a prime example of its proactive and constructive engagement in international governance and multilateral processes (Gao, 2016: 239). Moreover, in 2014 and 2015, China and the United States issued two joint statements that provided significant momentum for the Paris Conference. In advancing post-2020 climate talks, China shifted its focus away from debates over differentiated responsibilities and instead emphasized shared commitments, urging all parties to act under the future climate framework (Jiang, 2021: 116-117). China's active participation and leadership in climate conferences have facilitated opportunities for building consensus between the global North and South.
This diplomatic repositioning not only aimed to improve China's international image but also aligned with domestic priorities to foster innovation, energy efficiency, and global leadership in renewable technologies.

In this sense, China's environmental challenges have become both a constraint and a catalyst for its green industrial transformation. The same state apparatus that once drove high-emission industrialization now plays a central role in steering the transition toward clean energy, using a combination of regulation, investment, and long-term strategic planning to reposition the country as a leader in the global low-carbon economy.

2.2 Key strategies and initiatives in green industrial policy

China represents an interesting example to analyze the effectiveness of green industrial policies due to its prominent economic and environmental development contradictions.

The following section provides an overview and critical discussion of the principal policy frameworks shaping China's green industrial transformation and its broader green development agenda.

Policy's name	**Year**	**Main topic(s)**
12th China Five Year Plan	2010	Advancing green development through strategic industrial transformation
Made in China	2015	Reduction of reliance on foreign technology and China as a global leader in high-tech manufacturing, including the introduction of explicit green innovation (GI) requirements
Industrial Green Development	2016	Acceleration of ecological progress and promotion of industrial green development.
14th China Five Year Plan	2020	Development of a green economy and of a green policy system

Table 1:Summary of key Chinese initiatives on Green Industrial Policies

Among the core policy instruments shaping both green and industrial strategies in China are the Five-Year Plans. These policies offer an ideal empirical context for studying green innovation as a response to green industrial policy. Originally derived from the Soviet model and later adopted by most socialist countries, the Five-Year Plans constitute one of China's key formal institutional frameworks. They outline the central government's economic vision and development targets for the upcoming five years, clarifying national strategic priorities, guiding the behavior of market participants, and specifying the responsibilities of government bodies. Given the complexity and multiple objectives of green industrial policy, nearly all local industrial policies in China are formulated in alignment with the central and provincial Five-Year Plans. The main indicators of these plans include promoting cleaner production technologies, phasing out outdated production processes and equipment within specified timeframes, continually tightening requirements for governments at all levels to fulfill their environmental

responsibilities, and introducing more stringent emission standards across various industries. (Zhu and Tan, 2022: 60)

Green industrial policy constitutes a key component of these plans and serves as a means for government intervention in the market economy. In practice, it applies differentiated measures across industries and combines market-oriented policy tools with direct governmental actions, such as financial subsidies and market-entry approvals, and indirect instruments like credit support and tax incentives.

Consequently, China's Five-Year Plan represents the most comprehensive and structured medium-term policy framework. It ensures policy continuity, and its top-down vertical governance system helps minimize conflicts during implementation. Thus, the environmental protection elements embedded in the Five-Year Plans offer a coherent and wide-ranging basis for capturing green industrial policy (Zhu and Tan, 2022: 60).

The analysis focuses on the 12th and 14th Five-Year Plans, as they contain the most significant provisions related to green industrial policy.

The 12th Five-Year Plan for National Economic and Social Development of the People's Republic of China (2011–2015) is a comprehensive program aimed at fostering economic growth, innovation, competitiveness, and social development, including improved access to education. The plan prioritizes growth across three main sectors: agriculture, industry, and services. Particular attention is given to green development, environmental protection, and energy conservation.

The plan sets binding energy and environmental targets, including achieving a share of non-fossil fuel resources of 11.4% of primary energy consumption by 2015, reducing energy consumption per unit of GDP by 16%, and lowering CO_2 emissions per unit of GDP by 17% within the same period. It also establishes concrete renewable energy deployment goals, such as the construction of 120 GW of hydropower, 70 GW of wind capacity through six onshore and two coastal/offshore large wind power bases, and 5 GW of solar power stations, primarily in Tibet, Inner Mongolia, Gansu, Ningxia, Qinghai, Xinjiang, and Yunnan (IEA, 2011).

The 12th Five-Year Plan identifies seven priority "strategic" sectors to drive green-oriented economic expansion. These include advanced materials, renewable and alternative energy, information technology, high-end equipment manufacturing,

biotechnology, energy efficiency and environmental protection, as well as new energy vehicles such as electric and hybrid models.

China's rapid growth has largely been fueled by exports and heavy investment, particularly in energy- and carbon-intensive industries. However, these sectors impose significant environmental pressures and are incompatible with China's long-term vision of sustainable competitiveness. The government therefore sought to transition from a resource-intensive, low value-added development model to one centered on knowledge, innovation, and higher value creation. In line with this shift, the services sector was expected to take on a larger role, with its share of GDP projected to rise by four percentage points by 2015.

The wider effort to expand green development included in the 12th Plan is closely tied to China's longer-term energy security and climate policy objectives. Fundamentally, the push to support the seven emerging industries is grounded in the pursuit of higher productivity and clean energy innovation. The green growth strategy of the 12th Plan emphasizes improving economic performance through productivity gains, while simultaneously supporting advanced, low-carbon and less energy-intensive sectors. (Li and Wang, 2012: 520)

Additionally, the 12th Five-Year Plan introduces a range of new industrial measures aimed at fostering clean energy sectors and related technologies. The targeted areas include nuclear, solar, wind, and biomass energy technologies, as well as hybrid and electric vehicles, and technologies focused on energy efficiency and environmental protection. These so-called "strategic and emerging industries" are being advanced to replace the older strategic sectors, such as coal and telecommunications, which have traditionally been state-dominated and long benefited from government backing. This shift in China's industrial priorities marks the beginning of a new phase of policy support for the emerging sectors, potentially involving access to dedicated state funds, greater openness to private capital, and additional industrial policy tools, including preferential lending and increased R&D financing. These initiatives collectively aim to drive China toward a more sustainable and energy-efficient industrial and economic structure (Lewis, 2011).

The Plan explicitly calls for a shift from an extensive, low value-added development model toward green, higher-quality growth over the next five years. If situated within a

coherent climate and energy policy framework, this restructuring could generate notable gains in energy efficiency and reductions in CO_2 emissions. Policies that drive this transition could also produce wider benefits, including job creation in emerging sectors, improved human capital, increased household consumption, conservation of finite natural resources, and innovation in high value-added technologies such as clean energy and biotechnology, along with environmental improvements like reduced air pollution. Green industrial restructuring must have been aligned with inclusive development goals emphasized in the Plan. This required establishing protective mechanisms and adaptive institutions to ease macroeconomic shocks associated with sectoral shifts. Thus, a central task for policymakers under the 12th Plan has been to redirect economic resources via macroeconomic adjustment to support consumption-led expansion and development of lower-carbon industries through a broad policy recalibration and strong institutional coordination between national and local authorities (Li and Wang, 2012: 524).

Building on the green-oriented restructuring and long-term sustainability vision laid out in the 12th Five-Year Plan, China's commitment to a low-carbon future was further reinforced when the Chinese President, Xi Jinping, announced in 2020 its intention to achieve carbon neutrality by 2050 at the United Nations General. It was the first time that China made a clear policy statements and declared a timeline for action on carbon neutrality to the world (Lee, 2025). The transition to sustainable growth established in China represent a credible economy strategy for China and can help establishing China's competitive leadership in the global economy. This plan included the structural transformation of industry towards higher skills and technology, the redesign of energy and transports and the development of new technologies (Hepburn et al., 2021: 2).

In this context, and as a natural continuation of China's strategic shift toward low-carbon development, shortly after, the China's 14th Five-Year Plan for 2021–2025 was launched. It offers a significant opportunity for the country to align its long-term climate objectives with its short- and medium-term social and economic development strategies. This plan focalizes on three categories: the energy transition, a new type of sustainable urban development, and investment priorities (Hepburn et al., 2021: 1). This plan is essential to peak carbon dioxide emissions before 2030 and to achieve the 2060 target set by the Chinese President since it accelerates the actions and investments needed for the

transition to sustainable growth and allows China to harvest earlier the economic benefits of these actions and investments (Hepburn et al., 2021: 1).

A central aspect of the 14th China Five Year Plan is represented by the need to generate most of China's electricity from non-fossil-fuels sources and the urgency to expand the use of clean energy. This also means that it is essential to reduce industrial coal consumption through reconstructing and technological process.

The goals of the Plan closely associated with green industrial policies are articulated in Article XXXIX of Part Eleven. In this article, priority is assigned to protecting the ecological environment and advancing green development, with an emphasis on integrated resource management, scientific allocation, broad conservation, and recycling. This approach is intended to support high-quality economic growth alongside high-level environmental protection.

Section Three and Four of Article XXXIX focalize on green economy and green development. In Section 3, emphasis is placed on the vigorous development of a green economy through the curbing of high energy-consuming and high-emission projects and the promotion of green transformation for sustainable growth. Measures include strengthening energy conservation, environmental protection, clean production, clean energy, ecological preservation, green infrastructure upgrades, and green services. Service models such as contract energy management, contract water-conservation management, and third-party environmental governance are encouraged. The clean and efficient use of fossil fuels, including coal, is promoted, alongside the green transformation of steel, petrochemical, building materials, and other industries. A market-oriented green technology innovation system is being established, encompassing research initiatives and benchmarking programs to improve resource efficiency in key industries and products. A unified system for green product standards, certification, and labeling is being developed, complemented by mechanisms to promote energy-saving appliances, high-efficiency lighting, and water-conserving products. Initiatives to cultivate a green lifestyle are also being carried out extensively.

Section 4 focuses on building a green development policy system. Legal and policy frameworks are being strengthened to support green development, including tax policies that incentivize energy conservation, environmental protection, and comprehensive resource utilization. Green finance is being actively developed, and systems for the paid

use of natural resources are being improved, alongside innovative pricing mechanisms for natural resources, wastewater and waste treatment, and energy and water usage. Reforms in energy conservation audits, supervision, and management of key energy-consuming units in fixed-asset investment projects are being implemented, along with enhancements to energy and water efficiency "pacesetter" systems.

In other words, to promote energy conservation, emissions reduction, and comprehensive pollutant control, efforts should focus on key industrial sectors such as steel and iron, nonferrous metals, building materials, and petrochemicals. Industrial enterprises are encouraged to cluster within industrial parks, where energy systems can be optimized and overall pollution management improved.

In the transport and logistics sectors, cutting energy use and emissions involves developing green infrastructure, including railways, highways, ports, shipping routes, and airports,as well as expanding facilities for electric vehicle charging and battery swapping, gas and hydrogen refueling, and shore power supply at ports and airports.

The plan also calls for refining policies and mechanisms aimed at curbing total energy consumption, energy intensity, and overall pollutant emissions. Projects characterized by high energy use and high emissions should be firmly discouraged. Additionally, the plan urges the strengthening of market-based mechanisms by advancing pilot programs for trading energy-use rights and aligning them with carbon emissions trading. It also promotes enhancing energy accounting and online energy-consumption monitoring systems for major energy users. (*The State Council - The People's Republic of China*, 2022).

In short, the current Five-Year Plans define China's environmental protection tasks and industrial development pathways, placing particular emphasis on energy-saving and emission-reduction requirements for industries with high pollution levels and high energy consumption.

In 2015, in line with this strategic shift toward sustainable and high-quality growth, China launched one of the most ambitious industrial initiatives: *Made in China 2025* (MIC 2025). It is a state-driven policy aimed at reducing reliance on foreign technology and establishing China as a global leader in high-tech manufacturing. The plan focuses on ten strategic high-tech sectors, including advanced robotics and artificial intelligence, next-generation IT and telecommunications, and new energy vehicles and

related equipment. It sets concrete targets for production capacity, output levels, and market shares, both domestically and internationally. For instance, China aims to achieve 70% self-sufficiency in high-tech industries by 2025 and to secure a dominant position in global markets by 2049, the centenary of the People's Republic of China (Li and Du, 2024: 264).

To realize these objectives, the government has implemented a wide range of measures, including strategic guidance, substantial subsidies, favorable tax policies, land allocations, preferential access to government procurement, overseas mergers and acquisitions, and other financial and regulatory support (Li and Du, 2024: 264).

The MIC 2025 initiative also prioritizes leadership in the manufacturing of energy-saving and new energy vehicles, as well as maintaining an 80% share of renewable energy equipment production (Li and Du, 2024: 264). In other words, it seeks to tackle the challenges of low energy efficiency and environmental pollution in China's manufacturing sector (Xu, 2025: 2).

It aligns the industry with sustainable development principles by encouraging the adoption of energy-saving and environmentally friendly technologies, advancing the circular economy, building green manufacturing systems, and promoting ecological industrial upgrading. The plan also sets phased goals, aiming to reduce energy, material, and pollutant intensities in key industries by 2020 and to reach internationally advanced standards by 2025 (Xu, 2025: 2-3).

Made in China 2025 designates green manufacturing as a priority and introduces explicit green innovation (GI) requirements across energy use, production processes, and product life cycles in traditional manufacturing (Xu, 2025: 2-3). Indeed, the promotion of green manufacturing is one of the nine priority strategic tasks identified in the MIC (Khonkhlong, 2020: 2).

The green development indicators defined under "Made in China 2025" are evaluated across several dimensions, including the reduction of energy consumption per unit of industrial added value in enterprises above a designated size, the decline in carbon dioxide emissions relative to manufacturing output, the decrease in water usage per unit of industrial added value, and the improvement in the utilization of solid industrial waste. Guided by the concept of "Green Production," the plan reflects China's commitment to sustainable development. The central government strongly supports the deployment of

energy-saving technologies and environmental protection measures that can facilitate cleaner industrial growth. The entire production system is expected to follow the principles of a circular economy, increase resource productivity, and establish a long-term sustainable industrial framework (Khonkhlong, 2020: 3).

China is also working to strengthen its research capacity in the field of innovative energy-saving and environmental technologies. This effort includes accelerating industrial upgrading, expanding waste heat and pressure recovery, encouraging water recycling, reducing emissions of heavy metals and other hazardous substances, and improving desulfurization and dust-removal systems. In parallel, the government plans to build green data centers and base stations and to support the development of advanced materials, new battery technologies, low-carbon equipment, and lightweight and recyclable industrial technologies (Khonkhlong, 2020: 3).

By 2025, the level of green development and the use of green products are projected to reach internationally advanced standards, ultimately leading to a fully developed green manufacturing system. These green transition goals create both opportunities and challenges for state-owned enterprises, compelling them to adapt and upgrade to remain viable in an era of rapid industrial change (Khonkhlong, 2020: 3).

“Made in China 2025” seeks to guide green upgrading particularly within SOEs, especially those in traditional heavy industries such as cement, nonferrous metals, plastics, construction materials, and light manufacturing. Many SOEs are expected to invest in new infrastructure and improve energy efficiency in equipment such as turbines, boilers, and combustion systems. This policy support is intended to promote technological innovation and leaner production, helping to reduce overcapacity. The government is also encouraging SOEs to strengthen their capabilities in high-end and intelligent manufacturing and to adopt certification systems that ensure the long-term development of industries beyond traditional production methods.

These changes will also affect many non-SOE enterprises, as the government introduces specific standards and assessment systems aimed at controlling sources of air, water, and soil pollution (Khonkhlong, 2020: 3).

In addition, the initiative outlines measures to foster the green transformation of emerging industries. These include reducing energy and chemical inputs in the production and use of electronic information products, establishing green data centers and green

communication base stations, and advancing low-carbon development in high-end equipment manufacturing. (Xu, 2025: 2-3)

The strategic goals of MIC 2025 are both qualitative and quantitative. Indeed, it aims to decrease major contaminant emission intensity in major industries will decrease by 20% in 2025. Furthermore, it also highlights green development goals, as described in *Figure 1.*

Category	Indicator	2013	2015	2020	2025
Green Development	Energy consumption decrease per unit of industrial value added (% decrease over 2015)	-	-	18	34
	Carbon dioxide emission decrease rate per unit of industrial value (% decrease over 2015)	-	-	22	40
	Water consumption decrease per unit industrial value added (% decrease over 2015)	-	-	23	41
	Industrial solid wastes comprehensive utilization ratio (%)	62	65	73	79

Table 2: Green Development Indicator 2013-2025. Source: Made in China 2025.

To conclude, it interesting to underline that these state-led policies are designed to strengthen both the supply and demand sides of the renewable energy sector, reinforcing China's global competitiveness in green manufacturing. (Li and Du, 2024: 264).

Parallel to the ambitions outlined in Made in China 2025, the government also sought to institutionalize green development through the Industrial Green Development Plan (2016–2020).

In 2016, The Ministry of Industry and Information Technology (MIIT) of the People's Republic of China released the "Industrial Green Development Plan (2016-2020)", an implementation of the 13th Five-Year Plan for National Economic and Social Development. It aimed to accelerate ecological progress and promote industrial green development.

The plan emphasizes that China should focus on transforming traditional industries, implementing green manufacturing initiatives, and accelerating the establishment of comprehensive green manufacturing systems. It calls for strengthening the development of the green manufacturing sector, creating and consolidating a long-term framework for

green industry growth, and following a path of green development characterized by efficiency, cleanliness, low carbon emissions, and recycling.

This plan also notes that Chinese industry continues to operate under a model marked by high input, high consumption, and high emissions, resulting in significant resource and energy use. Moreover, the country faces serious ecological and environmental challenges. A central objective is the improvement of resource utilization efficiency. Industrial energy consumption growth is to be slowed, and the contribution of the six most energy-intensive industries to total industrial value added is expected to decline. In certain heavy chemical sectors, energy consumption is projected to reach an inflection point, while energy use per unit of output in major industries is anticipated to reach or approach international advanced standards. Carbon emissions in some industries are expected to peak, and the share of green and low-carbon energy in total industrial energy consumption is set to increase.

Enhancing resource management is also a key goal. Water consumption per unit of industrial output is projected to decrease steadily, comprehensive utilization of solid waste in bulk industries will continue to rise, and the recycling of renewable resources is expected to improve consistently.

The development of clean production capabilities is another priority. Advanced technologies and equipment for clean production are to be widely adopted, particularly in steel, cement, and paper industries, resulting in substantial reductions in emissions of sulfur dioxide, nitrogen oxides, ammonia nitrogen, chemical oxygen demand, and other high-risk pollutants.

Simultaneously, the green manufacturing sector is expected to grow rapidly. Production of green products will expand significantly, while manufacturing capabilities for electric vehicles and other new-energy technologies, including solar and wind power, will be strengthened. This development is intended to foster new economic growth areas driven by green industries, including energy-efficient environmental products and services.

Finally, the plan seeks to establish a foundational green manufacturing system. This includes the creation of a basic standard framework for green manufacturing, widespread application of green design and assessment, construction of hundreds of green demonstration parks and thousands of green factories, promotion of tens of thousands of

green products, and the development of green supply chains across major industries. (Partnership for Action on Green Economy, 2016)

In the same context of the Industrial Development Plan, the Green Factory Evaluation (GFE) was introduced as a key policy instrument for advancing green manufacturing in China. Its primary goal is to promote sustainable manufacturing by setting demonstration benchmarks within the industry and providing guidance and standardization for factories. The concept of a green factory was first introduced in the "Made in China 2025" initiative as part of efforts to establish a comprehensive green manufacturing system.

formally launching GFE and specifying its objective of conducting green evaluations. GFE operates across three administrative levels: national, provincial, and municipal. The MIIT rigorously oversees the application and selection process for national green factories, while local industry and IT departments compile and submit applications in stages. Finally, MIIT reviews and verifies the enterprises that qualify as GFE-certified.

GFE encompasses four main components: the development of green evaluation standards, third-party assessment and certification, policy incentives, and ongoing supervision and evaluation. (Dong et al., 2025: 4)

In summary, China's green industrial policies, embedded across the Five-Year Plans, *Made in China 2025*, and the Industrial Green Development Plan, demonstrate a comprehensive and multi-layered approach to promoting sustainable industrial growth. While the Five-Year Plans provide coherence and continuity, and initiatives such as *Made in China 2025* and the Industrial Green Development Plan foster technological innovation and resource efficiency, the ultimate effectiveness of these policies depends on implementation at local and sectoral levels. These policies establish the foundation for a transition toward a low-carbon economy while aligning industrial development with environmental objectives. Understanding these dynamics is essential for evaluating China's progress toward its climate and sustainable development targets.

2.3 The role of the state and key institutional dynamics in shaping the Chinese Green Industrial Policy

To understand the evolution of China's green transition, it is essential to consider how state intervention, firm characteristics, and regional heterogeneity shape the outcomes of

green industrial policies. The section below explores these dynamics and their implications for innovation and sustainable development.

The influence of China's socialist past remains still visible in the Chinese economy, industrial policy and green industrial policy. Government intervention in business decisions is still common, senior management positions in state-linked enterprises often depend on official approval, and state-owned enterprises continue to dominate bank lending and investment flows—even though their overall share of manufacturing output has declined.

The Chinese state plays an assertive and directive role in steering the renewable energy sector. Rather than relying solely on market mechanisms, the government actively enforces regulations and exerts pressure on both major power-generating companies and provincial authorities to achieve renewable energy targets. For instance, large state-owned generation enterprises have been mandated to ensure that at least 9% of their total electricity output came from renewable sources by 2020. Similarly, the central government establishes annual province-level minimum quotas for the share of non-hydropower renewables in total electricity consumption, and it closely monitors provincial compliance through detailed audits.

Furthermore, national initiatives and campaigns to develop large-scale renewable energy bases function as both incentives and instruments of state pressure, compelling state-owned enterprises to participate. The government also plays a crucial role in ensuring financing not only for renewable power plants but also for the broader industrial ecosystem, including the supply chains and construction infrastructure required to sustain clean energy expansion. By leveraging the tools of industrial policy, the Chinese state has enabled domestic suppliers to continuously reduce production costs, thereby enhancing the economic competitiveness and long-term viability of renewable energy development (Li and Du, 2024: 265). In this context, political connections can support companies' innovation efforts by providing access to financial resources and by enhancing their understanding of government initiatives and policies through reliable channels. The government has mandated that firms promote green innovation and sustainable development through various institutional and regulatory frameworks. Nevertheless, many Chinese enterprises remain hesitant to adopt green technologies, largely due to

limited financial support and insufficient infrastructural conditions (Shaheen and Luo, 2023: 97499).

Given the central role of state intervention in shaping China's green transition, the behavior of state-owned enterprises becomes particularly relevant in understanding how green industrial policies are implemented in practice.

State-owned enterprises (SOEs) and non-state firms approach green innovation differently due to their distinct profit objectives and roles in serving social welfare. Unlike non-state enterprises, SOEs are expected to fulfill not only economic and political tasks but also additional policy responsibilities related to green development. As a result, SOEs operating in heavily polluting sectors in China tend to respond more proactively to green industrial policies.

Local governments also apply more relaxed regulatory oversight to SOEs and are more inclined to prioritize addressing their green innovation challenges. SOEs can more easily obtain government support for major green innovation initiatives, ultimately increasing their green investment and innovation efforts. Furthermore, managers of heavily polluting SOEs often possess strong political awareness and tend to seek political connections, leading them to align corporate strategies closely with government policy directions. They adjust their investment decisions to match the requirements of national green industrial policies. In particular, SOEs face fewer barriers in accessing preferential treatment, loan subsidies, and other forms of financial assistance provided through green industrial policy. This enhanced access further motivates SOEs to expand their green innovation activities, contributing positively to sustainable development. (Zhu and Tan, 2022: 64)

These contrasts between SOEs and non-state firms intersect with another key dimension: the deep regional inequalities that significantly influence firms' capacity to engage in green innovation. China's regional economic development is highly uneven, and the effectiveness of green industrial policies differs across enterprises depending on their location. Compared with the central and western regions, the eastern part of the country has experienced much faster growth, thanks to its geographic advantages and aggressively pursuing industrialization during the reform and opening-up period. However, as industrialization has advanced, the eastern region has begun to face various resource constraints and environmental challenges. Many large, heavily polluting industries that

once fueled its economic rise now encounter increasing limitations on their survival and development (Zhu and Tan, 2022: 64).

The eastern region's higher degree of marketization and more advanced industrial structure create a more level playing field for firms to access preferential green industrial policies than in the less developed central and western regions. Market forces can allocate resources more efficiently based on the signals generated by green policy preferences, such as directing funds and support toward cleaner and more competitive firms, stimulating green innovation. The success of green industrial policy in driving firms' green transformation depends on each region's economic conditions and policy enforcement capacity. Because the eastern region offers a more open innovation environment and higher-quality innovation resources, enterprises located there are better positioned to obtain green policy support. As a result, these firms experience a stronger positive impact of green industrial policy on their green innovation activities (Zhu and Tan, 2022: 64).

The combined effect of ownership structures and regional disparities reveals important gaps in policy implementation, making it necessary to refine China's green industrial policy to ensure more consistent and sustainable outcomes. This analysis shows that green industrial policies in China have evolved in a multifaceted system which aims to promote green innovation and pollution reduction. Despite that, the Government needs to provide timely and long-term policy commitments to enable enterprises to achieve sustainable green innovation.

Indeed, the government should focus on the top-level design of green industrial policies, support enterprise green innovation from a national strategic perspective and should adopt forward-looking policies that coordinate economic and environmental objectives and facilitate the green transformation of high-pollution sectors.

Furthermore, government should emphasize the leading role of green industrial policies, increase subsidies to support industries, and supervise the effective use of funds in real time. These measures can address financial constraints and encourage enterprise green innovation.

Lastly, governments should accelerate the development of regionally targeted and differentiated green industrial policies based on local and regional conditions and property rights heterogeneity. (Zhu and Tan, 2022: 64)

Chapter 3 – European Union Green Industrial Policy

The European Union represents a uniquely important case for the study of Green Industrial Policy due to its ambitious climate objectives, multilayered governance structure and significant role in the global economy. As the first continent to commit to achieving climate neutrality by 2050, the EU has positioned decarbonization at the core of its long-term development strategy.

This chapter explore the historical and political-economic evolution of EU's Industrial policies and its transformation toward a green industrial policy. It analyzes the key regulatory and policy frameworks driving the green transition, the sectoral mechanisms supporting decarbonization, innovation, and competitiveness, and the strategic challenges of multi-level governance, coordination across Member States, and global competitive pressures. It aims to understand how these policies collectively shape Europe's transition toward a competitive, low-carbon, and sustainable industrial economy.

3.1 Evolution and political-economic context of green industrial policy in the EU

The evolution of industrial policy in Europe reflects a continuous shift of economic priorities, political pressures, and institutional development, as summarized in *Figure 4*. Each phase has redefined the role of the state in the economy and the tools deployed to support strategic sectors. Understanding the EU trajectory of green industrial policy is essential as Europe confronts new challenges linked to decarbonization, global competition and economic resilience.

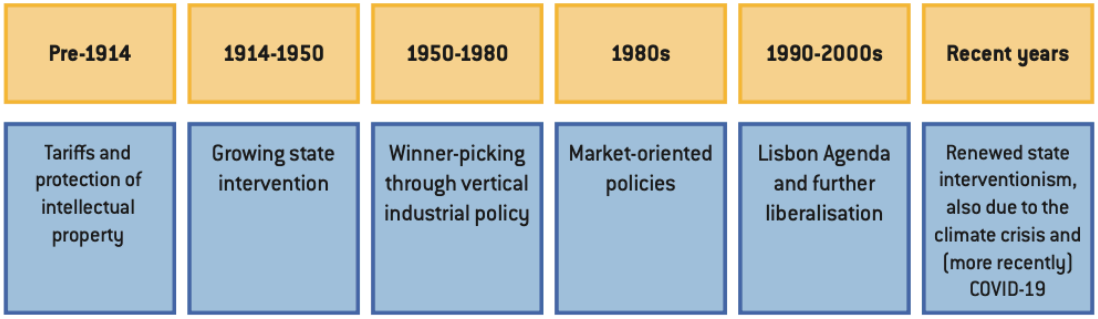

Figure 4: Timeline of European Industrial Policy. Source: Tagliapietra, S. and Veugelers, R. (2020) Green Industrial Policy for Europe, Bruegel

Before 1914, industrial policy in Europe primarily aimed to protect national economies via tariffs. Government involvement largely centered on building infrastructure and supporting certain manufacturing sectors in which the state held ownership stakes or investment interests. Intervention typically targeted sectors considered natural monopolies, such as railways and public utilities. Tariffs on both industrial and agricultural goods were the main policy instruments, and their use varied significantly across countries, often reflecting economic competition. Less-developed nations tended to impose higher tariffs, while more advanced economies were relatively open. Protection of intellectual property served as another tool to encourage innovation, although countries attempting to catch up technologically often benefited from the absence of such protections (Tagliapietra and Veugelers, 2020: 17).

From 1914 to 1950, European governments expanded their intervention as they intervened in economies destroyed by war. The state assumed a central role in directing resources, not only under authoritarian regimes but also in traditionally liberal countries like France and Belgium. The economic turmoil triggered by the 1929 crash resulted in multiple industrial crises, which further necessitated state action. National debates increasingly justified this type of intervention by pointing to the apparent success of Soviet economic planning in avoiding severe depression (Tagliapietra and Veugelers, 2020: 17-18).

After the Second World War, Europe embarked on a reconstruction effort that prioritized key strategic sectors such as coal, steel, electricity, and rail transport. The period from the 1950s to the 1980s is often described as the golden age of industrial policy, marked by a growing determination to close the competitiveness gap with the United States (Owen, 2012). Industrial policy during these decades was highly interventionist. Indeed, European governments actively attempted to pick winners through sector-specific or vertical policies. These interventions focused on industries considered vital for long-term growth (Tagliapietra and Veugelers, 2020: 17-18).

This era witnessed widespread nationalization, the expansion of state-owned enterprises, and the creation of powerful government-led programs. Most of these initiatives remained at national level, as European institutions were still in the early stages of development during this period (Tagliapietra and Veugelers, 2020: 17-18).

The 1980s represented a new wave of liberalization, led by Margaret Thatcher and Ronald Reagan. During the era of the Washington Consensus, state intervention was viewed as harmful to economic growth, giving rise to market-driven policies and a largely laissez-faire stance on industrial policy. Across Europe, governments reduced their direct involvement in the economy, liberalized markets, and sought to avoid the shortcomings associated with earlier interventionist policies aimed at picking winners (Tagliapietra and Veugelers, 2020: 19).

At the European level, the inefficiencies of fragmented national industrial policies became evident, prompting the creation of two major EU-wide instruments: the internal market and competition policy. The 1986 Single European Act also provided the legal foundation for government support in research and development. During this period, the European Communities introduced several initiatives to promote cooperation in research and innovation (Tagliapietra and Veugelers, 2020: 20).

Throughout the 1990s and early 2000s, liberalization continued. A growing consensus emerged at the EU level around a comprehensive, integrated, and horizontal approach to industrial policy. The EU's role became primarily one of setting the right enabling conditions through internal market and competition tools, while stimulating R&D and innovation. This resulted in the Lisbon Strategy [4], which aimed "to transform the EU into the most competitive and dynamic knowledge-based economy in the world, capable of sustainable economic growth with more and better jobs and greater social cohesion". The strategy sought to deliver broad structural reforms centered on fostering innovation, increasing R&D investment, deepening the internal market, improving competitiveness, and making labor markets more flexible (Tagliapietra and Veugelers, 2020: 20-21).

The 2008 Great Recession and its aftermath renewed interest in industrial policy across Europe, as prolonged economic distress strained manufacturing output and industrial employment. In response, the European Commission issued a revised plan for Europe's reindustrialization, calling for a coherent strategy to enhance the competitiveness of European firms. This involved mobilizing all available EU policy levers, including the

[4] The Lisbon strategy was approved during a special meeting of the European Council on 23rd-24th March 2000 in Lisbon to agree a new strategic goal for the Union in order to strengthen employment, economic reform and social cohesion as part of a knowledge-based economy.
Source: https://www.europarl.europa.eu/summits/lis1_en.htm

single market, trade policy, SME policy, competition rules, environmental policy, and research policy (Tagliapietra and Veugelers, 2020: 21).

Since then, a broad agreement has taken shape around the idea of mainstreaming industrial policy and recognizing the need for government intervention. The debate has shifted from whether industrial policy should exist to how it can be designed effectively. Rising pressure to decarbonize Europe and confront global climate change, but also the COVID-19 pandemic, has further reinforced the state's role and required a more intensive intervention of governments to manage the crisis (Tagliapietra and Veugelers, 2020: 21). This demonstrates that Industrial Policy has reemerged at the EU policy-making level in the wake of the Green Industrial Plan and as a response to industrial policies of other nations and competitors, such as China and the US, the climate challenge, and a more geopolitical perspective on economic integration. This resulted in a redefinition of industrial policy not only as a tool for competitiveness and sustainability but also as a pillar of strategic autonomy (De Ville, 2023).

Climate policy started being discussed by the European Council in 1990 in preparation of the upcoming negotiations on the United Nation Framework Convention on Climate Change (UNFCCC). This happened shortly after the release of the first summary report of the Intergovernmental Panel on Climate Change (IPCC). In this context, EU leaders committed to keeping the European Community's greenhouse gas emissions at 1990 levels by 2000. The agreement did not specify how these reductions should be achieved, so it initiated a debate on the need for common and coordinated policies and measures. In this early phase of climate policy development, three key areas emerged that remain central today: cutting GHG emissions, promoting renewable energy sources, and enhancing energy efficiency (Climate Policy Info Hub, no date).

Formally, climate and decarbonization goals started being included in the EU agenda at the beginning of the 21st century. Indeed, in 2005, The EU Trading System (EU ETS) were launched and represented the world's first carbon market and among the largest ones globally. This system was introduced with the aim to helps decreasing overall EU emissions while generating revenues to finance the green transition (Climate Action, no date).

Over the past twenty years, the number of green policies integrated with industrial policy has increased significantly, while the European Union's role in supporting the green

transition has strengthened. Indeed, since 2019, the European Green Deal has reframed the EU's industrial transformation as a systemic economic shift. This new 'transformation narrative' positions climate neutrality as an engine of competitiveness, turning industrial policy into a core instrument to align technological upgrading, strategic autonomy, and decarbonization. This evolution has fostered greater coherence between environmental objectives and economic development strategies, encouraging innovation, sustainable investment, and a growing convergence among Member States.

At the same time, the global context significantly influenced the evolution of the EU's green industrial policy. China's rapid rise as a clean-tech leader, particularly in solar photovoltaics, batteries, and electric mobility, as well as the United States' adoption of the Inflation Reduction Act (IRA)[5] in 2022, increased competitive pressure on Europe. These developments increased concerns over technological dependence, supply-chain vulnerabilities, and the risk of industrial leakage. As a result, the EU progressively integrated objectives of strategic autonomy and economic security into its industrial strategy, complementing its climate ambitions with instruments aimed at scaling up domestic manufacturing capacity and safeguarding access to critical raw materials (Veugelers et al., 2024: 4).

To sum up, the political–economic evolution of the EU has progressively moved from market liberalization to an active state-led approach combining industrial competitiveness and climate ambitions. This historical trajectory sets the foundation for the regulatory and policy frameworks examined in the following section.

3.2 Regulatory and policy frameworks

The EU shapes its green industrial policies across the entire region through its competition rules, trade policy, single market regulations, climate initiatives, research and innovation programs, its public investment and regional development strategies. It employs a broad set of instruments, such as funding for green research, development, and

[5] The Inflation Reduction Act of 2022 is the most significant climate legislation in U.S. history, offering funding, programs, and incentives to accelerate the transition to a clean energy economy and will likely drive significant deployment of new clean electricity resources.
The Inflation Reduction Act incentives reduce renewable energy costs for organizations like Green Power Partners – businesses, nonprofits, educational institutions, and state, local, and tribal organizations. Taking advantage of Inflation Reduction Act incentives, such as tax credits, is key to lowering GHG emission footprints and accelerating the clean energy transition. Source: https://www.epa.gov/green-power-markets/summary-inflation-reduction-act-provisions-related-renewable-energy.

the rollout of clean technologies, as well as green public procurement and clean-energy standards (Tagliapietra et al., 2023: 54-55).

The next section outlines and critically examines the main policy frameworks that underpin the EU's green industrial transformation and its wider sustainable development strategy.

Policy's name	**Year**	**Main topic(s)**
European Green Deal	2019	Promotion of a climate-neutral economy through the reduction of carbon emissions
Green Deal Industrial Plan for the Net-Zero Aage	2023	Addressing the economic aspects of the net-zero target, specifically focusing on the EU's industry, by providing, with the resources needed to transition to net zero
Fito for 55 package	2021	Introduction of set of laws designed to cut EU greenhouse gas emissions
Industrial Alliances	2017-2020	Development of the employment, growth, and investment opportunities offered by emerging green technologies
Clean Industrial Deal	2025	Transformation of decarbonization into a driver of growth for European industries

Table 3: Summary of key EU initiatives on Green Industrial Policies

In December 2019, the European Commission announced the European Green Deal (EGD). It represents an effort at EU level without precedent in promoting the transition towards the common goal of a climate-neutral economy by reducing carbon emissions by at least 50%, compared with 1990 levels, by 2030 (and towards 55%) and achieving carbon neutrality by 2050. The European Commission framed its work around the idea of redirecting EU activities toward environmental priorities in areas designated as key action fields of the EGD Communication. These areas include climate ambition, clean affordable and secure energy, industrial strategy for a clean and circular economy, sustainable and smart mobility, agriculture and fisheries, biodiversity, zero pollution and toxic-free environment, mainstreaming sustainability and trade and foreign (Sikora, 2020: 682).

The European Green Deal is intended as: "*a roadmap, a strategy for making the EU's economy sustainable, becoming the first climate-neutral continent, by proposing a*

number of measures to reduce the greenhouse gas emissions (GHG) and increasing biodiversity turning climate and environmental challenges into opportunities across all policy areas and making the transition just and inclusive for all." (Sikora, 2020: 687). It means that this initiative seeks not only to mitigate environmental degradation but also to foster a comprehensive transformation of the EU's economic and social systems, promoting sustainable growth, enhancing societal well-being, and ensuring long-term ecological and climate resilience.

The EGD is widely recognized as an opportunity to reshape the horizontal regulatory framework through more effective and efficient instruments in both the short and long term. This opportunity derives from a series of legal developments and political commitments that have embedded climate law within the EU legal order, formally consolidated with the Lisbon Treaty and reinforced by key international milestones such as the Paris Agreement, the UN 2030 Agenda, and the Sustainable Development Goals (Sikora, 2020: 683).

An in-depth analysis of the Communication of the European Council on the European Green Deal shows the relevance and interconnections with industrial policy and climate policy.

Section 2.1.1 defines the goals and the strategy that the EU plan to adopt. As introduced before, the European Commission has outlined a clear vision for achieving climate neutrality by 2050, which will serve as the foundation of the EU's long-term strategy to be submitted to the United Nations Framework Convention on Climate Change. To ensure an effective, fair and irreversible transition, as well as to provide long-term predictability for investors, the Commission will propose the first European Climate Law. This law will enshrine the 2050 climate neutrality objective into EU legislation and ensure that all EU policies and economic sectors contribute to this goal.

To achieve this, all major climate-related policy instruments will be reviewed and revised, including the Emissions Trading System, targets for non-ETS sectors, and rules on land use, land-use change and forestry.

These reforms aim to strengthen carbon pricing across the entire economy, encouraging changes in consumer and business behavior while stimulating sustainable public and private investment. Aligning taxation with climate objectives is also considered essential,

and the Commission intends to revise the Energy Taxation Directive to better reflect environmental considerations and support climate goals.

At the same time, the EU recognizes the risk of carbon leakage if international partners do not match its level of climate ambition. To address this, the Commission may introduce a carbon border adjustment mechanism for selected sectors, ensuring that imported goods reflect their carbon content while remaining compliant with World Trade Organization rules. The Commission will also adopt a more ambitious EU strategy on climate change adaptation, acknowledging that climate impacts will continue despite mitigation efforts. This strategy will focus on resilience, prevention, preparedness, and climate-proofing investments, including nature-based solutions, while improving access to data and tools to help businesses, investors, cities and citizens integrate climate risks into their decision-making processes.

Section 2.1.2 focuses on *"Supplying clean, affordable and secure energy"*. In this section, it is made clear that further decarbonization of the energy system is essential to achieving the EU's climate objectives for 2030 and 2050, as energy production and consumption account for more than 75% of the EU's greenhouse gas emissions. Energy efficiency must therefore be prioritized, alongside the development of a power sector largely based on renewable energy sources. This transition requires the rapid phase-out of coal and the progressive decarbonization of gas, while ensuring that energy remains secure and affordable for both consumers and businesses. To support this, the European energy market must become fully integrated, interconnected and digitalized, while maintaining technological neutrality.

Member States are required to submit revised national energy and climate plans, setting out ambitious contributions to EU-wide targets. The Commission will assess these plans and propose additional measures if their level of ambition proves insufficient. This process has been included into the revision of EU energy legislation by 2021, ensuring alignment with higher climate ambitions for 2030. Member States planned to update their plans again in 2023, expecting to reflect these strengthened targets, with the Commission continuing to ensure effective enforcement of all relevant legislation.

The clean energy transition is intended to actively involve and benefit consumers. Renewable energy will play a central role. The smart integration of renewables, energy efficiency measures and other sustainable solutions across sectors will enable cost-

effective decarbonization. Falling renewable energy costs and improved support schemes have already reduced the impact on household energy bills. The Commission aims to introduce measures to promote this smart integration and will also support the decarbonization of the gas sector, including the development of renewable and low-carbon gases and the reduction of energy-related methane emissions.

It means that the transition to climate neutrality requires modern and resilient energy infrastructure. Enhanced cross-border and regional cooperation will help deliver the benefits of the clean energy transition at affordable prices. The EU's regulatory framework for energy infrastructure will be reviewed to ensure consistency with climate neutrality goals and to support the deployment of innovative solutions such as smart grids, hydrogen networks, energy storage, and carbon capture technologies. Existing infrastructure will also need to be upgraded to remain climate-resilient and fit for purpose.

Section 2.1.3 focuses on *"Mobilising Industry for a Clean and Circular Economy."* It emphasizes that achieving a climate-neutral and circular economy requires the full mobilization of industry, as transforming industrial sectors and their value chains typically takes around 25 years. To meet the 2050 climate objectives. The Deal clarifies the need to take decisive actions within five years from the launch of the Deal. Since 1970, global material extraction has tripled and continues to grow, posing significant environmental risks. Although EU industry has already begun its transition, it still accounts for about 20% of the EU's greenhouse gas emissions and remains largely linear, relying heavily on newly extracted materials, with only around 12% of inputs coming from recycling.

This transition represents a major opportunity for sustainable economic growth and job creation, particularly in low-emission technologies, sustainable products, and circular business models. The European Green Deal aims to accelerate this transformation through an EU industrial strategy and a new circular economy action plan, designed to modernize the European economy and develop lead markets for climate-neutral and circular products both within the EU and globally.

Energy-intensive industries such as steel, chemicals and cement are essential to Europe's economy and play a critical role in key value chains; their decarbonization and modernization are therefore indispensable. In this context, the EU will support industrial frontrunners and the deployment of breakthrough technologies, including clean hydrogen,

energy storage, carbon capture, zero-carbon steel production, and sustainable battery value chains. These efforts will be backed by strategic industrial alliances and EU funding instruments.

Digital technologies will act as key enablers of the Green Deal by improving resource efficiency, enabling environmental monitoring, and supporting more sustainable industrial practices. At the same time, the digital sector itself will be required to enhance its energy efficiency and circularity, ensuring that digitalization contributes effectively to Europe's sustainability objectives.

To sum up, the European Green Deal can be understood as a cornerstone of EU green industrial policies, as it aligns climate ambition with industrial strategy by promoting decarbonization, circularity and digitalization across key value chains, fostering innovation and investment in clean technologies, and strengthening Europe's industrial competitiveness while ensuring a just, inclusive and sustainable transition towards climate neutrality.

In the context of the European Green Deal, in 2023 the European Commission launched "*A Green Deal Industrial Plan for the Net-Zero Age*", aimed at addressing the economic aspects of the net-zero target, specifically focusing on the EU's industry.

The EU's Industrial Plan seeks to provide Europe's economic model, based on the Single Market, with the resources needed to transition to net zero. It aims to drive significant growth in technological innovation, manufacturing, and the deployment of net-zero products and energy over the next decade, while simultaneously addressing associated challenges, such as global competition for raw materials and skilled labor (Nicolai and Münchmeyer, 2024).

The Green Deal Industrial Plan is made by two new legislative initiatives supporting Europe's clean technology sector: the Net-Zero Industry Act (NZIA) and the Critical Raw Materials Act (CRMA). These measures aim to strengthen, diversify, and secure supply chains, ensuring the EU can achieve its ambitious decarbonization, energy efficiency, and renewable energy goals at the speed required to reach net zero by 2050. Both Acts also establish a new governance framework for reinforcing the EU's clean tech sector, structured around five main components that follow a similar approach (Nicolai and Münchmeyer, 2024).

More specifically, the Net-Zero Industry Act (NZIA) represents an industrial policy framework aimed at strengthening cleantech manufacturing in the European territory and is structured around four main pillars.

First, it identifies a set of net-zero technologies described as "strategic". These include solar photovoltaic and solar thermal technologies, onshore wind and offshore renewables, batteries and energy storage, heat pumps and geothermal energy, sustainable biogas and biomethane, carbon capture and storage (CCS)[6], as well as grid technologies. Second, the NZIA establishes an indicative benchmark under which EU-based manufacturing of these technologies should cover at least 40 percent of the Union's annual deployment needs by 2030. In addition, it sets a target of achieving an annual CO_2 storage injection capacity of 50 megatons by 2030, with the aim of accelerating the development of CCS infrastructure. Third, the proposal introduces a governance framework centered on the designation of Net-Zero Strategic Projects (NZSPs) by member states, subject to a limited screening role for the European Commission. To qualify, NZSPs must contribute to emissions reductions, enhance competitiveness, and improve security of supply, while relying on technologies that are close to market deployment. This marks a shift away from previous EU support models, which largely focused on earlier stages of the innovation cycle such as research, demonstration, and prototyping. Fourth, the NZIA sets out a toolbox of policy measures, primarily implemented at national level, to support these projects. These include faster permitting and streamlined administrative procedures within EU-defined timelines, notably through the establishment of national one-stop-shop authorities; mechanisms to mobilize and coordinate private investment, with the Commission estimating that achieving the 40 percent manufacturing target by 2030 will require approximately €92 billion, around 80 percent of which is expected to come from private sources and to be facilitated via a Net-Zero Europe Platform building on existing industrial alliances; and limited public financial support, mainly provided by member states (Tagliapietra et al., 2023: 3-4)

Beyond these core elements, the NZIA refers to complementary initiatives but without detailed implementation plans.

[6] *Definition of Carbon Capture and Storage:* "Carbon Capture and Storage (or "Sequestration") - known as CCS - refers to technologies that capture the greenhouse gas carbon dioxide (CO_2) with the aim of the storing it safely underground (sequestration) for permanent isolation. It could be one of the key tools to help tackle global warming.". Source: https://www.imo.org/en/mediacentre/hottopics/pages/carbon-capture-and-storage-(ccs).aspx

Given that member states are expected to provide the bulk of public funding for NZSPs, the NZIA should be read alongside the Temporary Crisis and Transition Framework (TCTF), revised by the European Commission in March 2023 in response to the US Inflation Reduction Act. The TCTF specifies the conditions under which state aid may be approved to accelerate investment in sectors considered strategic for the transition to a net-zero economy. Under this framework, member states are permitted to provide higher levels of support for cleantech manufacturing in disadvantaged regions, subject to ceilings linked to investment costs and beneficiary size; to offer increased aid intensities when support takes the form of tax incentives, loans, or guarantees, allowing operating expenditures to be covered up to the identified funding gap, a relatively novel approach in the EU context; and to grant "matching aid", corresponding either to the support available in alternative locations or to the minimum amount needed to secure investment in the EU (Tagliapietra et al., 2023: 4).

Taken together, these instruments illustrate how the EU is increasingly relying on industrial policy to underpin the scale, speed, and resilience of the net-zero transition, while leaving critical questions open regarding coordination, implementation, and the distribution of financial and administrative responsibilities across governance levels.

The Green Deal Industrial Plan is not the only policy outcome of the European Green Deal; another central initiative developed within this framework is the *Fit for 55 package.*

The Fit for 55 package is a comprehensive set of laws designed to cut EU greenhouse gas emissions by at least 55% by 2030 and to put the Union on track to achieve climate neutrality by 2050. It aims to ensure a just and socially equitable transition, while supporting the innovation and competitiveness of European industry and maintaining a level playing field with international competitors. At the same time, the package reinforces the EU's role as a global leader in addressing climate change (European Council – Fit for 55).

This policy contains numerous elements of interest that are closely connected to the EU's green industrial policies and represents an important aspect to take into consideration in order to reach EU climate targets in a fair, cost effective and competitive way.

A key component of the Fit for 55 package focuses on strengthening the EU Emissions Trading System (EU ETS). For this reason, the European Commission has proposed a

series of amendments to reinforce the existing EU ETS and to introduce a new, separate system for buildings and transport. The reforms aim to significantly increase greenhouse gas emission reductions, targeting a 61% reduction by 2030 in sectors covered by the ETS compared with 2005 levels. The proposal raises the annual linear reduction factor for allowances from 2.2% to 4.2% to accelerate emission cuts across all sectors (Schlacke et al., 2022: 4-5).

To prevent carbon leakage, where production might shift to countries with less stringent climate rules, the Commission has introduced the Carbon Border Adjustment Mechanism (CBAM). Under CBAM, importers of selected goods will need to purchase certificates corresponding to the embedded emissions in their products, with prices aligned to the EU ETS allowance price. At the same time, free allocation of allowances for domestic producers will be gradually phased out over a ten-year transition period starting in 2026, ending completely in 2036 for sectors covered by CBAM (Schlacke et al., 2022: 4-5).

Together, these measures aim to strengthen the EU ETS, ensure fair competition for EU industries, incentivize significant emission reductions, and support the broader transition to a low-carbon and sustainable industrial economy.

The Renewable Energy Directive of the Fit for 55 package sets a goal for renewable energy to account for 42.5% of the EU's total energy consumption by 2030, with an additional 2.5% indicative margin to potentially reach 45%. Each member state is expected to contribute toward achieving this collective target. More specifically, industry is required to increase its use of renewable energy by 1.6% each year. By 2030, EU member states have agreed that 42% of the hydrogen consumed in industry should come from renewable fuels of non-biological origin, rising to 60% by 2035 (European Council – Renewable Energy: Council Adopts New Rules).

Complementing the regulatory and market-based measures of the Fit for 55 package, the EU also relies on Industrial Alliances to translate policy into concrete action, fostering collaboration between public authorities, industry, and finance to accelerate innovation, secure critical resources, and build a competitive and sustainable industrial ecosystem.

Industrial Alliances serve as instruments to foster public–private collaboration, playing an increasingly prominent role in shaping regulations and channeling funding toward the strategic priorities set by the European Commission. Their purpose is to unlock the

employment, growth, and investment opportunities offered by emerging green technologies, while reducing the risk of technological dependence on non-EU competitors. In practical terms, these Alliances bring together networks of industrial and innovation stakeholders (including SMEs), regional and national authorities, the European Commission, and the European Investment Bank (Tagliapietra et al., 2023: 56). Three out of the nine existing Industrial Alliances focus specifically on clean-technology sectors

Established in 2017, *the European Battery Alliance (EBA)* aims to drive cutting-edge innovation across the entire battery value chain, from the extraction and processing of raw materials to the production of advanced chemical components, the design of cells and modules, their integration into smart systems, and finally the recycling and repurposing of end-of-life batteries (Tagliapietra et al., 2020: 57). This means that this alliance supports the development of new and innovative sustainable technologies for more sustainable and safer lithium-ion batteries (Tagliapietra and Veugelers, 2021: 64). More specifically, the Alliance is designed to reinforce Europe's battery sector across multiple dimensions. It aims to secure reliable access to raw materials by partnering with resource-rich countries outside the EU, enhancing domestic sourcing, and promoting the use of recycled secondary materials. It also supports the expansion of European battery cell production and the development of a fully competitive value chain, facilitating large-scale, cross-border manufacturing projects through collaboration with key industry actors, national authorities, and the European Investment Bank. In parallel, the Alliance accelerates research and innovation in both advanced technologies, such as lithium-ion, and frontier solutions, like solid-state batteries, while fostering a highly skilled workforce across the entire value chain through training, re-skilling, and attracting top global experts. Sustainability is a core focus, with requirements to ensure battery production in Europe minimizes environmental impact. Finally, the Alliance works to align its initiatives with the broader EU regulatory landscape, including clean energy strategies, mobility policies, and trade frameworks (Tagliapietra and Veugelers, 2021: 64-65). The initiative also focuses on providing appropriate EU- and national-level training, reskilling, and upskilling, attracting top global experts, and ensuring that Europe's battery-cell manufacturing sector develops with the lowest possible environmental footprint (Tagliapietra et al., 2023: 57).

Launched in 2020, the *European Clean Hydrogen Alliance* seeks to accelerate the rollout of hydrogen technologies by 2030, connecting renewable and low-carbon hydrogen production with demand across industry, transport, and other sectors, as well as with hydrogen transport and distribution infrastructure. Its key objectives include reaching 6 gigawatts (GW) of clean hydrogen production by 2024, followed by 40 GW within the EU and an additional 40 GW outside the EU by 2030. The Alliance encompasses around 750 projects across six thematic areas, ranging from renewable and low-carbon hydrogen generation to industrial and energy applications (Tagliapietra et al., 2023: 57). This alliance is part of the EU's broader efforts to secure industrial leadership and speed up the decarbonization of industry in line with climate objectives. To meet these goals, the Alliance is organized into three roundtables covering hydrogen production, hydrogen transmission, distribution and storage, and hydrogen end use. These roundtables are mainly composed of project promoters from the Alliance's project pipeline, with additional participation from public authorities and civil society (European Commission – European Clean Hydrogen Alliance).

Also inaugurated in 2020, the *European Raw Materials Alliance (ERMA)* concentrates on ensuring access to resources considered strategic for the development of a green industrial value chain, while stimulating investment and innovation in this field. Its establishment aligns with the Critical Raw Materials Action Plan, which calls for reducing Europe's dependence on third countries, diversifying supply from primary and secondary sources, improving resource efficiency and circularity, and fostering responsible sourcing worldwide (Tagliapietra et al., 2023: 57).

As an EU alliance, ERMA is expected to deliver four main outcomes. It will put in place a flexible and inclusive process for consulting stakeholders, support EU industrial policy by addressing regulatory and financing obstacles and establish a Raw Materials Investment Platform (RMIP) to help mobilize investment for a pipeline of strategic projects. In addition, ERMA will promote greater strategic awareness, including public acceptance and a forward-looking understanding of the role of raw and advanced materials in the transition towards a green and digital economy (Schäfer et al., 2020: 416). The new initiative, in cooperation with relevant stakeholders, aims to support Europe's transition to a green economy, strengthen the resilience of European industrial

ecosystems, and bring raw materials back to the core of the European Union's development strategy (Schäfer et al., 2020: 416).

The EU is now continuing to pursue broader strategies to support industrial transformation, drive sustainability, and strengthen Europe's competitiveness in the green economy. Building on the momentum and lessons learned from previous initiatives, the *Clean Industrial Deal,* launched on 26th February 2025, sets out concrete actions to turn decarbonization into a driver of growth for European industries by lowering energy costs, creating quality jobs, and fostering conditions for businesses to thrive. It aims to support industries that are highly energy-intensive, such as steel, metals, and chemicals, helping them transition to clean energy while addressing high costs, unfair global competition, and complex regulations. The Deal also focuses on the clean-tech sector, which is central to future competitiveness and essential for industrial transformation, circularity, and decarbonization. Another key element regards promoting circularity, reducing waste, and extending the lifespan of materials, while maximizing EU resources and reducing dependence on third-country suppliers to ensure a competitive and resilient market (European Commission – Clean Industrial Deal).

Section 2 of the Clean Industrial Deal highlights how high energy prices in Europe represent a major constraint on industrial competitiveness, especially for energy-intensive sectors. For this reason, one of the main objectives of the Clean Industrial Deal is about ensuring access to affordable, secure and clean energy.

This section focalizes on the importance of reducing energy costs in the EU and the need to provide accelerated electrification, a rapid shift towards domestically produced clean energy, the completion of the internal energy market through physical interconnections, and improved energy efficiency to reach its objectives. It introduces the *Action Plan for Affordable Energy*, which combines short-term measures to lower energy bills for industry, businesses and households with longer-term structural reforms. Delivered largely by 2025 and implemented in cooperation with Member States and the private sector, the Action Plan is designed to reinforce the business case for industrial electrification and decarbonization while respecting the principle of technology neutrality (European Commission – Clean Industrial Deal).

Within this framework, the acceleration of clean energy deployment and manufacturing is particularly relevant for green industrial policy. Energy-intensive industries depend on

a stable and predictable supply of affordable clean energy while lengthy permitting procedures remain a major obstacle for renewables, grids and energy storage projects. Although the revised Renewable Energy Directive introduced streamlined permitting rules, only a limited number of Member States have fully implemented them, despite clear evidence of positive effects where they are in force. To address this gap, the Clean Industrial Deal explicates the effort of the European Commission to support Member States in transposition and implementation, while promoting best practices and launching a structured dialogue on energy permitting (European Commission – Clean Industrial Deal).

Permitting delays also constrain industrial electrification and decarbonization investments and for this reason the *Industrial Decarbonisation Accelerator Act* is launched as a measure to facilitate industrial access to energy while maintaining environmental and health protections.

Another important aspect of this section focuses on digitalization and its role as a strategic tool for accelerating clean energy and industrial projects. By promoting the use of data spaces, EU space-based services and artificial intelligence, the Commission aims to ensure that relevant datasets, such as geological, spatial, environmental and emissions data, are easily accessible to national authorities (European Commission – Clean Industrial Deal). This data-driven approach supports faster, more transparent decision-making and strengthens the alignment between energy policy and the EU's long-term green industrial transformation**.**

Section 3 of the Clean Industrial Deal emphasizes that businesses will only invest in low-carbon technologies and production if they see a guaranteed market for their products.

To stimulate this market, the EU aims to create lead markets for European clean technologies and products, particularly in energy-intensive sectors such as steel, aluminum, cement, chemicals, and other materials-intensive industries. Establishing these lead markets strengthens the EU's global competitiveness in clean technologies, promotes sustainable manufacturing, and safeguards employment, while enabling economies of scale, cost reductions, and broader access to sustainable alternatives for both consumers and businesses. In turn, increased demand provides industries with incentives to accelerate decarbonization and adopt circular production methods,

generating both environmental and economic benefits (European Commission – Clean Industrial Deal).

The EU is complementing these efforts with measures to develop a market for carbon removal. Through the Industrial Carbon Management Strategy and the additional review of the ETS Directive in 2026, the Commission will support investments in permanent carbon removals to offset residual emissions from hard-to-abate sectors.

Public procurement is highlighted as a powerful tool to stimulate demand for low-carbon products and support the EU's sustainable industrial ecosystem. By incorporating non-price criteria, such as sustainability, resilience, and EU-content requirements, into procurement rules, public spending can support innovation, decarbonization, and job creation while ensuring compliance with EU legal obligations. The *Industrial Decarbonisation Accelerator Act* will further embed these criteria for energy-intensive sectors, promoting clean, resilient, circular, and cybersecure products. Non-price criteria will also be extended to national support programs and private procurement.

Furthermore, hydrogen is identified as essential for decarbonizing hard-to-abate sectors where electrification is not yet feasible. To provide regulatory certainty for investors, the Commission adopted a delegated act on low-carbon hydrogen in early 2025, establishing clear production rules. To accelerate uptake, the Commission will launch a third call under the Hydrogen Bank with a EUR 1 billion budget and promote the use of its auctions-as-a-service platform, supporting Member States in leveraging unspent EU funds. Additionally, the Commission is also preparing a review of the delegated act on renewable fuels of non-biological origin by assessing the hydrogen framework's effectiveness and identifying barriers to scaling renewable hydrogen (European Commission – Clean Industrial Deal).

To sum up, the Clean Industrial Deal combines energy affordability, regulatory support, market creation, and strategic technology deployment to accelerate Europe's industrial decarbonization, strengthen competitiveness, and lay the foundation for a resilient and sustainable low-carbon economy.

In brief, the EU's approach to green industrial policy integrates multiple initiatives, including the European Green Deal, the Fit for 55 package, the Green Deal Industrial Plan, and the Industrial Alliances, creating a comprehensive framework for sustainable industrial development. Strategic measures, such as the Net-Zero Industry Act, drive

innovation, decarbonization, and resource efficiency across sectors. The effectiveness of these policies depends on coordinated implementation at both EU and national levels. Altogether, they lay the groundwork for a competitive, resilient, and climate-aligned European industrial ecosystem.

3.3 Challenges and strategic dimensions of the EU's Green Industrial Policy implementation

The previous paragraph and the available literature show that the current European landscape consists of numerous green industrial policy initiatives spread across regional, national, and EU levels, but these efforts are rarely aligned and can even work at cross-purposes.

At the EU level, the Union sets the framework for green industrial policies through competition policy, trade policy, single market rules, energy and climate policy, research and innovation policy, the macroeconomic framework governing Member States' public expenditure, and regional development policy. The various initiatives are based on a combination of a horizontal approach, aimed at establishing general framework conditions conducive to green industrial development, and a vertical approach, which allows for more targeted support for specific green technologies.
Overall, green industrial policy consists of a multitude of initiatives that are largely uncoordinated and, in some cases, even conflicting. Issues of geographical coordination arise, as green industrial policy operates across multiple levels of governance, regional, national, and EU, as well as challenges related to coordination across different policy competences (Veugelers et al., 2024: 7).

As introduced, the EU's governance model adds further complexity and distinctiveness. Policymaking must navigate the interaction between supranational institutions and 27 member states with heterogeneous economic structures, political priorities, and industrial capacities. While this multi-level system can slow decision-making, it also enables policy experimentation and cross-national learning (Tagliapietra and Veugelers, 2020: 81). Regions pursue their own smart specialization strategies to strengthen or create competitive advantages in specific green technology sectors, while member states rely on a variety of instruments, ranging from public funding for green

innovation and subsidies for green technology deployment to green public procurement and clean energy standards, to advance their national agendas.

Furthermore, EU member states differ significantly in their industrial structures, geographic conditions, technological preferences, and fiscal capacities. These divergences shape national perspectives on resilience and open strategic autonomy and often make EU-level initiatives politically contentious. Even abstracting from these national differences, there is no clear consensus on how resilience and strategic autonomy should be defined or pursued. Policymakers face difficult questions about which instruments are most effective and cost-efficient, how such policies interact with other key objectives, such as economic efficiency, growth, and rapid decarbonization, and whether the EU should shift from a largely horizontal framework based on competition policy and open trade toward more targeted, sector-specific interventions (Tagliapietra et al., 2023: 2).

This diversity of approaches risks fragmenting the EU single market and weakening fair competition across countries, highlighting the need for robust coordination at the European level. The EU itself also has a wide range of tools across different policy domains, including competition, climate, research and innovation, public investment, Single Market regulation, and development policy, that can be mobilized to support a coherent green industrial strategy.

Moving to the role and authority of the EU, it is clear that the European Commission has strong authority in areas such as competition and trade, but it possesses fewer tools to directly shape public investment, innovation, and skills development (Tagliapietra et al., 2023: 2). Over time, the European Commission has itself played an active role in industrial policy, exercising its legal mandate under Article 173 of the Treaty on the Functioning of the European Union (TFEU) (Terzi et al., 2023: 848).

The article 173 establishes that:

"1. The Union and the Member States shall ensure that the conditions necessary for the competitiveness of the Union's industry exist.

For that purpose, in accordance with a system of open and competitive markets, their action shall be aimed at:

— speeding up the adjustment of industry to structural changes,

—encouraging an environment favourable to initiative and to the development of undertakings throughout the Union, particularly small and medium-sized undertakings,

—encouraging an environment favourable to cooperation between undertakings,

—fostering better exploitation of the industrial potential of policies of innovation, research and technological development.

2. The Member States shall consult each other in liaison with the Commission and, where necessary, shall coordinate their action. The Commission may take any useful initiative to promote such coordination, in particular initiatives aiming at the establishment of guidelines and indicators, the organisation of exchange of best practice, and the preparation of the necessary elements for periodic monitoring and evaluation. The European Parliament shall be kept fully informed.

3. The Union shall contribute to the achievement of the objectives set out in paragraph 1 through the policies and activities it pursues under other provisions of the Treaties. The European Parliament and the Council, acting in accordance with the ordinary legislative procedure and after consulting the Economic and Social Committee, may decide on specific measures in support of action taken in the Member States to achieve the objectives set out in paragraph 1, excluding any harmonisation of the laws and regulations of the Member States.

*This Title shall not provide a basis for the introduction by the Union of any measure which could lead to a distortion of competition or contains tax provisions or provisions relating to the rights and interests of employed persons" (*Consolidated Version of the Treaty on the Functioning of the European Union, 2012)

This passage helps to clarify the nature of the European Commission's role in industrial policy by highlighting the distinction between objectives and instruments at the EU level. Article 173 TFEU assigns the Union the responsibility in ensuring the conditions for industrial competitiveness, particularly by promoting innovation, structural adjustment, cooperation among firms, and the development of small and medium-sized enterprises. However, the article also makes explicit that the Commission's mandate is not one of direct intervention or centralized control. Instead, its authority is exercised mainly through coordination, guidance, and support of Member State actions, while explicitly excluding harmonization, fiscal measures, and any intervention that could distort

competition. This legal framework explains why, despite the Commission's active engagement in industrial policy over time, its influence remains largely indirect and complementary, rather than structured on binding investment or regulatory powers.

Another aspect to consider when discussing the implementation of industrial policy in the European Union regards global competition. Indeed, the EU's green industrial agenda is increasingly shaped by global competitive pressures. External developments such as the United States' Inflation Reduction Act and China's dominance in key clean-tech value chains have prompted the EU to rethink its approach to strategic autonomy, resilience, and technological leadership.

More precisely, the enactment of the Inflation Reduction Act (IRA) by the United States in August 2022 raised concerns in Europe about the potential relocation of clean-technology industries to the US, driven by generous subsidy schemes and protectionist local-content provisions. The changing geoeconomic landscape creates significant challenges for Europe. In particular, the EU is already trailing both Asia and the United States in the development of digital technologies and therefore cannot risk losing ground in the global competition for clean technologies or forgoing the industrial growth opportunities associated with the green transition (Tagliapietra et al., 2023: 52).

On the other hand, as introduced above, China's strong position in green technologies, the result of long-term state support and large-scale domestic innovation, has become an additional source of concern for the EU in terms of supply chain security. Europe's heavy reliance on China for key clean-tech components, exacerbated by events such as the COVID-19 pandemic and Russia's invasion of Ukraine, has heightened awareness of the risks associated with dependence on a single supplier for strategic goods. In response, the EU has begun to strengthen its industrial and trade policy toolkit through initiatives such as the Net Zero Industry Act, aimed at expanding domestic production capacity and diversifying supply chains via international partnerships. At the same time, the EU has taken a more defensive stance by launching anti-subsidy investigations and introducing measures addressing human rights concerns in global value chains. Nevertheless, a rapid disengagement from China would risk undermining both the EU's climate objectives and the resilience of its green industrial strategy. Given the scale of investment and time required to develop alternative supply chains, some degree of continued dependence on

China appears unavoidable, making a pragmatic and balanced de-risking approach essential to safeguarding Europe's green transition (Schäpe, 2024).

Overall, the European green industrial landscape is shaped by a complex interplay of multi-level governance, diverse national priorities, limited EU direct intervention tools, and mounting global competitive pressures. This combination underscores the need for a coherent and strategic approach that balances coordination across Member States, targeted support for key technologies, and pragmatic engagement with international partners, to enhance Europe's resilience, strategic autonomy, and leadership in the global green transition.

Chapter 4 – Comparative Analysis of China and EU's Green Industrial Policies

After defining and analyzing the theoretical framework of Green Industrial Policy and examining the strategies adopted by China and the European Union, this chapter aims to compare these two models and highlight their convergences, divergences, and impact on the global energy transition. Although both actors share the fundamental goal of decarbonization and the desire to strengthen their leadership in the clean energy sector, they operate through different paradigms which are influenced by their respective political, economic, and institutional contexts.

The analysis focus on comparing policy approaches, examining how China's top-down strategy and direct state intervention contrast with the European Union's model, which is based on regulation, market mechanisms, and multi-level governance. Furthermore, the chapter evaluate the role of these policies in determining global leadership in the green energy transition, observing how China has achieved production and market dominance in key sectors, while the EU has consolidated its role through a normative and institutional leadership. This chapter is fundamental to analyze and understand to what extent do China and the European Union's green industrial policies strengthen their leadership in clean energy.

4.1 Policy approaches: instruments, targets, and governance

China and the European Union rely on a broad range of green industrial policy instruments, including subsidies, public investment, and support for research and development. However, these instruments differ substantially in different aspects. Both Europe and China place strong emphasis on green and low-carbon development and have made notable progress in policymaking, industrial restructuring, and energy transition. Nevertheless, their approaches and priorities differ. Europe focuses on reshaping its energy mix and advancing green technological innovation through regulatory frameworks and international cooperation. China follows a top-down strategy centered on policy direction, industrial upgrading, and optimization of the energy system, exploring distinct pathways toward green and low-carbon development (Ma et al., 2025: 5).

As analyzed previously in *Chapter 2*, China's approach is characterized by direct and state-led intervention. The Five-Year Plans, *Made in China 2025*, and the Industrial Green Development Plan are policy instruments which are deployed through a vertical approach in which strategic priorities are defined at the central level and implemented through a hierarchical governance structure involving local governments and firms. These instruments establish quantitative targets, technological standards, making compliance with national industrial strategies largely compulsory for economic actors. Within this framework, public resources are strategically concentrated on sectors considered critical for both the green transition and long-term industrial competitiveness, including renewable energy technologies, electric vehicles, batteries, and green manufacturing (*The State Council - The People's Republic of China*, 2022).

State support is delivered through a broad mix of instruments, such as direct subsidies, preferential access to credit, land allocation, and the use of public procurement as an industrial policy tool. These measures are designed to simultaneously strengthen supply and demand, accelerate the diffusion of clean technologies, and generate economies of scale in priority sectors.

By contrast, the EU adopts a more indirect and regulatory-based policy mix, according to the policies analyzed in *Chapter 3*. European green industrial policy combines market-based instruments, such as the Emissions Trading System, with regulatory standards and targeted financial support. Initiatives such as the European Green Deal, the Fit for 55 package, and the Net-Zero Industry Act define the strategic direction of EU green industrial policy by setting long-term climate objectives, sectoral targets, and common rules across Member States (Sikora, 2020: 687). Public intervention thus focuses on shaping the conditions under which markets operate, rather than directly allocating resources or directing production. Instruments like the Industrial Alliances support strategic sectors, but within a framework that preserves competition and internal market rules. As a result, the EU's green industrial policy operates primarily as an enabling framework, in which regulation and market incentives play a dominant role in driving the green transition.

Differences between China and the EU are also evident in the formulation of policy targets and objectives.

China’s green industrial policy is characterized by a quantitative and sector-specific targets. For example, the 12th Five-Year Plan (2011–2015) established binding environmental goals, such as increasing the share of non-fossil fuels in primary energy consumption to 11.4% and reducing CO2 emissions per unit of GDP by 17%. These were supported by specific capacity targets, including 120 GW for hydropower, 70 GW for wind, and 5 GW for solar power. This directive nature was further strengthened by the Made in China 2025 strategy, which integrated green development as a key indicator for industrial success, aiming to reduce foreign technological dependence while fostering leadership in new energy vehicles and high-end equipment.

Furthermore, the Industrial Green Development Plan (2016–2020) focused on the structural transformation of the six most energy-intensive industries, promoting the creation of "Green Factories" and standardized green manufacturing systems. These sectoral efforts have improved in the 14th Five-Year Plan, which accelerates the transition by targeting a carbon emissions peak before 2030. By utilizing these top-down mandates, China ensures that its environmental transition functions as a primary engine for economic growth and technological sovereignty, distinguishing its results-oriented planning from the more regulatory-focused framework of the European Union.

Indeed, in the EU, policy targets are primarily climate-oriented and normatively defined. The goal of climate neutrality by 2050 and the intermediate target of reducing greenhouse gas emissions by at least 55 percent by 2030 provide the central reference points for policy design. Industrial transformation is treated as a necessary means to achieve these climate commitments rather than as an autonomous objective. While recent initiatives increasingly emphasize competitiveness and strategic autonomy, EU targets remain predominantly horizontal and outcome-based, focusing on emissions reductions rather than prescribing specific industrial structures or production outcomes.

Governance structures constitute another aspect of divergence between the Chinese and European approach to green industrial policies.

China’s green industrial policy is characterized by a highly centralized and hierarchical governance system that derives from its socialist past. A defining feature of this model is the assertive role of the state and the central position held by SOEs. As outlined in strategies like Made in China 2025, SOEs act as key agents in implementing green industrial policies, functioning as effective means between national strategic objectives

and concrete industrial outcomes. For instance, SOEs were specifically mandated to ensure that at least 9% of total electricity generation came from renewable sources by 2020 (Li and Du, 2024: 265). Their privileged access to finance and policy support enables them to lead technological upgrading and emissions reduction, particularly in energy-intensive industries. In this vertically coordinated approach, central authorities define priorities through Five-Year Plans, while provincial and local governments are responsible for implementation. This structure allows for rapid policy deployment and strict monitoring through detailed audits of provincial compliance. However, this model carries risks such as policy overreach, uneven local implementation, and the persistence of overcapacity in certain green sectors (Zhu and Tan, 2022: 64).

In contrast, the EU operates within a multilevel and fragmented governance system, where authority is shared among European institutions, national governments, and regional actors. Unlike the Chinese model, the European Commission does not have a mandate for direct intervention or control over specific enterprises. According to Article 173 of the TFEU, the EU's role is primarily one of coordination, consultation, and support, explicitly excluding the harmonization of national laws or interventions that could distort competition.

Policy design in the EU requires extensive negotiation and consensus-building, which may result in slower decision-making but ensures greater political accountability, legal certainty, and policy legitimacy. The EU's approach functions as an "enabling framework," seeking to guide markets through regulatory standards and market-based instruments, such as the ETS, rather than replacing market mechanisms with state mandates (Tagliapietra et al., 2023: 2). While the institutional complexity of the EU creates challenges in coordination between the Commission and Member States, it also fosters policy experimentation and transnational learning across the region.

Taken together, these differences reveal two distinct models and approaches towards green industrial policy. China's approach functions as a tool of industrial planning by leveraging state power and the central role of SOEs. The EU's approach, instead, emphasizes regulatory stability and market integration, seeking to align private incentives with climate objectives through an enabling framework. This model is characterized by a multi-level governance system that prioritizes legal certainty and political legitimacy. These differences in policy instruments, targets, and governance

structures shape not only domestic industrial transformation, but also how China and the EU project leadership in the global clean energy transition.

4.2 Role in the global green energy transition leadership

Leadership in the global green energy transition is increasingly shaped by major actors such as the European Union and China. Indeed, their strategies define the future of climate governance and sustainable development. This paragraph analyses how their policy approaches and international engagements contribute to advancing the clean energy transition and aim to define how these two global actors and their green industrial policies strengthen their leadership in clean energy sector.

The European Union is widely recognized as a global leader in developing policies. Indeed, the EU is able to tackle climate and environmental challenges while fostering the sustainable development of the economy and society. Since the late twentieth century, the EU has progressively introduced legislation on nature conservation, air quality, water protection, and waste management. In parallel, it has gained importance for its ambitious climate action framework. Its objectives are embedded across the EU's broader policy toolbox, the single market and public procurement rules, financing instruments, the digital and skills agendas, innovation policy, as well as trade and diplomatic actions (Hedberg and Šipka, 2022: 87).

The environmental domain has played a crucial role in allowing the EU to position itself as a more visible and influential actor on the global stage. While the EU's prominence in this field is widely acknowledged, its role has not followed a linear trajectory and has experienced periods of both progress and stagnation since the 1990s. Nevertheless, the EU deliberately chose to invest politically and institutionally in environmental governance as a means of strengthening its identity as a normative or civilian power. This choice was strategic, as environmental issues represented an area in which the EU was less likely to be overshadowed by other major international actors (Ruiz-Campillo, 2020: 5).

The EU has been able to sustain its leadership in environmental matters through two interconnected strategies operating at both the international and domestic levels. At the international level, the Union has consistently sought to shape global environmental rules

in ways that align with its own interests and reflect its internal regulatory model. This approach allows the EU to project its policy preferences outward while minimizing conflicts with its domestic frameworks. At the same time, in order to reinforce its credibility and authority internationally, the EU has recognized the need to demonstrate commitment through action in its region. This has involved adopting ambitious internal environmental policies to meet international obligations, ranging from the legally binding commitments of the Kyoto Protocol to the more flexible framework established under the Paris Agreement. In this sense, the EU's leadership has been built not only on diplomacy, but also on its willingness to "lead by example." (Ruiz-Campillo, 2020: 6).

Since the early 1990s, the EU has steadily expanded its international presence in environmental affairs by embracing a progressively stronger sustainability agenda. This evolution was formally acknowledged in 1990, when the European Council declared that the Union had a "special responsibility" for environmental protection, both toward its own citizens and toward the international community. The Council explicitly accepted a leadership role in promoting coordinated and effective global environmental action and tasked the European Commission with taking on a more proactive role, including through regular monitoring and reporting. Shortly thereafter, and in anticipation of the 1992 Rio Earth Summit, the Commission introduced its first comprehensive strategy aimed at limiting carbon dioxide emissions and enhancing energy efficiency. This strategy encompassed a broad set of policy instruments, such as investments in research and development, measures to promote renewable energy sources, and a mix of fiscal and voluntary initiatives. Through these actions, the EU encouraged its Member States to assume both leadership and responsibility in guiding developed and developing countries toward environmental protection and sustainable resource use, with a clear intergenerational perspective (Ruiz-Campillo, 2020: 6).

The practice of issuing policy initiatives, communications, or strategic documents in advance of major international environmental conferences has since become a recurring feature of EU governance. This approach allows the EU to shape the agenda of international negotiations, to consolidate a common internal position, and to present a unified stance externally through both Member States and EU institutions. By reaching internal compromises the EU has been able to enhance its credibility and influence in international forums (Ruiz-Campillo, 2020: 7).

The signing of the United Nations Framework Convention on Climate Change (UNFCCC) in 1992 is widely regarded as the first major success of European countries in the field of international climate negotiations. Benefiting from its growing involvement in environmental governance and from a temporary weakening of U.S. leadership, the EU managed to secure a central role in global environmental diplomacy from that point onward. This role was underpinned by an increasingly comprehensive set of environmental norms and standards adopted at the EU level. European leadership in environmental matters since the 1990s can therefore be understood as the outcome of both internal political dynamics and international regulatory competition (Ruiz-Campillo, 2020: 7).

Over the past two decades, the European Union has emerged as a central actor in the field of environmental policy. This role is partly explained by the relative disengagement of other major powers such as the United States and China. By leveraging the European Commission's right of initiative and its external competences, the EU has advanced a broad and ambitious environmental agenda, ranging from the creation of a common energy market to the ban on single-use plastics. Despite this proactive stance, the Union's environmental leadership in the 1990s was undermined by a persistent gap between its international commitments and their domestic implementation, resulting in a credibility deficit. This gap, however, gradually narrowed with the adoption of the Kyoto Protocol and subsequent international agreements. The EU's decisive involvement in the Kyoto negotiations, including its efforts to ensure the participation of key global actors, represented a turning point in its international role. Through the Kyoto Protocol and the UNFCCC framework, the European Union consolidated its leadership in global environmental governance and promoted the diffusion of its regulatory standards and environmental technologies beyond its borders (Ruiz-Campillo, 2020: 8).

Maintaining this leadership has required the EU to comply with its international commitments, often necessitating significant transformations of its economy and energy systems. This process illustrates the extent to which the EU has embraced the principle of leading by example, even when doing so has involved substantial domestic adjustments and ambitious emission reduction targets that surpassed those of other major industrialized countries (Ruiz-Campillo, 2020: 8).

However, from around 2007 onwards, the EU began to lose its dominant position in international climate negotiations, despite continuing to adopt policies supportive of growth and sustainable development. This decline in leadership can be explained by a combination of internal and external factors. Internally, the global economic and financial crisis affected Member States unevenly, exacerbating divisions within the EU over how to respond to the downturn. These divergences weakened the Union's ability to act cohesively and to speak with a single voice in international forums, thereby undermining its credibility and influence. Externally, the return of the United States as an active leader in environmental governance following the election of Barack Obama significantly altered the balance of power. The EU, which had benefited for years from US disengagement, was quickly overshadowed by renewed American leadership. This shift became particularly evident at the Copenhagen Summit in 2009, where the EU, despite presenting an ambitious and innovative proposal, was marginalized from the core negotiations. The Copenhagen Accord was ultimately negotiated by the United States and the BASIC[7] countries outside the UNFCCC framework. The agreement laid the foundations for a new climate governance architecture that inverted the EU-driven, top-down model previously dominant (Ruiz-Campillo, 2020: 10).

Further evidence of the EU's weakened position emerged during the second commitment period of the Kyoto Protocol (2013–2020), in which only the EU together with other European countries and Australia had binding targets, following the withdrawal of Canada and Russia's refusal to participate. Nonetheless, extending Kyoto remained crucial for the EU, as it was the only legally binding international climate instrument in place until the Paris Agreement (Ruiz-Campillo, 2020: 11).

Between 2012 and 2015, the EU significantly intensified its diplomatic efforts to secure a global agreement in Paris. This included institutional innovations and the launch of ambitious internal commitment, such as the adoption of the 2030 Climate and Energy Framework in 2014. These targets formed the EU's contribution to the Paris Agreement and were complemented by longer-term aspirations, including a potential 80% reduction in emissions by 2050 (Ruiz-Campillo, 2020: 11).

The Paris Agreement, signed in 2015, represented a landmark in global climate governance, as it was the first agreement in which all countries committed to emission

[7] *BASIC countries*: Brazil, South Africa, India, China.

reductions, regardless of their level of development. Unlike Kyoto, which imposed binding obligations primarily on developed countries, Paris institutionalized a universal, though non-binding, system of nationally determined contributions. The success of the Paris negotiations was also a prerequisite for the adoption of ambitious unilateral EU climate policies. The Agreement entered into force in November 2016 with unprecedented speed, shortly before the US presidential election that brought Donald Trump to power. Although the EU facilitated early entry into force through partial ratification, major emitters such as China, the United States, and India ratified before the EU, limiting the leadership role the Union might otherwise have played. With the subsequent withdrawal of US leadership under the Trump administration and China showing increasing openness to sustainable development, the EU once again finds itself in a position where it could reclaim a central role in global environmental governance, provided it is able to sustain momentum and internal cohesion (Ruiz-Campillo, 2020: 12). EU's leadership in green energy investments and climate policy has various forms and go beyond the *leadership by example,* briefly introduced above. *Figure 5* describes the various leadership styles applied by the EU.

	Leadership by example	***Leadership through coalition***	***Leadership through assistance***	***Leadership by coercion***
Goal(s)	Give direction, set anchor for common goals	Broker mutually beneficial agreements	Assist in reaching common goals	Impose costs on non-compliance to set goals
Success criteria	Notice of efforts by partners, acceptance of new ambitions	(Broad) acceptance of agreement in partner countries	Policy change through improved management in partner county	Policy change of previously reluctant partners
Instruments	Domestic innovation, force of attraction, ideational inspiration	Coalition building in existing international bodies, institutionalization, establishment of new multilateral bodies	Sharing knowledge (technical cooperation), providing concessional finance/grants/ market access	Regulating market access, name-and-shame in international fora, sanctions

Figure 5: Conceptualisations of leadership. Source: Grimm, S. et al. (2022) 'Leadership and partnerships for the European Green Deal: Eu Relations with (re)emerging economies', L'Europe en Formation, n° 393(2), pp. 40–63. doi:10.3917/eufor.393.0040.

The European Union frequently exercises its climate leadership through the so-called *leadership by coalition*, aiming both to shape global climate governance and to create incentives for a broader green transition. This approach is deeply rooted in the EU's internal decision-making processes, which rely on constant negotiation and deliberation among member states across multiple levels of governance. Externally, the EU leverages diplomatic channels within bilateral and multilateral forums such as the United Nations, the G7, and the G20 to uphold and reinforce its commitment to the Paris Agreement. Through this dual strategy, the EU has been able to guide international climate policy while also serving as a mediator among other global actors (Grimm et al., 2021: 45).

Beyond coalition-building and diplomacy, the EU advances green policies through *leadership through assistance* finalized to global partners. These programs are also intentionally deployed to promote broader objectives, such as the ecological transition. Instruments such as pre-accession or development aid, knowledge-sharing, and the dissemination of best practices allow the EU to leverage domestic resources mobilized by partner countries. The European Green Deal places particular emphasis on facilitating ecological transitions in the EU's immediate neighborhood, including the Western Balkans, Southern Neighborhood, and Eastern Partnership countries, while also prioritizing engagement with major global actors such as China and fostering green alliances with African nations and the broader Global South (Grimm et al., 2021: 45).

In addition to ideational and regulatory influence, the EU also possesses substantial material leverage to advance its green agenda. Its *leadership by power* is closely tied to the power inherent in its single market, which remains one of the Union's core competencies and most effective tools of external action. Through the EGD, the EU aims to align its trade policy with ecological objectives, ensuring that sustainability principles are embedded in international trade agreements. A key proposal under this framework is to make compliance with the Paris Agreement an essential condition for all future comprehensive trade agreements. Such a measure has the potential to significantly reshape the EU's trade relations with partners demonstrating lower levels of climate ambition, including countries like Australia and Brazil, thereby linking environmental goals with economic leverage in a way that could reinforce the EU's position as a global climate leader (Grimm et al., 2021: 45).

To sum up, The European Union has leveraged its green industrial policies to strengthen its leadership in the global clean energy transition through a combination of regulatory, economic, and diplomatic tools. Domestically, the European Green Deal and ambitious renewable energy targets, exemplify leadership by example, signaling the Union's commitment to a sustainable energy future. Externally, the EU employs leadership by coalition and power, using diplomatic forums such as the G20 and trade agreements to promote adherence to climate standards, while linking compliance with sustainability goals to market access. Moreover, programs supporting technological transfer, development aid, and knowledge-sharing facilitate the adoption of clean energy solutions in partner countries, reinforcing the EU's global influence.

As briefly introduced in *Section 2.1,* Since the 2010s, China's position in international climate negotiations has gradually evolved as it aimed to reconcile its economic development objectives with growing expectations to contribute to global emissions reduction. Early engagement in international climate norm-making facilitated China's integration into the emerging global climate governance system and increased its awareness of environmental challenges, although its initial influence over negotiation agendas remained limited. The ratification of the Kyoto Protocol in 2002 marked a clear commitment to global climate cooperation and triggered significant domestic institutional reforms, integrating climate policy into China's broader economic and development strategy. This transformation of domestic climate governance enabled China to adopt a more proactive and assertive role internationally, culminating in its leadership during the 2015 Paris Agreement. By promoting cooperative, inclusive, and shared responsibility and by fostering consensus between developed and developing countries, China strengthened its international standing while aligning climate diplomacy with domestic priorities such as innovation, energy efficiency, and leadership in renewable energy technologies.

Nowadays, China's green transition extends beyond international commitments or ideological considerations. It is fundamentally shaped by strong domestic pressures to confront persistent environmental degradation, protect public health, and modernize its industrial structure. The pursuit of cleaner air and a more sustainable economic model therefore represent not merely a strategic policy option, but a pressing necessity rooted in China's socio-economic conditions. These internal drivers place China in a distinctive

position to promote the formation of a “non-politicized global green coalition,” one that prioritizes practical cooperation and common solutions over ideological divisions (Chao, 2025).

Chinese leadership in global green energy transition is reflected in quantitative indicators: China accounts for over 75 percent of global lithium-ion battery manufacturing, nearly 80 percent of solar module production, and the largest share of worldwide electric vehicle output. High-speed rail has become a prominent demonstration of its engineering capabilities, while rapid advances in robotics and sensor technologies have further narrowed the gap with leading global innovators (Kuo, 2025).

Furthermore, between 2010 and 2019, China invested $758 billion in renewable capacity, surpassing the United States ($356 billion) and Japan ($202 billion). By 2018, China led global spending across a wide range of clean energy areas, including offshore wind, concentrated solar power, distributed solar, industrial and building energy efficiency, transport and heating renewables, energy research and development, grid-scale battery storage, and transmission infrastructure. From 2009 to 2017, Chinese national and local governments also allocated nearly $60 billion to support the electric vehicle sector through subsidies, research, procurement, and tax incentives. The impact of this large-scale investment has been transformative. China now leads the world in wind and solar photovoltaic power, bioelectricity, solar water heating, and geothermal energy. Its installed wind capacity of 210 GW and solar capacity of 200 GW are double that of the United States, making up roughly one-third of global capacity for both wind and solar PV (Finamore, 2020: 6).

In the transportation sector, China leads in high-speed rail, subways, lithium-ion batteries, and electric vehicles, including buses, taxis, low-speed vehicles, and bicycles. Ninety-nine percent of the world’s electric buses operate in China, and the country has the largest EV charging network globally. By 2017, seven of the top ten EV battery producers were Chinese, with forecasts suggesting China would control 65% of the battery market by 2021 (Finamore, 2020: 7).

China’s investments have driven global cost reductions in clean energy. Solar power costs have fallen nearly 90% and wind power by almost 50% in the past decade, making renewables the cheapest form of new electricity generation for more than two-thirds of the world’s population. Consequently, renewable capacity additions have exceeded those

of fossil fuels and nuclear for four consecutive years. Similarly, declining battery costs have lowered electric vehicle prices, with lithium-ion battery pack costs dropping 87% between 2010 and 2019, bringing EVs close to cost parity with fossil fuel vehicles as early as 2022 (Finamore, 2020: 7-8).

Its dominance in green energy transition has been driven by coordinated government policies and substantial investment. This approach has contributed to lower production costs and greater global availability of essential technologies, such as lithium-ion batteries. At the same time, this concentration of production raises significant concerns for the shift toward a zero-emissions, climate-resilient global economy and for the economic competitiveness of other countries. Manufacturing and supply chains are not only sensitive to China's policy choices, such as the introduction of trade controls, but are also exposed to risks stemming from their geographic concentration. This concentration heightens the possibilities of disruptions caused by localized natural disasters and extreme weather events, whose frequency and intensity are increasing due to climate change. As a result, China itself, along with other nations, faces growing exposure to the consequences of these structural vulnerabilities (Bian et al. 2024: 12).

Moving on recent events, China's pursuit of global green leadership after COP30[8] reflects a selective and strategic approach to climate governance. On the one hand, China presents itself as a central actor in the global energy transition by emphasizing its technological and industrial capacity rather than binding emissions reductions. China leverages its dominant position in renewable energy technologies, such as solar panels, batteries, wind power, and electric vehicles, by framing climate action as an issue of clean technology deployment, industrial scale, and trade, in order to consolidate international influence while maintaining flexibility in its climate commitments (Lo Professor, 2025). On the other hand, the expansion of green leadership aligns closely with China's economic and commercial interests. As the world's largest exporter of clean technologies, China benefits from global decarbonization trends that open new markets for its industries. Promoting open trade in green technologies allows China to counter protectionist measures introduced by the European Union and the United States, while legitimizing its industrial policy and reinforcing its competitive advantage in strategic sectors. In this sense, climate leadership functions not only as an environmental objective

[8] UN Climate Change Conference held in Belém (Brazil) from November10th 21st, 2025.

but also as an instrument of economic statecraft (Lo Professor, 2025). China's strategy reached the international arena through the Belt and Road Initiative (BRI), which has emerged as a key mechanism for supporting renewable energy investments globally. Since 2015, China has allocated more than USD 50 billion to renewable energy projects across Asia, reinforcing its influence in sustainable infrastructure development (Energy Asia).

In 2024, energy-related projects continued to dominate the BRI portfolio, with total investments approaching USD 40 billion, the highest level since 2017. Of this, USD 11.8 billion was invested specifically in green energy initiatives, including solar, wind, and waste-to-energy projects, representing a 60% increase compared to 2023. By funding clean energy development in partner countries, China is promoting technology transfer, decreasing reliance on fossil fuels, and enhancing regional energy security (Energy Asia). Indeed, climate cooperation further serves as a diplomatic tool to strengthen China's relations with developing countries. Through technology transfer, infrastructure investment, and climate-related assistance, particularly in the Global South and among small island states, China positions itself as a partner distinct from Western powers and reinforces its identity as a leader of the developing world. This approach supports broader geopolitical goals while expanding China's influence in key regions Lo Professor, 2025). However, China's willingness to assume global green leadership remains limited. Accepting a role comparable to that of traditional climate leaders would require greater responsibility for historical and current emissions, as well as more ambitious and immediate mitigation commitments. By continuing to frame itself as a developing country within international climate negotiations, China avoids binding obligations that could constrain domestic development priorities (Lo Professor, 2025).

Domestic economic constraints further restrict the scope of China's climate leadership. Slowing economic growth, financial pressures on local governments, and social challenges, such as youth unemployment, reduce the political and fiscal space for far-reaching climate commitments and large-scale international climate finance contributions. Consequently, China favors a form of leadership that maximizes strategic and economic benefits while minimizing political, economic, and regulatory costs.

Overall, China's approach to global green leadership is characterized by pragmatism and selectivity. While it plays a decisive role in enabling the global energy transition through

technology, investment, and trade, it deliberately avoids assuming full normative and regulatory leadership in global climate governance. This model reflects broader transformations in the international system, where leadership increasingly emerges from industrial capacity and economic influence rather than from binding multilateral commitments (Lo Professor, 2025).

China's leading position in green technologies represents a major challenge for the European Union. Although initiatives such as the European Battery Alliance launched in 2017 sought to strengthen Europe's autonomy, the EU continues to rely heavily on Chinese manufacturing capabilities. Consequently, the Union has shifted its approach toward reinforcing its industrial base, stimulating innovation, and countering distortive trade practices. In this context, the Green Deal Industrial Plan aims to establish a supportive regulatory framework, facilitate access to funding, develop skills, and preserve open trade to secure supply chains. Building on this strategy, the Net Zero Industry Act identifies strategic sectors in which Europe intends to curb external dependencies and enhance its global competitiveness. At the same time, the European Union has intensified scrutiny of China's use of subsidies and trade policies that undermine fair competition. In the electric vehicle sector, for example, the European Commission found that Chinese producers benefit from unfair state support, enabling them to gain a significant competitive advantage (Fabrègue, 2024).

Although green technologies contribute to reducing dependence on petrostates, European governments must acknowledge that an effective climate policy requires a coherent industrial strategy. China's technological leadership has largely been driven by an industrial model centered on state-owned and vertically integrated enterprises, combined with targeted subsidies, large-scale investments, and domestic market deployment. This reality challenges the long-standing paradigm based on globalization, free trade, and economic and technological cooperation primarily oriented toward efficiency. That framework enabled the offshoring and expansion of technology manufacturing in China, fueling its remarkable economic growth over the past four decades. However, in the context of a "new" phase of globalization, global actors are increasingly compelled to reassess the broader consequences of free trade and deep economic interdependence (Fabrègue, 2024).

In conclusion, both China and the European Union have strengthened their leadership in clean energy through different but complementary approaches shaped by domestic priorities, industrial policies and international strategies.

The European Union has improved regulatory frameworks, ambitious domestic targets, and multilateral diplomacy to project leadership rooted in normative and structural influence. Through the European Green Deal, the EU demonstrates leadership by example, while its leadership by coalition and power reinforces global adoption of sustainable practices. The EU's model emphasizes resilience, governance, and systemic sustainability, allowing it to shape global standards and incentives for clean energy.

On the other hand, China's state-led model, characterized by investments, coordinated subsidies, and strategic industrial planning, allowed to achieve rapid technological and market dominance in solar PV, wind, lithium-ion batteries, and electric vehicles. Its Belt and Road Initiative extends this influence by promoting clean energy deployment and technology transfer globally and consolidate China's position as a leader in the global energy transition. However, this leadership is constrained by domestic economic pressures, supply chain vulnerabilities, and the strategic imperative to maintain flexibility in climate commitments.

Overall, China's policies have translated into rapid, measurable gains in technological and industrial dominance, whereas the EU's approach strengthens long-term normative and institutional leadership. These strategies illustrate how green industrial policies can reinforce global clean energy leadership through both market power and governance influence, highlighting the diverse pathways through which states can drive the energy transition.

4.3 Concluding remarks on China and EU's approaches

The comparative analysis conducted in this chapter highlights two different but interconnected models of Green Industrial Policy. On one hand, China's approach allowed an unprecedented improvement of manufacturing capacities, making it one of the main global hub for green technologies. On the other hand, the European Union has developed its regulatory power and multi-level governance to create a framework that prioritizes market standards, sustainability, and transparency.

However, both actors face a common challenge: balancing domestic economic growth with the urgent need for a global decarbonization process.

As this chapter has demonstrated, the leadership of China and the EU is no longer defined solely by their internal achievements but also by their ability to influence the global trajectory of the energy transition. This brings to a crucial question: how do these different forms of leadership align with the international obligations and goals established in the Paris Agreement?

Chapter 5 – Green Industrial Policy and the Paris Agreement

5.1 Focus on the Paris agreement: framework and goals

The Paris Agreement was adopted on December 12th, 2015, at the 21st Conference of the Parties (COP21) of the United Nations Framework Convention on Climate Change and has been ratified by 195 countries. The Agreement created a positive push for all international actors to achieve collectively global climate commitments and aimed to strengthen the global response to climate change over the course of the 21st century (Matsumoto et al., 2019: 7).

Under the Agreement, all parties are obligated to develop Nationally Determined Contributions (NDCs) and implement domestic policies to meet climate goals. Furthermore, the Agreement encourages the creation of Long-Term Low Emission Development Strategies (LT-LEDS). These strategies allow countries to envision the systemic economic shifts required to meet Paris Agreement targets and provide a roadmap that strengthens the immediate goals set in NDCs. Consequently, many nations have started updating their climate policies and transition plans based on these long-term visions (Matsumoto et al., 2019: 6). This voluntary national ambitions represent the main difference in comparison from the Kyoto Protocol, which is often considered unsuccessfully at the international level, also for its non-binding nature.

NDCs are defined under Article 4(9) of the Agreement, which states that: "*Each Party shall communicate a nationally determined contribution every five years in accordance with decision 1/CP.21 and any relevant decisions of the Conference of the Parties serving as the meeting of the Parties to this Agreement and be informed by the outcomes of the global stocktake referred to in Article 14"* (The Paris Agreement, 2015).

This means that these NDCs must be updated every five years, with the expectation that each round will be more ambitious than the last. The 160 "intended" NDCs submitted during the negotiations served as a clear signal that this continuous progression is essential for global success (Falkner, 2016: 13).

NDCs are fundamental to meet GHG reduction. Indeed, the UN Climate Change aims to illustrate that the implementation of the new NDCs of 2025 is projected to reduce total greenhouse gas emissions to approximately 13.0 Gt CO2 eq by 2035. This represents a 6 per cent decrease compared to the 2030 targets established in previous NDCs and a more

significant 17 per cent reduction relative to 2019 levels. Under a scenario of full implementation. Most of the updated NDCs are strategically aligned with long-term decarbonization pathways, aiming for net-zero emissions between 2040 and 2060, with the majority targeting 2050.

Another point of divergence from the Kyoto Protocol regards the participation of all countries in the mitigation effort of the Agreement. Indeed, the Kyoto Protocol assigned emission reduction mandates exclusively to developed nations, while the Paris Agreement requires all emitters to implement national strategies to decrease global temperature rise (Falkner, 2016: 14).

The Paris Agreement offers a more realistic framework for global emission reductions by aligning international policy with political realities. For this reason, it acknowledges that major emitters are generally unwilling to commit to rigid, legally binding reduction quotas and it bypasses the contentious issue of burden-sharing by avoiding the need to negotiate 'fair' distribution of efforts and facilitates broader cooperation (Falkner, 2016: 19).

Moving more specifically to the analysis of the Paris Agreement, article 2 is the core of the Agreement and explicates the main goal of the Agreement:

"1. This Agreement, in enhancing the implementation of the Convention, including its objective, aims to strengthen the global response to the threat of climate change, in the context of sustainable development and efforts to eradicate poverty, including by:

> *a. Holding the increase in the global average temperature to well below 2 °C above pre- industrial levels and pursuing efforts to limit the temperature increase to 1.5 °C above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change;*
>
> *b. Increasing the ability to adapt to the adverse impacts of climate change and foster climate resilience and low greenhouse gas emissions development, in a manner that does not threaten food production; and*
>
> *c. Making finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development.*

2. This Agreement will be implemented to reflect equity and the principle of common but differentiated responsibilities and respective capabilities, in the light of different national circumstances." (The Paris Agreement, 2015).

This article is also central for the development of the Chinese and European leadership in green energy transition. Indeed, this comma guides the trajectories of these two approaches and, as described in the previous chapters, the limit of 2°C evolved from a merely scientific and quantitative data to a market driver for economic and social development. Indeed, transforming this limit into a binding political objective, represents a change in environmental diplomacy and started a process of green transition, which has seen a competition between the major global actors in the last decade

When talking about green energy leadership, it is also interesting to focalize on comma 2.2 and the principle of "common but differentiated responsibilities". This article partially explains how two different models of leadership, in this case the Chinese and the European approach, as analyzed in Chapter 4, can coexist towards the same goal and can reflect the specific necessities of each area.

For the European Union, these capabilities have been translated into a duty of normative and institutional vanguard. This approach, centered on the European Green Deal and the Fit for 55 package, aims to export high environmental standards globally. By setting stringent binding targets for 2050, the EU exercises a normative leadership, also known as "Brussels effect" [9], that seeks to define the global rules of the green transition.

On the other hand, China utilizes the flexibility of the "common but differentiated responsibilities" principle to balance its status as a major industrial power with its continuing development needs. China has focused on the large-scale manufacturing of clean technologies, rather than focusing on immediate emission cuts, as explored in Chapter 2 through China's 2060 carbon neutrality goal and its strategy. Furthermore, by dominating the global supply chains of solar panels, wind turbines, and electric vehicles, China has fulfilled the Paris Agreement's mandate by making these technologies economically accessible.

[9] *Definition of the "Brussels Effect":* it refers to the European Union's unilateral power to regulate global markets by establishing high standards in fields such as competition, environmental protection, and digital privacy. This phenomenon operates through two distinct mechanisms: the de facto effect occurs when multinational corporations voluntarily adopt EU regulations across their entire global operations to avoid the logistical costs of complying with multiple regulatory regimes; meanwhile, the de jure effect involves foreign governments formally adopting EU-style legislation as a template. By leveraging its position as one of the world's largest and wealthiest consumer markets, the EU effectively "outsources" its regulatory framework globally, transforming its internal rules into international standards through market forces and technical expertise rather than formal coercion. (Source: Bradford, A. (2021), *The European Union in a globalised world: the "Brussels effect"*, pp. 75-79. Available at: https://geopolitique.eu/en/articles/the-european-union-in-a-globalised-world-the-brussels-effect/)

This means that the Paris Agreement has redefined the essence of global climate leadership by transforming environmental mandates into a framework for strategic industrial positioning. While the European Union has assumed a primary role in defining the regulatory and normative architecture of this transition, China has leveraged the Agreement's flexibility to establish itself as a green manufacturing leader. To understand how these theoretical mandates are operationalized into concrete strategies, the following sections will examine the evolution of China and EU's approaches and their contribution to the global climate goals.

5.2 China's green industrial policies and the Paris Agreement

China's high-level engagement at the Paris Conference highlights its strategic necessity to integrate climate action into its broader national ecological initiatives, fostering sustainable socioeconomic growth while asserting its role as a responsible global power. During the negotiations, the Chinese leadership advocated for a multilateral governance model based on 'win-win' cooperation, where each nation contributes according to its respective capabilities, as defined in the article 2.2 of the Agreement. This vision emphasized the role of important values, such as fairness, justice, and mutual development. China's constructive role in securing the Paris Agreement serves as a landmark model for its active participation in international governance. These principles now serve as the foundational guidelines for China's implementation of the Agreement and its ongoing commitment to shaping the global climate architecture in a responsible and inclusive way (Gao, 2016: 239).

As introduced in Chapter 2, the role of China as a global climate leader acquired more importance during the speech of the Chinese President at the UN General Assembly in 2020 when he announced that China would aim to peak its carbon dioxide emissions before 2030 and achieve carbon neutrality before 2060.

The Paris Agreement goals serve as the foundation for most green industrial policies discussed in Chapter 2. Moreover, Chinese policies are vital for meeting NDC targets, highlighting China's leadership in the global transition to a green economy.

The submission in June 2015 of the '*Enhanced Actions on Climate Change: China's Intended Nationally Determined Contributions (INDC)*' represents the formalization of

China’s commitment to the Paris Agreement. In this preliminary framework, China aimed to reach its CO2 emissions peak in 2030, while simultaneously aiming to reduce carbon intensity by 60% to 65% compared to 2005 levels. Key targets also included increasing the share of non-fossil fuels in primary energy consumption to approximately 20% and expanding forest stock by 4.5 billion cubic meters. To support these goals, China introduced fifteen categories of policies and measures, demonstrating a proactive approach to climate risk mitigation. *(*China’s Achievements, New Goals and New Measures for Nationally Determined Contributions*, 2021: 2)*

However, as discussed in the context of China's evolving leadership, these commitments were significantly strengthened in recent years. China’s updated NDC goals reflect a more determined decarbonization pathway. Indeed, the target for carbon intensity reduction has been raised to over 65%, and the non-fossil fuel share is projected to reach 25% by 2030. Furthermore, China has committed to a total installed capacity of wind and solar power exceeding 1.2 billion kilowatts by 2030, a cornerstone of its strategy to achieve carbon neutrality before 2060 (China’s Achievements, New Goals and New Measures for Nationally Determined Contributions, 2021: 2).

The Industrial Green Development Plan (2016–2020) can be considered as the starting point of the Chinese green industrial approach trough the lenses of the Agreement. As previously analyzed, this plan represented the first systematic attempt to align the nation’s heavy industrial base with the newly adopted Paris Agreement. By focusing on energy-intensive industries and resource efficiency, the plan aimed to strengthening the development of the green manufacturing sector, and create and consolidate a long-term framework for green industry growth, through a path of green development

Central to this phase was the implementation of a green factories evaluation system and the promotion of green industrial parks, which were designed to lower energy and water consumption per unit of output. These measures were not merely domestic technical requirements but were explicitly designed to support the NDC 2030 targets regarding GHG reduction. By fostering a circular economy and incentivizing the adoption of clean energy at the industry level, this plan directly operationalized the Paris goals within the Chinese manufacturing sector. This plan demonstrates that industrial decarbonization could serve as a driver for both climate compliance and competitive manufacturing (Li and Du, 2024: 265).

Thus, the international duties of the Paris Agreement are not merely diplomatic statements but acquire a concrete and operational role in domestic legislation. As analyzed in Chapter 2, the 14th Five-Year Plan (2021–2025) serves as the primary vehicle for achieving these milestones through a renewable energy expansion which include a green development of the industrial sector. By accelerating the transition to non-fossil electricity, China is directly addressing its commitment to peak CO_2 emissions before 2030. This domestic push is supported by a significant emphasis on green technology innovation . Moreover, the 14th Five-Year Plan establishes a much stronger alignment with the Paris Agreement's long-term goals than previous iterations. By embedding concrete energy transition measures and binding environmental indicators into the national budget and provincial performance evaluations, the Plan ensures that the path toward carbon neutrality by 2060is consistent and irreversible. The integration of NDC targets into national development goals shows that the Chinese government has ensured that the mandates of the Paris Agreement are included in the industrial and economic planning and integrated within long-term goals (China's State Council, 2021).

Another interesting aspect of the alignment of Chinese green industrial policies and the Paris Agreement regards Made in China 2025. As a matter of fact, MIC 2025, as explained by Li and Du (2024) and by Xu (2025), prioritizes leadership in the manufacturing of energy-saving and new energy vehicles, trying to face the challenges of low energy efficiency and environmental pollution in China's manufacturing sector and aligns the industry with sustainable development principles by encouraging the adoption of energy-saving and environmentally friendly technologies. This policy framework is indirectly aligned with the Paris Agreement. MIC 2025 does not explicitly cite the Agreement's goals as its primary mandate, but MIC's sectoral goals are indispensable for the fulfillment of China's international duties. By transforming the manufacturing landscape, MIC 2025 provides the technological capacity and the efficiency gains required to meet the carbon peaking and neutrality targets. In this sense, the pursuit of industrial modernization and "green manufacturing" serves as the material foundation upon which the success of the Paris Agreement targets explained in Article 2.

Lastly, in the case of China, it is necessary to focus briefly on the role of State-owned enterprises to meet the targets set by the Paris Agreement due to their importance in the Chinese economy. As analyzed, SOEs are expected to fulfill not only economic and

political tasks but also additional policy responsibilities related to green development. As a result, SOEs operating in heavily polluting sectors in China tend to respond more proactively to green industrial policies.

Local governments also apply more relaxed regulatory oversight to SOEs and are more inclined to prioritize addressing their green innovation challenges and often possess strong political awareness and tend to seek political connections, leading them to align corporate strategies closely with government policy directions (Zhu and Tan, 2022: 64). SOEs represents some of most significant investors in green technology worldwide. These entities provide the share of infrastructure investment necessary for both climate mitigation and adaptation strategies. Due to their direct ownership stakes, the Chinese government is uniquely positioned to align SOE decision-making toward climate-relevant goals. The state ensures that these industrial giants act as the primary engines for the energy transition, effectively operationalizing national NDC targets through large-scale public financial management and industrial reform (De Kleine Feige, 2021: 1).

In conclusion, the Chinese alignment to the Paris Agreement demonstrates a synergy between international climate mandates and a state-led industrial approach. The operative use of NDC targets through centralized planning and policies such as the MIC 2025 created a model of leadership where green industrial development and climate policy are linked. This demonstrates, one more time, that for China, green industrial policies are not merely tools for environmental protection, but rather the essential instruments for a new phase of economic growth and global competitiveness.

5.3 Alignment of EU policies with the Paris Agreement goals

The European Union's performance at the COP21 Paris summit represent the starting point toward a more realistic and diplomatically active role. During the negotiations, the EU successfully utilized "instrumental leadership" by focusing on building coalitions and forming powerful alliances. A central element of this strategy was the creation of the "High Ambition Coalition," a group co-chaired and financially supported by the EU alongside various developed and developing nations to pressure major emitters to accept more rigorous targets (Parker et al., 2017: 242). To ensure a universal agreement, the EU showed increased flexibility by abandoning its previous insistence on a purely "top-

down" legal structure in favor of a hybrid model that combined national pledges with international transparency and review mechanisms (Parker et al., 2017: 242).
Furthermore, its strategy showed an intensive engagement within and outside UNFCCC channels, included the formation of strategic coalition to amplify its influence, and tried to act as a mediator to influence the outcome of COP21. These efforts were further enhanced by a favorable international political climate. Indeed, in the year prior to the conference, the EU distinguished itself through its high volume of policy contributions and active participation in high-level forums like the G20 and bilateral meetings, both at the UNFCCC negotiations meetings and beyond. The European Union's position during the Paris negotiations can be described as moderately ambitious. Indeed, while aiming for ambitious greenhouse gas reduction targets, it adopted a cautious approach regarding climate finance and climate adaptation (Oberthür and Groen, 2017: 4).
These diplomatic efforts resulted in high goal reaching, as the final draft of the Paris Agreement included most of the EU's core demands, such as the five-year review cycles and the science-based goal of limiting warming to well below 2°C. However, despite these successes, survey data from the summit indicates that the EU operated within a "fragmented leadership landscape" where it was not the sole undisputed leader (Parker et al., 2017: 244). In Paris, the EU's recognition as a leader among conference participants fell to 41%, leaving it behind the United States (59%) and China (54%) in terms of external perception. Lastly, the EU proved to be a unified and influential actor, demonstrating that its collective diplomacy could shape global outcomes more effectively than any individual member state (Parker et al., 2017: 248).
The diplomatic role is reflected in the region through a massive regulatory overhaul. Indeed, the green industrial policies analyzed in Chapter 3 represent not only economic strategies but also the primary instruments to reach goals set during COP21 and for maintaining its status as a 'regulatory superpower' in the global climate policy making.

When discussing about the alignment of European green industrial policies and the Paris Agreement, the main instrument related to the Agreement is the Fit for 55 package. Indeed, this plan is crucial to meet the goals set by the 2020's submission of the NDCs by the EU and its member states. These NDCs aimed to reduce greenhouse gas emissions by at least 55 percent by 2030 compared to 1990 levels (German Council on

Foreign Relations, no date). As explained in chapter 3, this is the exact same goal of the Fit for 55 package. In other words, the NDCs represent the strategic target, while the Fit for 55 package provides the operational means to reach it. This is achieved through the revision and strengthening of key directives, such as the EU Emissions Trading System and the Renewable Energy Directive which directly regulate industrial output and energy consumption (Schlacke et al., 2022: 4-5). Furthermore, by adopting this package, the EU has demonstrated its commitment to the five-year ambition cycles established by the Paris Agreement in article 4.9, ensuring that its domestic legislation evolves to reflect the highest possible level of climate ambition over time.

A central measure of the Fit for 55 is represented by the Carbon Adjustment Mechanism because it serves as a fundamental instrument for the EU to safeguard the integrity of its environmental objectives. It prevents the dilution of the EU's climate ambition by ensuring that imported products, often manufactured in jurisdictions with more lenient environmental standards, do not gain an unfair competitive advantage over domestic goods. By internalizing carbon costs for imports, the EU aims to establish a level playing field for its industrial base, while simultaneously exerting a normative influence on international partners, incentivizing them to strengthen their own climate frameworks in alignment with the Paris Agreement (EcoPurus, no date).

This alignment shows that for the EU, meeting NDC targets is not just an internal bureaucratic exercise but a strategic effort to lead the global green transition by setting the rules of the international marketplace (EcoPurus, no date).

As examined before, the European Green Deal has a significant role in the green transition of the area and its regional impact is also related to the Paris Agreement and, for this reason, has some consequences in the green energy leadership of the European Union. It essential to highlight that the European Green Deal is the result of EU’s international commitments, which includes the Paris Agreement, that needed to be turned into actual legislation, moving beyond mere environmental protection to a strategic industrial restructuring. The European Green Deal puts in place measures and rules to drastically cut emissions and transform the European economy to become climate-neutral by 2050. By establishing a clear and irreversible path toward decarbonization, the Green Deal provides the regulatory certainty needed to shift capital toward green technologies. This alignment with the Article 2 of the Paris Agreement’s ensures that financial flows are

consistent with a low-carbon trajectory. Furthermore, this domestic implementation serves a broader geopolitical purpose: it consolidates the EU's 'Normative Leadership' and the known 'Brussels Effect, by being the first major economy to establish a rigorous framework and setting the global technical and environmental standards for the green markets of the future (Tagliapietra and Veugelers, 2020: 4).

The alignment of the EU with the Agreement goes also beyond Article 2; indeed, article 6 is fundamental when discussing and analyzing the Clean Industrial Deal.
Article 6 defines that *"(...)2. Parties shall, where engaging on a voluntary basis in cooperative approaches that involve the use of internationally transferred mitigation outcomes towards nationally determined contributions, promote sustainable development and ensure environmental integrity and transparency, including in governance, and shall apply robust accounting to ensure, inter alia, the avoidance of double counting, consistent with guidance adopted by the Conference of the parties serving as the meeting of the Parties to this Agreement.*
3. The use of internationally transferred mitigation outcomes to achieve nationally determined contributions under this Agreement shall be voluntary and authorized by participating Parties.
4. A mechanism to contribute to the mitigation of greenhouse gas emissions and support sustainable development is hereby established under the authority and guidance of the Conference of the Parties serving as the meeting of the Parties to this Agreement for use by Parties on a voluntary basis. It shall be supervised by a body designated by the Conference of the Parties serving as the meeting of the Parties to this Agreement (...)" (The Paris Agreement, 2015). This means that the Paris Agreement establishes a framework for international cooperation through 'internationally transferred mitigation outcomes' and the creation of a global carbon mechanism, aiming to ensure environmental integrity and transparency while avoiding the double counting of emission reductions and it finds the practical application in the Clean Industrial Deal. Indeed, this policy sets out concrete actions to turn decarbonization into a driver of growth for European industries and support industries that are highly energy-intensive, such as steel, metals, and chemicals, in the transition to clean energy while addressing high costs, unfair global competition, and complex regulations (European Commission – Clean Industrial Deal).

In this perspective, the Clean Industrial Deal acts as the bridge between high climate ambition and industrial feasibility. Furthermore, targeting the implementation phase of the green transition by ensuring that energy-intensive sectors represent a strategic response to the Paris Agreement's mandate because the EU is creating the economic conditions to meet Paris' target while investing in its green economic development.

In conclusion, the analysis of the European Union's alignment with the Paris Agreement shows that EU has consistently sought to transform international climate mandates into a competitive advantage by trying to establish the regulatory benchmarks through the Brussels effect. Furthermore, this analysis demonstrates that the leadership of the European Union is rooted in the legislative and normative framework.

5.4 Lessons learned and policy implications for global climate governance

Comparing the Chinese and the European approach shows how the vision of green industrial evolved from a pure instrument of national economic development and became the main engine of the global climate governance under the Paris Agreement framework. On one hand, the top-down approach of China demonstrates the efficiency related to the scale production of green technologies. On the other hand, the European normative and multilateral approach establishes clean energy and sustainable standards that can influence the international landscape. Today, a decade after the adoption of the Paris Agreement, the increasing urgency to address climate change has transformed green industrial policies into an indispensable tool for global action. This ten-year milestone offers a critical vantage point to evaluate what has functioned and what must be improved. In this context, green industrial policy represents the strategic interface through which nations negotiate their role in a decarbonized global economy.

As showed by Veugelers et al. (2024), a fundamental lesson in terms of policy implications is that strong governance remains a prerequisite for effective climate action. Leadership must be competent, independent, and accountable to clear milestones, capable of coordinating different government groups to navigate the complexities of modern policymaking (Veugelers et al., 2024: 16). A long-term vision is essential to provide the certainty needed for private clean-tech investments, and this must be balanced with the

flexibility to adapt to high levels of uncertainty and risk. To avoid directionality failures, global governance should promote rigorous monitoring and evaluation to learn from policy interventions. Furthermore, increasing support for public-private ecosystems at scale is vital; policies must ensure that even new clean-tech startups can thrive and prevent the stagnation of green innovation (Veugelers et al., 2024: 18). Lastly, it is essential to underline that the success of the transition is inextricably linked to the development of human capital; ensuring a qualified workforce through dedicated skill agendas is not only a domestic necessity but a core implication for a just and productive global climate transition (Veugelers et al., 2024: 20).

Building upon these findings and the available literature, future global climate governance must incorporate specific design characteristics to maximize impact while minimizing systemic risks. Effective policies should be strictly future-oriented and technology-driven, avoiding the pitfall of "picking winners" among individual firms, which often leads to perverse incentives and reduced innovativeness. Instead, the focus must remain on fostering sectors where advanced capabilities are desirable for the global transition (Terzi et al., 2023: 851). Moreover, competition must be viewed as a strength; indeed, an effective industrial policy should not undermine the dynamic nature of markets but rather address the market failures that prevent a desirable environmental equilibrium. This requires a balanced "top-down but also bottom-up" approach that sets a clear strategic direction while encouraging experimentation and entrepreneurial creativity (Terzi et al., 2023: 852).

Looking ahead, the primary challenge for the Paris Agreement framework at ten years lies in bridging the "implementation gap" between high-level ambition and tangible industrial results (OECD, 2025). Managing the tension between the necessary rise of green industrial policies and the preservation of a stable global trade system will test the resilience of international cooperation as nations move toward the 2030 and 2050 milestones. Future challenges include the risk of "green protectionism", where defensive tools like the Carbon Border Adjustment Mechanism (CBAM) might be perceived as trade barriers rather than environmental safeguards. This could slow down the global diffusion of low-cost technologies, a critical factor for the success of the Agreement's mandate to make clean energy economically accessible. Moreover, the governance of critical raw material supply chains and the behavior of state-owned enterprises (SOEs) in

aligning with national NDC targets remain pivotal for long-term sustainability. Ultimately, the future effectiveness of the Paris Agreement will depend on whether these industrial strategies are seen as zero-sum geopolitical games or as a collaborative "race to the top" that reconciles strategic industrial autonomy with the sharing of scientific advancement for global decarbonization (Terzi et al., 2023: 852).

Conclusion

This thesis has analyzed the evolution and impact of green industrial policies in China and in the European Union, while trying to understand how these strategies have strengthened global leadership on clean energy and how the policies are aligned with the Paris Agreement's goals.

The primary objective of this research was to address the fundamental question: "To what extent do the green industrial policies of China and the European Union reinforce their leadership in clean energy, and how does this leadership reflect and align with the objectives of the Paris Agreement?".

Upon completing this comparative analysis, it is evident that both actors have successfully transformed the green transition from a mere environmental obligation into the cornerstone of their industrial strategy and geopolitical identity. The answer to this research question reveals a structural dichotomy where China has consolidated a leadership based on production scale and control of global supply chains, while the European Union has asserted its dominance through regulatory power and the definition of global sustainability standards.

These two trajectories, despite emerging from different institutional and economic contexts, converge in providing the practical implementation of the Paris Agreement's principles. China's leadership has proven to be deeply rooted in an extremely effective top-down model characterized by strong central coordination and the pervasive role of State-Owned Enterprises. Through instruments such as the Five-Year Plans and the "Made in China 2025" strategy, China has not only aimed at domestic decarbonization but at the total dominance of the global market for clean technologies. This approach has allowed China to drastically reduce the production costs of solar, wind, and battery technologies, making the energy transition economically accessible on a global scale. In terms of alignment with the Paris Agreement, China has utilized its industrial policy to ensure the peak of carbon emissions before 2030, integrating international climate goals into its own vision and technological sovereignty. However, this production dominance poses significant challenges for multilateral cooperation, as the concentration of supply chains in a single actor creates vulnerabilities for global energy security.

On the other hand, the European Union has responded to these challenges by proposing a unique model of leadership based on the so-called "Brussels Effect". With the European Green Deal and the Fit for 55 package, the EU has not only established climate neutrality targets for 2050 but has also created a regulatory system that imposes sustainability as a competitive standard. European leadership is reflected in its ability to align financial flows with a low-carbon trajectory, in full harmony with Article 2 of the Paris Agreement. Through instruments like the Net-Zero Industry Act and the Carbon Border Adjustment Mechanism (CBAM), the EU seeks to balance climate ambition with the protection of its industrial base and strategic autonomy. The European answer to the research question lies in its ability to export environmental standards, influencing the policies of trading partners and promoting global climate governance based on rules and transparency.

One of the most significant findings of this comparison is the nature of the competition between China and the EU. While geopolitical tensions and the search for industrial sovereignty might appear as obstacles to cooperation, this "green competition" actually acts as a powerful catalyst for global climate action. The race for technological leadership is accelerating innovation and lowering costs, making it easier for all signatories of the Paris Agreement to submit more ambitious Nationally Determined Contributions every five years. The Chinese model demonstrates that speed and scale are possible through state-led investment, while the European model proves that a normative, market-based framework can lead the way in legislative sophistication and carbon pricing.

Both models are essential to meet the Paris Agreement's goal of limiting global warming to well below 2 degrees Celsius. However, the closing of the "implementation gap" between diplomatic promises and industrial outcomes remains the primary challenge for the next decade. The lessons learned show that strong governance, rigorous monitoring, and the development of human capital are indispensable prerequisites for a transition that is not only effective but also just and productive. This research highlights that the clean energy race is inherently tied to the restructuring of global trade relations and confirms that green industrial policies are the primary vehicles through which these two powers exercise their global influence.

In conclusion, China and the European Union represent two complementary engines of the global energy transition. If China provides the productive engine needed to deploy technologies at scale, the EU provides the regulatory mechanism and legislative benchmarks for long-term sustainability. Their ability to navigate the tensions between national interests and multilateral obligations will determine the ultimate success of the Paris Agreement. The future of climate governance will depend on the capacity to transform industrial rivalry into a virtuous cycle of innovation, where leadership is measured not only by market share but by the effective contribution to stabilizing the global climate. By integrating these different strategic visions, it will be possible to bridge the gap between ambition and reality, ensuring a decarbonized and resilient future for generations to come.

The final assessment of this study underscores that the clean energy transition is a multifaceted process where industrial policy and climate diplomacy are inextricably linked, and where the leadership of China and the EU remains one of the most decisive factor in the global fight against climate change. Only through a balanced approach that respects both the need for rapid industrial scaling and the necessity of high environmental and social standards can the international community hope to fulfill the promise made in Paris in 2015.

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